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Policy Research in the Area of Agricultural Productivity

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AGRICULTURE SECTOR MODERNIZATION PROJECT

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EXECUTIVE SUMMARY

This Study intends to carry out an in-depth policy research in the area of Agricultural Productivity. MARGA was commissioned by the Project Maagement Unit of the ASMP to identify knowledge gaps, policy and regulatory inconsistencies for the allocation of public agriculture expenditures to improve agriculture productivity, and to recommend adjustments, reforms or new policies needed to make agriculture sector more competitive, responsive to the market demands, sustainable and resilient. Study estimated agricultural growth trends and total and partial factor productivities of key agricultural sub-sectors in Sri Lanka and decomposed the agricultural growth into its sources of agricultural growth to assess the effects of public investments, such as research, extension, rural roads, irrigation, insurance, finance among others on productivity of selected agricultural sub-sectors with a comparison of regional countries. Output growth of ten crop sectors over the period from 1990 to 2018 was decomposed into growth due to input growth and TFP growth (growth of efficiency of input) and further decomposed into land expansion growth, growth of factor intensification on land and TFP growth. Total Factor Productivity (TFP) measures how efficiently agricultural land, labor, capital, and materials (agricultural inputs) are used to produce agricultural output. Based on the determinants of productivity growth, study proposes the required changes in policies and the changes required in prioritizing government expenditure allocations and essential changes in regulations as recommendations.

In the last few decades, there has been no or negligible structural change in farming in Sri Lanka. Food crop production is predominantly carried out by small farmers in the informal sector. Land, labour and capital are constraining factors for sector growth. Policies introduced after liberalization of the economy in various stages have focused on getting increased participation of the private/corporate sector especially in the market operations by relaxing the trade restrictions and providing incentives. Import tariffs are used continuously to protect the cereals and other food crops cultivating small farmer from competition as TFP growth in the domestic food crop sector has not been in par with the competing neighbouring countries. Export promotion strategy that has been adopted for fruit crops sector can benefit owing to the growing tropical fruit demand in the world and the 0% tariff regimes and fewer sanitary and phyto-sanitory restrictions in the importing destinations.

Technological innovations in increasing land productivity in the domestic food crop sector have been low mainly due to the limited availability of technology particularly in terms of new varieties with high yields and with better adaptability to farmers to adopt. Applied research programs directed toward these crops attaining ‘Research potential’ (RP) yield and new scientific discoveries (e.g., in biotechnology) utilized to attain the “science potential’ yield determine the extent to which Sri Lanka can bridge the research and science gap for technological innovations. The most significant technology breakthrough in the recent past is the introduction of chilli hybrid variety by the department of agriculture.

Government emphasis has largely been on irrigation investments and fertilizer subsidy transfers. Although irrigation and fertilizer are essential inputs for realization of yields of new varieties, the growth in output due to factor accumulation will eventually taper off, making the growth process unsustainable in the long run unless the technology frontier shifted upward with new technologies. Therefore, investment on research and development is essential for long-term growth. Particularly the research agenda of the world's richest countries during post green revolution era have been shifting away from the interests of the productivity-enhancing technologies to other areas. The role of international research agencies such as CGIAR as the global biological commons in genetic resources for agricultural productivity improvement in developing countries has now been to the interest of few states. Two international treaties on IPR have a strongly bearing on the incentives and rules of germplasm sharing. Private sector and multinational companies are now dominating in the seed industry and patenting of plants. Hence, open access to genetic resources and technology spill overs are becoming more constrained. Certain imported technologies are becoming costly and not adaptive. Therefore country will need to become more self-reliant in the provision of agricultural R&D. Public research system has the vital share in creating new knowledge and technology as private, corporate and non-governmental sectors have limited incentives for innovations compared to neighbouring countries

Due to the inadequate funding for agriculture research and not duly recognizing the role of Department of Agriculture as the main public research and extension arm of the domestic food crop sector, there is a large setback in agricultural R&D program in the food crop sector. Policies, programs, human resources and funding are not in place to undertake new technology research. However, countries such as India and more recently Bangladesh in South Asia, Vietnam have made remarkable achievements in adopting new technologies owing to the policies and institutional changes adopted. This study makes a strong case that effective public sector research system is critical in bridging the science and research gap for technology generation. Several recommendations have been made in this direction.

Sri Lanka is leading in South Asia in adopting mechanical technology in tillage, harvesting and processing largely to the rising wage rate in agriculture sector and imported technology by private sector. In transferring and up scaling technology, the role of value chain has made significant achievements globally. Sri Lanka also records similar achievements in sectors such as Maize and this is particularly important in the advent of devolved public sector extension system. Digital technology has several solutions to be merged into technology transfer programs.

Private sector's role is significant for productivity enhancement through mechanization, machinery production, quality seed production and being a partner of supply/value chain and risk management. It is therefore important to increase the space for private sector/corporate sector mainly by recognizing their role, facilitating financial and other infrastructure, maintaining stable trade policy regime, minimizing regulatory bottlenecks and establishing contract enforcement mechanism.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Sri Lanka's domestic agriculture sector is a small farmer dominant sector characterised by less abundant land and labour for cultivation. Paddy/Rice crops occupy about 820,000 ha of land, almost 80 percent of the cultivated field crop extent. Field crops cultivated other than rice, primarily constitutes a subsidiary food crop sector in Sri Lanka. It is mainly comprised of other field crops and vegetables cultivated in highlands and in the lowlands during dry season. Crops such as chilli, onion, potato and the traditional subsistence crops constitutes the subsidiary field crop sector and vegetables cultivated through two different farming systems, namely up country and low country constitutes the vegetables sector. Its cultivation is primarily for domestic consumption. Fruit crop sector is comprised of perennial crops that are cultivated mainly as intercrops or mixed crops. Currently fruit sector occupies about 150,000 ha.

In the long run, sustainable agricultural growth can only be achieved through increased productivity as resources are becoming scarce for production. There are limitations when further increasing land for agriculture as labour is moving out of agriculture and the cost of capital is increasing. Hence, increasing agricultural output growth can only be achieved through increased Total Factor Productivity (TFP), the amount of output per unit of total factors used in the production process and a more efficient use of resources becomes increasingly important as the country begin to face resource constraints in terms of land, labour and capital.

1.2 OBJECTIVES & SCOPE OF THE STUDY

This Study intends to carry out in-depth policy research in the area of Agricultural Productivity, in order to identify knowledge gaps, policy and regulatory inconsistencies in the area of Agricultural Productivity for the allocation of public agriculture expenditures to improve agriculture productivity, and to recommend adjustments, reforms or new policies needed to make agriculture sector more competitive, responsive to the market demands, sustainable and resilient.

Study attempt to estimate agricultural growth trends and total and partial factor productivities of key agricultural sub-sectors in Sri Lanka, and to assess the effects of public investments, such as research, extension, rural roads, irrigation, insurance, finance among others on productivity of selected agricultural sub-sectors with a comparison of regional countries.

Recommendations will be drawn on policy reforms, new policy formulations or strategies in order to address the identified issues.

Specific Objectives

- Estimate the Partial Factor Productivity growth of Agricultural sub sectors and specific crop sectors namely Rice, Maize, Soybean, Big Onion, Potato, Chili, Banana, Papaya, Pineapple & Passion fruit with special emphasis on land and labor productivity while comparing the situation in Sri Lanka with that of regional countries such as India, Bangladesh, Thailand, and Vietnam.

- Estimate the Total Factor Productivity growth in different agricultural sub-sectors of Sri Lanka and decompose the agricultural output growth in Sri Lanka into their sub-components.
- Determine the effects of public investment such as Research & Extension, Rural roads, Irrigation, Credit and Insurance on total factor productivity growth.

- Examine the nature and magnitude of private sector investment on agriculture and ascertain its determinants.

- Identify the major policy and regulatory changes that affected the partial factor productivities of the Agricultural sub sectors and provide suggestions/recommendations for policy/regulatory changes to improve Partial Factor Productivities with the details of the responsible authorities to undertake changes.

- Recommend appropriate policy instruments that the government could use to implement the proposed policy changes to which improve the agriculture sector competitiveness & sustainability, identify the implementing authorities (Relevant Ministries, Departments or other Organization) and the procedure to be followed in order to make policy changes/policy formulation a reality.

1.3 CONCEPTUAL FRAMEWORK AND RESEARCH METHODOLOGY

1.3.1 Research Hypothesis

Limitations for further increasing land for cultivation coinciding with labour moving out of agriculture and rising cost of capital poses the challenges for increasing output growth in the domestic food crop sector. Increasing productivity of inputs is the only option left for achieving output growth.

Decomposing output growth to its sources of growth helps understand the growth through its total input use and the growth due to productivity of all inputs, which is measured by Total Factor Productivity (TFP). Technological progress, changes in factor utilization rates, product market competition, returns to scale, and changes in input quality including climate disturbances determines the TFP growth. The changes required in policies, institutions and the allocation of public agriculture expenditures influencing TFP growth can be studied by building a relationship between TFP growth and its determinants.

The evidence is that rapid growth in public investment in research and development, irrigation and other infrastructure, extension and human resource development along with crop production strategy and policy support have helped to expand TFP and output growth in many developing countries.

Analysing the trend of partial factor productivities; labour and land productivity in agriculture helps understand the relative endowments of land and labour as well as the possible technologies in relation to labour and land saving technologies for TFP growth.

1.3.2 Technical Approach

Defining partial factor productivity growth

Partial productivity of input i,

$Ai, = Qt/ Xi,$ (Q – output X – inputs A- Productivity)

Then the partial productivity growth of input i at time t is

$\Delta\ln Ai, = \Delta\ln Qt - \Delta\ln Xi,t$

where $\Delta\ln Qt = \ln Qt - \ln Qt-1$ $\Delta\ln Xi,t = \ln Xi,t - \ln Xi,t\text{-}1$

Partial productivity growth of input i = output growth – growth of input i

Labour productivity growth = output growth – labour input growth

Land productivity growth = output growth – land input growth

Total Factor Productivity and Total Factor Productivity Growth(TFPG)

Total Factor Productivity = Multifactor Productivity

Total factor productivity measures the increase in total output which is not accounted for by increases in total inputs.

Output Growth = Accumulation of Factor Inputs (Factor Input Growth)
Land, Labour, Capital
+
Total Factor Productivity Growth (TFPG)

Portion of output not explained by the amount of inputs used in production

TFP and Partial Factor Productivity

TFP growth is the weighted sum of the partial productivity growth rates for all the inputs, where the weights are the inputs' cost-share weights.

$$\Delta \ln A_t = \Delta \ln Q_t - \Delta \ln X_t$$

$$\Delta \ln X_t = \sum_{i=1}^{N} \omega_{i,t} \Delta \ln X_{i,t}$$

.

$$\Delta \ln A_t = \sum_{i=1}^{N} \omega_{i,t} (\Delta \ln Q_t - \Delta \ln X_{i,t})$$
$$= \sum_{i=1}^{N} \omega_{i,t} \Delta \ln A_{i,t}$$

Partial productivity measures are driven by TFP growth in the long run.

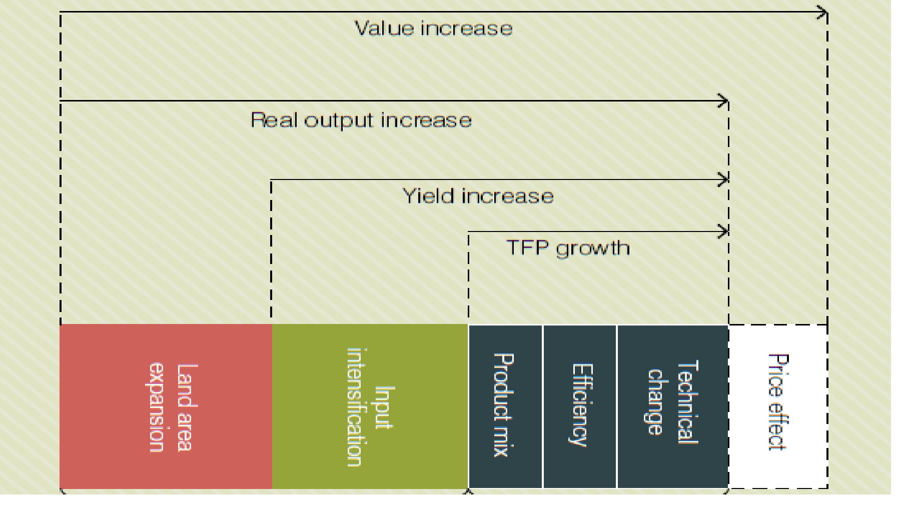
If labour and capital are considered,

Labour productivity growth is TFP growth and capital deepening,

$$\Delta \ln A_{L,t} = \Delta \ln A_t + \omega_{K,t} \Delta \ln \left(\frac{K_t}{L_t} \right)$$

If land and other inputs (labour, capital) are considered,

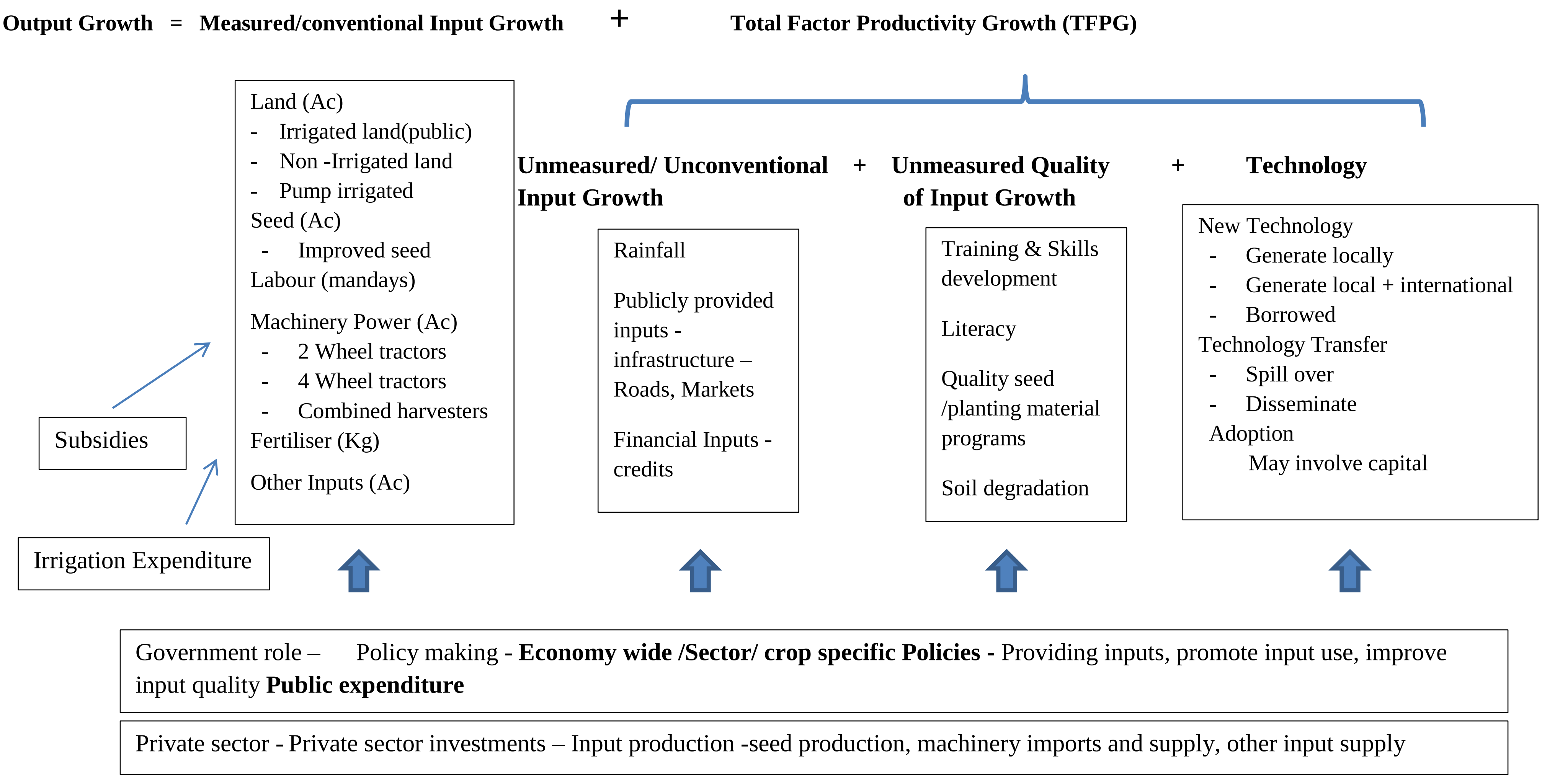
Land productivity (Yield) growth is TFP growth and input (labour, capital) intensification



The growth in the primary factors (commonly called as factor accumulation) is subject to diminishing returns. Therefore, the growth in output due to factor accumulation will eventually taper off, making the growth process unsustainable in the long run. However, the growth in factor productivity has increasing returns characteristics. That is, there is no limit to the growth in output that is due to factor productivity.

1.3.3 Conceptual Framework

TFP growth influencing factors –



1.4 EMPIRICAL ANALYSIS

1.4.1 Analysis of import substitution Crop Sector

Crops Studied
Rice/Paddy sub sector
Maize sub sector -Second largest field crop grown mainly for the production of animal feed
Other Field Crop Sector
- Chili
- Big Onion
- Soybean
- Potato

Methods of TFP and PFP Measurements

In this study, Tornqvist- Theil index approach of the Growth Accounting method was employed to calculate the TFP growth of import substitution crop sector for which time series data was available. A detailed description of the method is given in appendix (Appendix 1). (Y= output, X = input, n= number of inputs, A =TFP and β = factor share)

TFP growth is estimated by subtracting total input growth from output growth;

- Cobb-Douglas constant-returns-to-scale production function

$$Y = A \prod_{i=1}^{n} X^{\beta_i}$$

- Growth decomposition by input costs (β_i = cost share of input X_i)

$$\dot{Y} = \dot{A} + \sum_{i=1}^{n} \beta_i \dot{X}_i$$

$$\dot{A} = \dot{Y} - \sum_{i=1}^{n} \beta_i \dot{X}_i$$

Land productivity and labour productivity can be directly measured, nevertheless growth decomposition by resources also gives rise to the same productivity growth explained in $\dot{X}_{Land}$, and $\dot{X}_{Labour}$,

- Growth decomposition by resources (X_1 = land, including irrigated land)

$$\dot{Y} = \dot{X}_1 + \frac{\dot{Y}}{X_1}$$

$$\dot{Y} = \dot{X}_1 + \dot{A} + \sum_{i=2}^{n} \beta_i \left(\frac{\dot{X}_i}{X_1}\right)$$

- Underlying this theory is the assumption that inputs are substitutable

TFP estimated by Tornqvist- Theil index approach of the Growth Accounting method has been described as "a measure of our ignorance"; it is a 'black box' of the residual part of the output growth that we cannot yet explain. Growth accounting approach therefore allows for the estimation of TFPG which not only includes the technological progress but also growth of unmeasured inputs and measured input quality. In addition it captures the effects of factors such as factor utilization rates, imperfect competition in product markets and non-constant returns to scale.

Inputs and Outputs

- Output is measured in terms of farm output at producer level
- Inputs include broadly land, labour and capital. It is also considered land and land saving capital, labour and labour saving capital
- Irrigation considered as a quality parameter of land for paddy
  Irrigated Land =1.7 * rainfed area
- Pesticide and weedicides are considered as foreign exchange spent in US Dollar terms
- Fertiliser in quantities
- Machinery use is equated to land area mechanized.
- Aggregation of output and input into national level

Agriculture sub sectors	**Crops**	**TFPG estimation method**	**Data and approach**
Rice	Rice	From 1990- 2017 Growth accounting – Residual TFPG Tornqvist-Theil index	Output *district total maha & yala* *national total* Input output coefficients - *taken from crop enterprise budget representing either districts or national* Factor shares from *Crop enterprise budget*
Maize	Maize		
Subsidiary Food Crop Sector	Soy bean Chilli Big Onion Potato		

Factors influencing Total Factor Productivity Growth (TFPG) and Input Intensification

In addition to technological progress, TFP growth (as conventionally measured) captures the changes in input quality, unmeasured inputs and the effects of factors such as factor utilization rates, imperfect competition in product markets and non-constant returns to scale. However, TFP growth does not capture technological progress that is embodied in new capital equipment.

The changes in policies, policy outcomes, institutions, availability of public goods and services, private sector, international partner's participation and economic integration that are influencing TFP growth and Input intensification in domestic food crop sector was studied by reviewing the sector with various information sources, including literature from developing countries.

Technology can be exotic, adapted or locally developed or may be embodied in new capital equipment or disembodied. Embodied technology is transferred through imports of new machinery and other equipment. By the way of economic integration, countries can benefit from foreign R&D through "technology spillovers". The Public and private sector's role of disseminating technology is important. The factors relating to the adoption of technology are also important that credit may play a role in adopting new technology.

Unmeasured/ Unconventional Input
Rainfall
Publicly provided inputs -infrastructure –Roads, Markets
Financial Inputs - credits

Unmeasured Quality of Input
Quality seed /planting material programs
Training & Skills development
Literacy and Rural education
Soil degradation

Main categories of Variables influencing Input intensification

Resource Endowments
Prices and costs
Input policies- subsidies
Infrastructure - irrigation
Institutions - promotions
Private sector involvement

1.4.2 Analysis of Export promotion fruit crop sector

Crops Studied

Pineapple
Banana
Papaya
Passionfruit

Factor Productivity Gap among fruit growing Farmers (efficiency gap)

Due to the limitation of time series data for productivity analysis, a cross sectional analysis is performed. Productivity gains through technical change as a result of research or by the transfer of new technologies, is considered to be constant within the year of the study and was not considered. Of the sources of agricultural growth, efficiency gains through the greater technical and allocative efficiency of farmers in response to better information and education is the focus of this analysis. This varies among farmers due to farmers' level of technical knowledge (a number of agronomic practices in crop establishment), socioeconomic status (education, tenure, and nonfarm income) and accessibility to information and markets. For export fruit crop sector, the factor productivity index was developed to measure the factor productivity gap between farmers.

Factors affecting the farmer's efficiency in using resources and choosing the existing technology for increasing productivity were estimated by developing a regression model. A proxy variable was constructed to measure the efficiency i.e. quantity production per Rs spent by farmer. This measure is approximated to Factor Productivity. Factor productivity is calculated as in the following equation. In the total cost calculation, financial cost was taken.

Factor Productivity = Total production (Q)/ Total Cost

This proxy variable is used to analyse the factor productivity gap among farmers within a year due to efficiency and was regressed with variables that are determinants of productivity across a year. If farmers get more output from money he spent on production, the farmer is considered to be more efficient in using his resources and in choosing the existing technology. Factors determining productivity are variables representing the farmers' level of technical knowledge (a number of agronomic practices in crop establishment) and socioeconomic status (education, tenure, and income).

The multiple regression model is expressed implicitly as:

$FPi = f(X, Z) +E$

X= technology used and technical knowledge
Z= socioeconomic factors

Partial productivity of land and labour was directly measured that it requires less data and relies on fewer methodological assumptions.
A stochastic frontier function was derived for pineapple farming.

1.5 DATA COLLECTION

Due consideration was given to;

* Conventional/ measured and unconventional/ unmeasured inputs
* Method of accounting for changes in quality of inputs and outputs
* Coverage and level of disaggregation of inputs and outputs
* Degree of spatial disaggregation of the input, output and price data

Method of data collection

Secondary sources: Existing databases and information in literature

- International data bases- FAO data, USDA ERS, IFPRI
- Countrywide data bases - Sector Model developed for Sri Lanka
- Department of Census and Statistics- Production and extent of all agricultural data, paddy statistics and other field crop statistics, labour statistics, literacy
- Department of agriculture- Cost of cultivation data, crop enterprise data, study reports, annual reports, journals, expenditure allocations, technology releases, adoption rates
- HARTI – price data, study reports, data bank data, library materials
- Central bank – annual reports, public expenditure, agriculture sector reviews

Primary data collection

Field Survey using structured questionnaire – Farm Survey

- to collect cost of production data for fruit crops and other related information.
- 100 Banana, Pineapple, Papaya farmers and 50 Passion fruit farmers from major producing areas

Papaya - A sample of 100 farmers were interviewed from Kurunegala and Vavuniya districts. Farmers represented *Mahawa*, *Nikaweratiya*, *Anamaduwa, Kotavehera, Vavuniya North*, *Cheddikulam* and *Vavuniya* ASC areas, the main papaya growing ASC's in the district. Data collection was carried out from 2019 September to November 2019 using pretested interview schedules/questionnaires by experienced field staff with the assistance of AI of the ASC.

Pineapple - A sample of 100 farmers were interviewed from Gampaha district. Farmers represented *Urapola, Mirigama, Vake,* ASC areas, the main pineapple growing ASC's in the district. Data collection was carried out from 2019 October to December 2019 using pretested interview schedules/questionnaires by experienced field staff with the assistance of AI of the ASC.

Banana - A sample of 100 farmers were interviewed from Rathnapura, Hambantota and Moneragala districts. Farmers represented *Embilipitiya, Ambalanthota, Thanamalwila, Sevanagala* and *Sooriyawewa* ASC areas, main banana growing ASC's in the district. Data collection was carried out from 2019 November to January 2020 using pretested interview schedules/questionnaires by experienced field staff with the assistance of AI of the ASC.

Passionfruit -A sample of 40 farmers were interviewed from Kalutara district. Farmers represented the ASC areas, main passiofruit growing ASC's in the district. Data collection was carried out from 2019 December to 2020 January using pretested interview schedules/questionnaires by experienced field staff with the assistance of AI of the ASC.

Structured Interviews with key informants from the public sector

- To gather information related to existing setup, its weakness in achieving the desired outcomes, policy options and necessary regulatory changes for agriculture productivity enhancement
- Verifiying the findings of the study
- Department of Agriculture, Mahaweli Authority,

Structured Interviews with key informants from the private sector

- To collect information related to the private sector's investment in agriculture and to ascertain its determinants
- Private sector input suppliers, importers or companies in agriculture and agribusiness, Chamber of commerce, Agents

Focus group discussion with farmer groups

Lesson learned from other countries

<u>PFP comparison among regional countries</u>
A comparative analysis within the regional countries was carried out in terms of partial factor productivity of land and labour in relation to crop sub sectors to get an insight to the possible technologies and economic statuses of crop farmers as well as the land utilization capacity.

<u>Success stories from the region</u>
Bangladesh's success story of maize and potato productivity improvements in the recent past with the private sector Involvement in Bangladesh Agriculture

1.6 ORGANIZATION OF THE REPORT

The next chapter gives a detail account of the past policies of the government that were aimed at achieving various objectives at different times from the period of liberalization of the economy. Effectiveness of those policies on agricultural productivity growth has also been reviewed when and where it is relevant with the supporting literature. Chapter 3 and 4 fill the knowledge gap. Performed functions by the private sector in achieving agricultural productivity growth in the domestic food crop sector and the determinants of their continued contribution in terms of investment and programs have been reviewed in chapter 3. Chapter 4 analyses the crop-wise partial factor productivities viz. land and labour productivity and the Total Factor productivity (TFP) growth estimated for rice, maize, chili, big onion, potato and soybean also the technical efficiency and factor productivity gap calculated for farmers cultivating pineapple, banana, papaya and passion-fruit against the technology, institutions, markets and the related policy and regulatory frameworks, public and private sector investments and international partners' participation in these sectors. This chapter identifies policy plus regulatory gaps along with inconsistencies in Sri Lanka's policy formulation compared to neighbouring countries in achieving agricultural productivity growth in domestic food crop sector. Chapter 5 summarizes the findings and proposes policy instruments as recommendations.

CHAPTER 2

REVIEW OF POLICIES ON AGRICULTURE

This section reviews the policies that have been in implementation in the last few decades and the influence it had on the domestic food crop sector and the specific polices and public expenditure programs which aimed at promoting efficient agricultural inputs use for the production and enhancement in the productivity of agricultural inputs for the growth in the domestic agriculture sector. Economy-wide, sectoral and crop specific policies, regulations, public expenditure programs and institutional framework are the focus of the policy survey.

2.1 ECONOMY-WIDE POLICIES AFFECTING AGRICULTURE

The present epoch in the economic history of Sri Lanka began with the economic and trade liberalization, along with deregulation of economic activities, adopted by the new government elected to power in 1977. The major changes effected by the government under this new policy regime were in macroeconomic and trade sectors of the economy and agriculture was not a direct target area. However, the changes in the overall economic policy had significant effects on the performance of the agricultural sector as well as the sector policies that shaped the future path of agricultural development in Sri Lanka. Particularly, liberalization of agricultural trade manifested profound impacts on the agricultural sector which hitherto operated under heavy trade protection proliferated under the inward looking economic policies held by the governments preceding 1977.

In addition to economic liberalization of 1977 and its policy derivatives that followed in subsequent years, there was another nationwide change which was political in its orientation that had far reaching implications on the agricultural sector of the country. This was the devolution of hitherto centralized administrative powers of the central government among nine newly formed provincial councils. Not all administrative functions were so devolved but agricultural administration and the agricultural extension service fell among the devolved functions. This proved to be a definitive policy change that affected agricultural production and productivity in the country.

Although numerous changes were effected over time in the areas of macroeconomic and trade policies, only the following major policy scenarios along with the devolution of power in 1988, listed in chronological order, are discussed in this study particularly in relation to their effects on the agricultural sector of Sri Lanka.

- 1977 - Liberalization of the economy
- 1984 - Second wave of liberalization
- 1987 - Structural adjustment policy

- 1988 - Devolution of power to provincial councils
- 1990 - Nationwide poverty alleviation program –"Jansaviya" program
- 1977 to 1990s - Export led growth and diversification
- 1995 - Ratifying WTO Uruguay round on agriculture
- 2000 onwards - Ratifying regional trade agreements

2.1.1 Liberalization of the economy – 1977

Economic liberalization in Sri Lanka in 1977 immediately followed the change of government in the electoral polls in 1977, but apparently without prior preparation and planning. This was neither following any worldwide wave of liberalization nor was guided by any recognized international organization such as the WTO (WTO came into being much later in 1995). As a result the economic liberalization in Sri Lanka in the beginning happened to be an unplanned operation effected primarily on a political motivation to expunge the inward looking economic paradigm of the day and launch on a rapid growth path with the economic opportunities presumably available within the ensuing liberal economic scenario. Its implementation continued, therefore, as a "learning by doing" exercise which caused both desirable as well as undesirable consequences over time particularly in relation to agriculture.

Among numerous stated objectives of liberalization relating to enhancement of the overall economy of Sri Lanka "rejuvenating the agricultural sector" was a prominent one. Nevertheless, no specific policy instruments relating to agriculture were laid out. In fact the strategies adopted in the period 1977 – 1980 were mainly aimed at reducing administrative controls and interventions in the economy (Karlic et al.,1996). This included reducing quantitative restrictions in trade, some reduction of tariffs and reducing export taxes on agricultural products. Expansion of fiscal expenditure especially in order to undertake the Accelerated Mahaweli River Diversion and Farmer Settlement project was another prominent feature of this period. This is one aspect of the policy package at the time which had a direct positive impact on agricultural production and rural employment, a result that emerged not at the current period but some six years later.

A negative impact on agricultural production and farm income ensued the depressed farm prices of locally produced food crops resulting from the liberalization of the imports of food products. IPS (2008) shows that the domestic food production sector was "ignored" at this period (in favor of industrial expansion) by way of reducing and holding static the government expenditure allocated for agricultural research and expenditure and this had a prolonged impact on agricultural productivity growth in the country.

However, the overall short term economic impact of liberalization (from 1977 to 1980) has been reported to be positive. According to Karlic et al. (1966) the overall economic impact had been as follows.

- Dismantling trade and payment restrictions, notably through the removal of most import licensing requirements.
- Unifying the exchange rate and allowing it to be reflected in developments in the balance of payments.
- Restructuring (plantation) agricultural prices and export taxes to increase resources for the essential tree crops sector.
- Adjusting the prices of essential consumer goods, production inputs and public services.
- Restructuring government priorities to promote investment while substantially reducing widespread subsidies on food and fertilizer.
- Liberalizing interest rates and curtailing central bank lending to promote savings and more rational allocation of credit.

As a result of these reforms, it was reported, that there were pronounced effects on economic activity and GDP growth doubled from 3 percent to 6 percent between 1977 and 1980.

The period between 1980 and 1987, however, marked a difference. The major policy thrust was on maintaining macroeconomic stability with the help of the IMF than on extending the aforesaid reforms. There were several factors responsible for the slowdown of economic reforms and the onset of prolonged civil unrest and disturbances was the prominent cause. The second factor was the discontinuation of the initial liberalization of trade and payments system while the third was the appreciation of the real effective exchange rate during the period 1980 – 1984. GDP growth fell during this period and the major event that had a direct bearing on agriculture was the freezing (in nominal terms) of the fertilizer subsidy and the national food stamp program.

2.1.2 Structural adjustment policy – 1988 – 90

The government developed a new economic plan in January 1988 with the objectives of reducing macroeconomic imbalances and removing structural impediments to growth. This program was supported by the Structural Adjustment Facility (SAF) of the IMF and was locally referred to as the Structural Adjustment Program (SAP). The brunt of the adjustments made under SAP was felt on the government expenditure budget and, among others, the allocations on subsidies and transfers plus the normal investment expenditure were seriously affected. This indicates the pressure applied by the budgetary process on food subsidies and the funds allocated for agricultural research and extension.

This was ingrained into the founding principles of the structural policies of SAP which envisage that "public sector claims on resources" should be reduced and the industrial sector supported by the state should be more outwardly oriented. An export oriented development program specifically aimed at the industrial sector was also undertaken under the SAP in 1988 and details of this endeavor will be discussed separately in a coming section.

In spite of the ambitious plan, the first year's (1988) performance of the SAP fell considerably short of expectations (Karlic et al.,1996). Real GDP grew by only 3 percent while the rate of inflation touched 15 percent. Overall balance of payments also recorded a substantial deficit. None of these, however, had any direct implications on the food crops agriculture of the country. The reasons for this failure of the SAP, though, was identified as a set of noneconomic factors i.e. rapid deterioration of national security and some decisions made on political grounds prior to the presidential polls and parliamentary elections in the end of 1988 and early 1989 respectively.

The macroeconomic crisis of 1988 continued into the second and third years of the SAP too and the response of the government to this was a pronounced tightening of fiscal and monetary policies and a depreciation of the SL Rupee. The impact of this was felt in the agricultural sector as the subsidies on fertilizer, rice and wheat were phased out in 1989 and 1990 and the prices of petroleum products were increased substantially as well.

Relatively restrained policies showed some positive impacts on the macroeconomy in late 1989 and continued into 1990, the third year of SAP, as well. Despite the macroeconomic improvements the food crop agriculture of Sri Lanka was adversely affected by the lagged effect of the rupee depreciation of the previous year and the increases of the controlled prices of wheat, sugar, fertilizer and petroleum products. Yet some improvements in the overall economy were discerned, according to Karlic et al. (1996), by the end of 1990, the third year of SAP, such as,

- A reduction in civil service employment by 10 percent
- Privatization of some small manufacturing enterprises
- Tariff reforms that reduced the maximum tariff to 50 percent, accompanied by an extension of the coverage of excise duties
- Liberalization of ocean freight and airline services
- Increases in foreign exchange allocations for education and travel.

2.1.3 Second wave of liberalization (SWL) – 1984

The so called Second Wave of Liberalization surrounds some confusion. SWL was not an official designation of a program but rather a popular epithet. In fact, there is some more confusion caused by implicating it with SAP undertaken in 1988, which was discussed in the previous section. Nevertheless, there are some features of SAP purposely left out of the discussion therein in order to be presented here as they were popularly held as the features of SWL.

As was elucidated in the previous section, 1984 was a year of macroeconomic stabilization but not one of domestic economic reforms. As such, treating 1984 as the year of SWL is somewhat inaccurate as the SWL was popularly interpreted as a mission of "privatization of state owned enterprises". In this case it is more appropriate to identify SWL more closely with SAP, specifically its first year 1987.

It was shown in the previous section that, in addition to macroeconomic stabilization SAP envisaged reducing the claims on resources by the public sector and supporting industrial establishments with government backing. This resulted in the SAP being inclined to,

- The conversion of some enterprises to public liability companies that would operate on commercial principles
- Privatization of selected enterprises
- Promotion of private sector access to activities previously reserved for the public sector

Consequently numerous public corporations were privatized and a number of agriculture and agro-industry based public corporations (such as Sugar Corporation, Oils and Fats Corporation and the Marketing Department) were also included in the lot. Current thinking in the field of economics supports this course of action on efficiency grounds but the state faced with stiff resistance by social and political activists. The reduction of country's agricultural output during these years was also implicated to the government's liberalization and privatization policy, but quite erroneously as it was a result of a persistent drought. The merits of this line of actions were equivocal and hotly debated mainly on social and political grounds.

2.1.4 Devolution of power to provincial councils – 1988

As consequence of the signing of the Indo-Lanka Peace Accord between India and Sri Lanka in 1988, hitherto centrally executed administration of Sri Lanka was devolved to the nine newly constituted Provincial Councils. Some functions of the central government were devolved and handed over to the provincial governments while some continued to be under the center. As far as agriculture is concerned, the Ministry of Agriculture, responsible for overall planning for the agricultural sector of the country and providing some directions to the provinces remained at the center as usual. But the main department under the ministry or the "work horse" of it, the Department of Agriculture (DOA), was partially devolved.

The DOA under the central government at the time consisted of 6 technical divisions namely the Research division (RD), Extension division(ED), Education and Training division (E&TD), Seeds and Planting Material division (SPMD), Seed Certification and Plant Protection division (SC&PPD) and Agricultural Economics and Planning division (AE&PD). Out of these the ED, E&TD and SE&PD were deemed suitable by the authorities to be devolved. The RD, SPMD and SC&PPD were retained in the DOA of the central government due to ‘technical reasons’ which will be explained in a later section. The AE&PD was later reverted to the central DOA based on the same technical reasons.

This devolution of functions of the DOA, in effect, led to a disintegration of the monolithic agricultural development program conducted and administered by the center in two main ways.

- The RD developed new crop varieties and new agricultural technologies and passed them to the training staff of the E&TD as well as the extension workers in the ED through the regular in-service training program conducted by the E&TD as well as through the Regional Technical Working Group (RTWG) meetings held seasonally. In addition to this technological flow from the researchers to the extension officers, there was a reverse flow of information from the extension officers on technical problems encountered in the field, to the research community. With the devolution of the extension service to the provincial administrations the aforesaid two-way information flow and the research-extension rapport completely broke down. Although the RTWGs were replaced by Provincial Technical Working Group meetings the intended results were not realized because the research personnel and the extension personnel belonged to two different administrations, central government and provincial governments respectively, with different agendas, not to mention the attitudes.

- When the DOA had all the functions under one umbrella driving countrywide or region-wide agricultural programs were technically and administratively feasible to a great extent. The program of breeding new improved rice varieties, producing high quality seeds of those varieties, popularizing them and realizing a near hundred percent adoption and doubling county’s rice production within 15 years (from 1968 to 1983) is a concrete example vouching for this. Nevertheless, due to the divergence of interests and priorities between the center and the provinces such achievements have now become all but impossible. This is a problem that the present political system has apparently failed to overcome.

2.1.5 Nationwide poverty alleviation program -1990

In keeping with the pre-election pledge the new president of Sri Lanka elected to power in December 1988 launched an ambitious poverty alleviation program named “Janasaviya” (People’s Power) in 1990. The pledge was to grant an income subsidy of Rs.5000 per month for every family falling below the poverty line of income. This, in economic terms, was clearly infeasible but the program was inaugurated with several scaling downs in coverage, but in all administrative districts of Sri Lanka. One main feature of the program was to reduce the size of the smallest administrative unit in the country, the Grama Niladhari (GN) division, in order to make it possible for the GNs to personally monitor the Janasaviya recipients and their progress. This necessitated the expansion of the GN carder by about 5000 additional carders. The strategy adopted by the government was to immediately absorb about 2000 village level agricultural extension workers (Krushikarma Vyapthi Sevakas) or the KVSs, as they were popularly known, of the DOA and a little higher a number of Cultivation Officers (COO) employed by the Department of Agrarian Services (DAS) in to the GN carder.

This resulted in a vacuum in the areas of agricultural extension services and agricultural service delivery at the village level. This was particularly a social loss as the KVSs were trained professionals holding one year diplomas from Schools of Agriculture of the DOA.

At the time of this change the KVSs were mainly engaged in the Training and Visiting (T&V) extension program of the DOA under which they had to visit selected groups of “contact farmers” according to a set schedule. This was the main mode of extension of the time supplemented with various group activities and on farm demonstrations, all of which were organized with the participation of the KVSs. This entire village level extension program was totally disrupted by the removal of the KVS carder from the rural institutional set up and this proved to be a significant blow to the agricultural development efforts of the country.

2.1.6 Export led growth and diversification program – 1977 to 1990s

Even though Export Led Growth (ELG) and agricultural diversification have become catch phrases in professional and policy circles since early 1990s there has not been a dedicated government program specifically committed to these purposes in Sri Lanka. In fact, product diversification and ELG were implicit but embedded in the principles behind the liberalization of the economy in 1977. This entails product diversification within agriculture as well as a movement of economic activity from agriculture to industry and services.

Diversification within agriculture first stated in late1970s with the drive of the Ministry of Agriculture that encouraged farmers producing traditional crops to switch to non-traditional crops such as cut flowers. This officially un-inaugurated program also established specialized “export crop villages” such as the beetle leaf producer’s villages in Gampaha district. Further, an agricultural project funded by USAID dedicated to research and extension on agricultural crop diversification, (MARD) aiming at newly irrigated Mahaweli project areas was established during this period. Much later in mid 1990s another foreign funded project entitled Perennial Crop Diversification Project (PECRODEP) was established in the Mid-Country areas of Sri Lanka to introduce diversification to the marginally productive perennial crop farms in the area.

The DOA, in spite of being the main agricultural research and extension arm of the government did not apparently field a concerted effort in the areas of crop diversification and agricultural export promotion. On the contrary, the Department of Minor Export Crops (presently the Department of Export Agriculture) from its beginning made a significant contribution of promoting quality spices for both local and export markets but Sri Lanka has not been a big player in the world spice market, except for cinnamon. The Export Development Board (EDB) of Sri Lanka, on the other hand is actively engaged in finding new markets for Sri Lankan agricultural products and providing information and advice to the current and prospective exporters of agricultural products.

Despite the efforts, crop diversification, neither for export nor for domestic market, have held foot among Sri Lankan small farmers. However, some medium scale farmers and large corporate organizations have adopted the concept of diversification aiming at foreign markets. Large and medium scale producers of cut flower and foliage as well as some exotic fruits such as cantaloupe and vegetables such as gherkin are good examples. Nevertheless, the extent and spread of such enterprises are not adequate to help Sri Lanka to achieve the coveted goal of export led growth. May be the recent advent of large irrigated farms producing local fruits like mango and a possible expansion of pineapple and newly introduced dragon fruit would be able to drive the country in this direction.

2.1.7 Ratifying WTO trade regulations - 1995

World Trade Organization (WTO) is the only international organization that regulates the global rules of trade between nations, aiming at ensuring to the extent possible, smooth, predictable and free international trade. Sri Lanka has been a member of it since its beginning in 1995 and Sri Lanka’s annual international trade volume has shown a marked growth since then (Kannangara and Keron, 2018).

However, as was mentioned earlier Sri Lanka’s trade liberalization (in 1977) well preceded the establishment of the WTO. The pre-WTO (or pre Uruguay Round) South Asian Economies including Sri Lanka were characterized by direct public sector incentives for production such as research and development, extension services and input subsidies i.e. for fertilizer, irrigation and credit (Mikik, 2007).

What is most important for agricultural trade is the Uruguay round of negotiations which resulted in the Agreement on Agriculture which Sri Lanka has ratified and hence obliged to adhere to. The other important event is the Doha round trade negotiations started in 2001. In this round discussions and negotiations were undertaken on the important issues of trade facilitation, Trade Related Aspects of Intellectual Property Rights (TRIPS) and “Aid for Trade”. Sri Lanka is still continuing negotiations on these issues.

The WTO operates on the economic principles of international trade and this dictates the total absence or having only very low subsidies as well as the absence of non-tariff barriers. South Asian economies including Sri Lanka, which used to have high levels of distortions, have tended to set their maximum bound rates of tariffs for their agricultural commodities at very high levels. However, Sri Lanka has agreed to set the maximum bound rate of tariff for her imports at 50 percent but the operational levels are around 30 percent. These are very low tariff levels for a country in the South Asian region. For example, India has set her maximum bound rate at 300 percent. As such, Sri Lanka has apparently been drawn in to a major blunder by her trade negotiators**.**

2.1.8 Ratifying regional trade agreements – 2000 onwards

Starting from 2000 Sri Lanka has ratified two bilateral trade agreements and three multilateral trade agreements, chiefly but not exclusively, within South Asia. The bilateral agreements are Indo-Sri Lanka Free Trade Agreement (ISFTA) of 2000 and Pakistan-Sri Lanka Free Trade Agreement (PSFTA) of 2006 while the multilateral agreements are the agreement on Global System of Tariff Preference (GSTP) of 1988, Asia Pacific Trade Agreement (APTA) of 2005 (previously Bangkok Agreement of 1975) and South Asia Free Trade Agreement (SAFTA) of 2006. Further, Sri Lanka is in the process of negotiating a China-Sri Lanka Free Trade Agreement and a SAARC Agreement on Trade in Services (Ministry of Foreign Affairs, 2016).

A free trade agreement among a group of countries is one that intends to promote, among other things, growth through employment generation by removing restrictions to inter-country movement of labor and eliminating all trade restrictions totally within the group. In this sense none of the above “free trade” agreements are actual free trade agreements. They could best be named as preferential trade agreements in which the member countries offer certain trade concessions like reduced tariff rates for trade within the group in order to promote trade volumes of the member countries and promote competition and thereby improve the quality of the commodities traded. Interestingly, the above agreements were earlier referred to as preferential trade agreements in official usage as well as in technical literature.

However, Sri Lankan agriculture doesn’t seem to have derived the aforesaid kind of benefits to a satisfactory degree. The composition of the volume of trade has been biased against agricultural commodities in favor of industrial goods. Agricultural commodities have only been classified as exemptions from the negative lists or have been excluded from the positive lists except in a few cases (Samaratunga et al., 2007). Thus, the main beneficiary in Sri Lanka from regional trade agreements has been the industrial sector.

2.2 AGRICULTURE SECTOR POLICIES & PUBLIC EXPENDITURE

Although subsequent political regimes adopted broadly a different approach to implement various sector policies and programs, all government gave its priority to develop irrigation infrastructure for dry zone agriculture development. The priority received for research and development, quality seed production and quality seed import, extension and technology transfer, mechanization, efficient fertiliser use, and other supportive services for risk management, credit facilities etc was mostly in line with the broad policy framework of the government and the changing international setting. Road infrastructure and other infrastructure development accelerated after mid 90’s have been positively effecting the functioning of agriculture input and output market. Except during the period 1990-1994, fertiliser subsidy has been in operation in the country either in the form of direct price subsidy or cash subsidy. Irrigation and fertiliser policy aimed to achieve the agriculture growth through factor accumulation. Yet, bringing new technology and innovations to farm are more vital in increasing land productivity through increasing total factor productivity.

In Sri Lanka it is found in most instances government policies are not well formulated with a set of objectives, instruments and implementation strategy rather incomprehensive policy documents prepared by the ministry time to time responsible for implementation of government programs are found.

This section first reviews the research policy coupled with science policy in the domestic food crop sector, its capacity in terms human capital and public expenditure allocations for achieving the undeclared objective of bridging the science gap and the research gap. Extension policy is reviewed next that underwent a complete transformation with the devolution and implementation of social welfare programs. Policies related to agriculture inputs mainly water and fertiliser and expenditure on these programs are next reviewed. Seed policy will be discussed next. Policies favouring mechanization and the development of rural road infrastructure are also discussed. Finally, credit and finance and insurance policies are reviewed.

2.2.1 Scientific Agriculture, Science Policy and Agricultural Research Policy

Emergence of scientific agriculture and agricultural education

Agricultural sector policies and investment are all about agricultural development and ultimately, overall economic development of a country. Agricultural growth, and thereby development, had transformed from a natural resource based industry to a science based (especially mechanical, chemical and biological sciences) industry during the 20^{th} century. The resulting attempts at ‘yield growth’ instead of ‘area growth’ in agriculture necessitated the practice of agricultural research, a new enterprise. The history of the world’s agricultural development elucidates that even the least developed countries had established agricultural research institutes of some form or the other by the mid-20^{th} century. Quite interestingly, the seeds of agricultural research had been laid in Sri Lanka in as early as 1822 at the Royal Botanic Garden at Peradeniya in the form of botanic investigations of indigenous plant varieties with possible commercial potentials (Pain, 1981). Since then the DOA’s research service has grown into a countrywide network of 18 research institutes and centers spread around the country. These subsequent developments will be discussed in a following section of this paper.

In addition to research, a concurrent need emerged for a service that provided education in newly discovered agricultural technologies to the rural populace: the agricultural extension service. The practice of science based agriculture gave rise to formal agricultural education at advanced technical college and university levels in order to turn out the trained man power required for growing research and extension sectors. This, in effect, led to increasing public investment aiming, somewhat indirectly though, at the final goal of agricultural growth and development.

Sri Lanka’s response to the need of agricultural education was initially visible very early, in 1880s. However this was rather an informal training of selected groups of trainees on research and various other activities of the Royal Botanic Garden. This was expanded in to the “School Garden Movement” under the newly established Department of Agriculture (DOA) at Peradeniya, yet again an informal program. The first formal institution of agricultural education in Sri Lanka was set up in 1916 in the form of School of Agriculture under the DOA at Peradeniya. The ‘School’ offered a two year diploma in English for those who were recruited by the DOA as Agricultural Instructors for extension work and a one year certificate course in Sinhala for teachers and Village Headmen (Natesan,1981). Later over the years, the number of ‘Schools’ had been increased to 8, and are spread all over the country. University level agricultural education, however, was late to start in Sri Lanka and the first Faculty of Agriculture was founded in University of Ceylon at Peradeniya in 1947. Nevertheless, the number of faculties specializing in agriculture in various state universities has risen to nine within a relatively short span of about 60 years.

Public vs. private sector contribution to modernization of agriculture

All the above developments viz. agricultural research, extension, education and allied institutional changes, emanated mainly from the public sector except in a few cases where private profit seeking entities had a role as input providers to the farmers through free or monopolistic (in varying degrees) market mechanism. The private sector does not venture into agricultural research, the products of which are quite often of public good or common property nature for which private property rights cannot be secured through patents or other legal processes. With no secure private property rights, it is clearly understood that the private firms are unable to sell their products in the open market and earn profits on their investments. Thus, it is evident the public sector involvement is mandatory in providing the farmers with the new technology needed for agricultural growth in the majority of circumstances. For the public sector to engage in this activity there should be sound public policies to guide its research, extension and other development activities. In pure economic terms, government allocates public funds for these activities and it is therefore accountable to the public that the investment made on providing new agricultural technology earns a justifiable rate of return on investment. Further, introduction of new technology leads to structural change in the economy and consequently results in social changes that, sometimes, could prove socially undesirable and politically unacceptable. Moreover, technological change needs new institutions to efficiently effect the desired changes. Thus, developing agriculture by means of generating and dissemination of new technology needs, as a necessary precursor, a set of well thought of research and development policies.

2.2.1.1 National science policy and agricultural research policy: A critical review

It is deemed appropriate to start this section with an important caveat. The heading of this section may perhaps imply a detailed description or analysis of a wide variety of issues viz. all possible components of a national science policy, mainly science education and man power development and scientific Research and Development (R&D) in a broad array of disciplines including agriculture. Further, agricultural research policy (of Sri Lanka) is another broad area of activities covering R&D in food crops sub-sector, plantation sector, export agricultural sector etc. However, the statement of objectives of this study explicitly indicates that the main thrust of current research is an analysis of total and partial factor productivity growth and the underlying past and present policy issues. In view of this background the reviews of science and agricultural policies keep away their science education involvement. Also the review relating to ‘agriculture’ is essentially centered on the policies and other developments pertaining to the food crops sub-sector.

2.2.1.1.a Development of a science policy and its impact on agriculture

As was indicated in the previous section, modern day drive towards economic growth and development is science and technology based and therefore, in ideal circumstances, guided by a sound national science policy. Agricultural research in a country, in fact, comprises a subset of activities undertaken within the guidelines provided by her national science policy, again under ideal circumstances (Ruttan, 1987). This may be the situation, at least to a substantial extent, in economically advanced and better organized countries. Nevertheless, in less developed nations the status quo often diverges substantially from the said ideal. The development of the national science policy and agricultural research policy in Sri Lanka is a telling example of this.

Scientific research, in some rudimentary form, started in Sri Lanka during British colonial rule. They took the form of explorations, surveying etc. in order to cater to the commercial interests of the colonial rule. Even agricultural research in the late 19th century largely belonged to this category as research on cultivation of coffee and tea at the time and rubber some years later were the responsibility of the DOA (Wickramasinghe, 2006). Even though such research were governed by the broad ‘commercial policy’ of the colonial government, that could hardly be classified as a development policy let alone a ‘research policy’. Somewhat more ‘genuine’ an agricultural development policy for Sri Lanka covering the food crop production activities of the predominantly rural populace was enacted by the colonial government after the Bengal famine of 1911 and the 1st World War that resulted in a shortage of food grains and the government of Ceylon (now Sri Lanka) found it difficult to import the necessary quantities of food (Wickramasinghe, 2006).

The series of events leading to the development of a national science policy in Sri Lanka was marked by the formation of the Sri Lanka (then Ceylon) Association for the Advancement of Science in 1944. Within four years of its formation it was able to begin an effective agitation by the local scientists to get the politicians and science administrators to recognize the role of science and scientists in national development. They pressed hard immediately after National Independence in 1948 for a national organization for science and technology following the model of Indian Science Policy Resolution (Wickramasinghe, 2006). However, this proposal had to be presented to several subsequent governments before it finally resulted in the formation of the National Science Council (NSC) in 1968. The ‘seven point Science Policy Statement’ was presented to the government and was officially accepted as the Science and Technology Policy of Sri Lanka in 1978. However, this policy concentrated more on science education than on research.

The NSC was replaced by the Natural Resources, Energy and Science Authority (NARESA) in 1982. NARESA and its predecessor NSC were semi government institutes under the Ministry of Science and Technology and they “played a major role in funding research in all areas of Science and Technology (S&T) including agriculture" (Wickramasinghe, 2006). But almost all research on food crops sector were undertaken by the DOA with the annual budgetary allocations from the Treasury in this field and the percentage financial contributions made by the above organizations proved to be minimal. The situation in other state organizations could well be the same while the major beneficiaries could be the university academics, although official statistics to support this view could not be traced.

Even though the said financial contributions to agricultural research by NSC or NARESA have been modest the S&T policy document published in1986 was a significant example of efforts made towards establishing an agricultural research policy for Sri Lanka. Following a recommendation of this document the Council for Agricultural Research Policy was set up in 1987 with a view to regulate, fund and monitor research activities in the entire agricultural sector of Sri Lanka. Funding agricultural research by NARESA seized to exist with the setting up of Sri Lanka Council for Agricultural Research Policy (SLCARP) as managing funds for agricultural research hence forth came under her purview. Creation of SLCARP also owes a great deal to the World Bank funded Agricultural Research Project (ARP) of the time. Nevertheless, according to Wickremasinghe (2006) ARP recommendations did not receive the endorsement of the larger section of the scientific community in Sri Lanka. The importance of this incident is in the major criticism leveled against the proposal that "it geared towards the establishment of new organizations rather than towards strengthening R&D capabilities within those already in existence": an argument apparently stands valid even at present as would be elaborated later on. Further details on SLCARP operations will be presented and discussed in the next section.

Further, NARESA was later reconstituted as the National Science Foundation (NSF) on the recommendation by the Presidential Task Force (PTF) of 1991. Parallel to the NSF a new commission was also established under the Ministry of Science and Technology as the National Science and Technology Commission (NASTC). This new commission has recently published a comprehensive policy document entitled "National Science and Technology Policy" with a mission for "A prosperous nation with scientifically literate and innovative people with a strong and stable economy based on highly developed scientific and technological capabilities". This is a detailed document comprising ten policy objectives that cover a wide range of science and technology related issues. The impact of this policy proposal is yet to be seen.

2.2.1.1.b Agricultural research policy: Development and performance

Ministry of Agriculture is the apex body that has direct access to the political stream and is responsible for policy and strategic planning for the entire food crop production sector along with relevant coordination, monitoring and evaluation activities. Unfortunately though, it often lacks technical expertise in agriculture, but is keen on maintaining the administrative supremacy, and this results in passing down many of her responsibilities to the technical Departments directly under her. This dilutes the contribution of the Ministry in planning policies and programs not only on research but also on extension and other development related activities. Consequently, planning of agricultural research (for the food crops sector) has historically become a function of the DOA with only minimal contribution from the ministry. It would have been more appropriate if the ministry is fortified with well qualified and experienced technocrats who could effectively translate the political needs and aspirations of the time to the scientists could in turn engage in forming research policies and strategies, and thereby actively participate in the policy process.

As introduced in the last section, establishment of SLCARP under the ministry, at least in part was supposed to fill this void. But SLCARP has under its purview not only the research in food crop agriculture but also research in other sectors as plantation agriculture, export agriculture sector, animal production sector etc. and this involves the allocation of funds, monitoring and evaluation of research programs of 13 research institutes. To perform all the above SLCARP has only seven qualified officers and 14 members of supporting staff which seems thoroughly inadequate. Moreover, under the present administrative setting in Sri Lanka nine ministries deal with agriculture and rural development and nearly all are involved in some type of agricultural research of extension (World Bank, 2007). In fairness to SLCARP, it should be acknowledged that the enormous task of coordinating this many organizations is bound to result in serious inefficiency for any organization in its place. This is especially so in the Sri Lankan context where administrative rigidities and often diverging political interests among the ministries pose significant problems of cooperation and collaboration.

Further, among multiple functions of SLCARP, the major activities are, 1) the INFORM program responsible for formulating and revising National Agricultural Research Programs and research priorities, 2) the program of disbursing allowances under agricultural research grants, 3) activities relating to the National Agricultural Research Plan (NARP) and 4) capacity building in agriculture. It is worth reiterating in this context that effective execution of all these responsibilities may not be expected from SLCARP with such inadequacies in manpower and other resources. Also, this situation is seemingly a serious hindrance to the design and operation of an effective agriculture research policy in Sri Lanka.

It was made clear in above sections that the DOA has been the driving force behind the food crops sector research in Sri Lanka, both before and after the attempts to formulate overall agricultural research policies. During her century old history the DOA has made numerous significant successes in generating technological breakthroughs in agriculture. Although the DOA has been the sole driving force behind these there has not been a well-articulated overarching research policy covering the entire agriculture sector. The

Hundred Year Anniversary publication of Tropical Agriculturist (1981), the DOA's technical journal, reviews the history of DOA's activities, but presents only some fragmented success stories but not a sign of such a policy. The discussion in previous sections did not reveal the presence of a strong national science policy, especially in recent decades, that guided DOA's agricultural research either. Yet this does not imply that the research efforts of the DOA had been going astray in the past. The following cursory look into the past achievements of the DOA with the 'fragmented' policies of her various programs, divisions and institutes, in the later years, bears testimony to this.

- The research program on 'understanding the influence of agro-ecological variation on dry-land agriculture' and the 'soil survey' started in Mahailuppallama research station in early 1950s culminated in the preparation of the 'agro-ecological map' for the entire island in 1960. This was further developed to include micro-level agro-ecological variations as well by the Land Use Division in peradeniya in subsequent years. The agro-ecological map finalized by 1970 is presently the base for regional and crop based planning of all agricultural activities and policies of Sri Lanka.
- The rice varietal improvement program of Sri Lanka began in early 1950s following the 'pure line selection' adopted so far was found incapable of achieving the desired yield potential. The program started with importing Indica varieties of rice and inter-breeding, but was replaced later by cross-breeding Indica and Japonica varieties which culminated in 1957 with the release the variety H4 which became widely popular and marking the start of the subsequent H series of varieties covering all age classes of rice. These varieties that are presently being called Old Improved Varieties (OIVs) led to a remarkable increase in the average yield of rice in Sri Lanka. The rice breeding program continued further, introducing the medium height plant type challenging the short statured plant type introduced Asia-wide by the International Rice Research Institute (IRRI) of the Philippines. This plant type resulted in remarkable success by releasing BG11-11 in early 1970s and it was followed by the BG series consisting of the New Improved Varieties (NIVs) that continues till today. In addition, the rice breeding program introduced the Coordinated Rice Varietal Trial (CRVT) program which also continues to date, in order to test the adaptability and stability of the yields of the large number of rice varieties under different agro-ecological conditions and thereby attain higher rice yield in all rice growing areas. The rice breeding program of the DOA has been instrumental in achieving near self-sufficiency in rice in Sri Lanka.
- Soil Chemistry division of then Central Agricultural Research Station (CARI) at Gannoruwa launched a research program to find fertilizer recommendations for rice with the introduction of highly fertilizer responsive rice varieties mentioned above. This was at a time of low prices of chemical fertilizer. But with the global oil crisis in 1973, the need for more 'conservational' use of chemical fertilizers, especially urea, arose and the research program switched its attention accordingly by concentrating on effective fertilizer placement instead of usual method of

broadcasting. In addition, through the accumulation of knowledge of some inefficiencies in the use of Fertilizer Mixtures (V mixtures and TDM), the ‘division’ changed her fertilizer policy entirely towards Straight Fertilizers (instead of mixtures) and through their research that followed, made a complete set of fertilizer recommendations for the whole country by 2000. However, blanket-recommendations for large areas are obviously a sub-optimal strategy since the presence of micro-level variations in agro-ecological conditions lead to concomitant variations in fertilizer needs, in different areas in Sri Lanka. This understanding led to a scheme of farm level soil testing and making appropriate fertilizer recommendations with the collaboration of the extension personnel, at recent times.

- The main ‘research policy’ governing the activities of the Dry Zone Agricultural Research Station (ARS) at Mahailuppallama at its inception in 1950 was identifying and promoting crops that could be cultivated in the Dry Zone, purely in dry lands under rain fed conditions. The activities undertaken for decades under this ‘policy’ are explained by Fernando (1981) and Pain (1981). Nevertheless in early 1970s came an important change with the inception of the Mahaweli River Diversion Project under which the first settlements were to be made in “System H” area surrounding Mahailuppallama. The government’s plan to establish small irrigated farms under the project made her priority to conduct research and to set up a small pilot project. This responsibility was vested upon ARS changing her long held program on dry land agriculture substantially. The ARS scientists stood up to the challenge by introducing new research areas such as water management and breeding crop varieties suitable for irrigated agriculture etc. as well as managing the “100 acre” pilot project, in addition to her existing dry land agricultural research. Much later in early1980s, the same station was made a Regional Research Station under the country wide Agricultural Extension and Adoptive Research Program funded by the World Bank and even later in early 1990s it was made the “Field Crop Research Institute” (FCRDI) as it continues to date. The point is that the responsibilities and even the name of this institute underwent many changes over a long period of time, but without much guidance from an overall agricultural research policy not to mention a national science policy. But, by and large, the responsibilities were fulfilled.

This is but a few of the numerous significant achievements. These were, however, purposefully selected and highlighted due to two reasons. First, they have lasted over long periods of time: starting even before the time the concept of overarching research policies were conceived, but have delivered the goods. Second, over their long periods of operation they had been undergoing changes, being repeatedly revised in response to changing technical challenges plus economic and political changes. These observations reveal that the research programs of the DOA, although led by “fragmented policies”, have had the ‘dynamism’ and the ‘resilience’, two essential characteristics of a successful research program or a policy, even by today's standards. This is not, nevertheless, to assert that the DOA research program was totally successful or foolproof in all areas. Yet, any scientific estimates do not exist to prove the social cost-benefit ratios pertaining to the agricultural research program of Sri Lanka either. Finally, the foregoing discussion may result in an open question as to how 'Socio- Economically' and 'Politically' viable would be the sizeable public investment being proposed currently on initiating a new overarching agricultural research policy in Sri Lanka, and creating a large institutional structure to plan and execute the same. This open question, however, is by no means meant to be a leading question cast upon the intelligent readership.

The above credentials notwithstanding, a word of caution is needed here. The Structural Reorganization of the DOA of early 1990s, or the "Restructuring" as it was popularly known, brought some profound changes to its research organization. The more or less discipline oriented organization so far of the Research Division of the DOA was rearranged to form four Institutes of crop group orientation as the "Horticultural Research and Development Institute" (HORDI), "Field Crop Research and Development Institute" (FCRDI), Rice Research and Development Institute" (RRDI) and "Fruit Crop Research and Development Institute" (FCRDI) and a host of Regional Research Centers (RRCs) were divided for administrative purposes to fall under the above four Institutes. Although the Institutes have been assigned with a Development responsibility in addition to research, no additional allocations of financial and manpower resources in significant proportions appear to have been made. A detailed appraisal of this Reorganization or the productivity of the resulting organization could not be traced. Thus, further elaboration on this last development in the DOA was found infeasible.

2.2.1.2 A new paradigm of research policy: Innovation and its prospects

The concept of research policy became a subject of wide discourse among the academics and professionals following, and as an outgrowth of, a major conference held at the University of Minnesota of USA in 1970 on the methodology of assessing and planning of agricultural research (Ruttan, 1982). According to Vernon Ruttan, an expert on agricultural research of world acclaim, "research policy is not a formal science and judgments make an integral part of it. Such judgments arise out of a combination of scientific analysis, professional experience and personal perceptions of people of their responsibility towards the results of scientific inquiry and technological development (Ruttan, 1982)". As such, the analysis of agricultural research policy presented in this paper comprises hard facts and their analyses as well as personal experiences and the viewpoints of the author. The concept mentioned above might, most probably, have undergone changes since and new paradigms emerged, but the said complexity of the subject of making and analyzing agricultural research policies still seem to exist unchanged.

The latest and apparently most highly placed policy document of Sri Lanka is entitled "Reviving Sri Lanka's Agricultural Research and Extension System; Towards More Innovation and Market Orientation" by the World Bank, Colombo (2007). As implied by the title this work introduces a 'new paradigm' centered on 'innovation' and 'market orientation'. In view of the theme of the current exercise, at least a brief review of this work is in order. The World Bank document covers a wide range of issues and delves in to depths of detail in some respects. However, the following discussion is confined mainly to the issues of agricultural research policy and the allied organizational amendments. The World Bank report treats research, extension and some other development issues in an interwoven fashion in many places but the following account treats research separately, mainly in order to conform to the layout chosen for this paper. Extension component will be exclusively dealt with later in a separate chapter.

The World Bank report observes that agricultural research in Sri Lanka has grown very slowly- slower than the growth of agriculture itself. They attribute the slow growth to the organization of agricultural research, may be the policies behind rather than to the very low public investment in it. The issue of public investment will be dealt with in a subsequent section and the emphasis here is on the organization and the policy relating to agriculture, specifically the food crop sector, of Sri Lanka.

The 'report' levels two major critiques on Sri Lankan food crop research system.

1. Research (and extension) in Sri Lanka is supply driven and Top- Down in its approach to the farmers.
2. It does not respond to the research demands of the users of technology and does not secure the participation of the private sector in designing research projects and programs.

Both these assertions are true, but there are valid reasons for these – and these reasons have not been given due consideration in the 'report'. The past achievements of Sri Lankan researchers have been ignored and implications of largely agrarian structure of Sri Lankan agriculture sector have not been properly recognized. On the other hand it is apparently over enthusiastic on propelling its innovation model and promoting the involvement of private sector- in Sri Lankan case the profit oriented corporate sector.

Scientific advancements, or scientific 'innovations' of the DOA mentioned earlier such as breeding rice varieties to achieve self- sufficiency in rice or formulating fertilizer recommendations for new rice varieties obviously entail top–down and supply driven approaches. The great majority of small farmers did not have any expertise needed for contributing to a bottom-up program. And the very few corporate sector organizations had neither the expertise nor any incentive to participate in a high level research policy designing exercise. Even in relation to the need stressed in the report for demand driven research, the aforesaid structure of the country's (food crop producing) agricultural sector poses serious problems. The research demands of the small farmers with low levels of education could be finding solutions, for instance, on countering a hitherto unknown pest problem or on the suitable fertilizer recommendation for a problem soil. Small farmers may feel the need for diversifying their activities to increase their farm incomes but they are in most cases unaware of alternative farming or cropping systems and new enterprises suitable for the agro-ecological regions they are operating in. The suitable bottom-up solution to these situations is usually found with the help of a village level extension worker who can better understand the problem in-situ and report it to the appropriate research organization. This sort of bottom-up research planning existed in the DOA in the form of RTWG system. Although this system has disappeared after the disintegration of the DOA extension system, due credit should be given to the presence of the concept of bottom-up and demand driven research planning in Sri Lanka. With the presently growing popularity of mobile phones and smart phones among the farmers and the advent of on-line agricultural extension services the modalities of operation may improve, but the importance of a grass root level extension and adaptive research is not likely to be totally eliminated.

The World Bank report proposes four wide ranging changes to the Agricultural Research Policy and the Related Institutional Setup in Sri Lanka. First, the ineffectiveness and inadequacy of SLCARP as the country's apex agricultural research policy organization is recognized. However, it is proposed that SLCARP be elevated to the proposed new apex body- the National Agricultural Innovation Council (NAIC) which is to be chaired by the President of the country, following the model of Council of Scientific and Industrial Research in India. This is supposed to provide a Platform for Innovations that gives importance to new areas of science. This idea is an encouraging one and if implemented, would bear great potentials. However, the deficiencies of SLCARP were discussed in some detail previously in this paper and accordingly, elevating it to NAIC could prove to be a task requiring a large public investment and organizational reforms. Furthermore, the NAIC and its operational process is supposed to entail the participation of academics, professionals from all concerned research organizations, bearcats from related public institutions such as trade ministry, environmentalists, perhaps civil society organizations and a host of interested private sector organizations and/or personnel. Even though this is not meant to be a note of discouragement, it is imperative to note the task is of monumental proportions and entails enormous challenges.

Second, the national agricultural policy is proposed to be formed as 8 to 10 Mission Oriented (or Mission Mode) programs focusing primarily on economic accomplishments such as "the development of dairy industry to reduce dairy imports to less than 40 percent of domestic consumption". The implementation of national innovation program will be assigned to a consortium representing the major stake holders around the topic, involving the private sector, universities, farmer organizations, research and extension and other government agencies".

This, nevertheless, is a development program rather than a research program. As the current paper is focused on research policies and programs further details are not discussed here.

Third, it is proposed to form "Provincial Agricultural Innovation Councils" (PIACs) in each province with direct links to the NAIC. They are to focus on 'strategic development initiatives at the provincial level'. This proposition is made following the success observed in district-based "Agricultural Technology Management Agencies" (ATMAs) of India. But in Sri Lanka there are a few issues of concern in this connection.

The political and administrative divide between the central government and provincial governments is one. Under this unfortunate political environment, the general experience shows that the priorities set by the center are not adhered to by the provinces because the provincial political priorities win the day.

Moreover, under the present system of devolving subjects and funds agricultural extension is a subject under provincial governments whereas research is under the central government and allocation of funds occurs accordingly. The poor functioning of the PTWGs mentioned previously is a good example for this dichotomy. On the other hand, if by some chance, the center coerces the provinces to spend on PAIC activities out of their financial allocations, that would further aggravate the situation as the provincial ministers always take the upper hand and manipulate the situation for getting their "pound of flesh".

The other point which is more on technical grounds emanate from the fact that the provinces in Sri Lanka, unlike the 'districts' in India, do not have enough trained manpower, particularly in agricultural research. Thus the success of ATMAs in India may not be replicated in PAICs in Sri Lanka. The last concern pertains to the participation of private sector. The NAIC, most certainly based in Colombo, may be able to secure some private sector participation and the participants would be a couple of large corporations, several firms involved in seed and planting material imports and some medium and small scale agri-business entrepreneurs. The concept of private sector participation presented in the World Bank document apparently holds this group at the back of her mind. But, in the far away provinces where bulk of the agricultural production of Sri Lanka is undertaken by hundreds of thousands of smallholder farmers who are with no more than primary education, finding qualified scientists for research (and development) planning is but a far cry.

Finally to reiterate, the New Paradigm based on Innovation presented in the World Bank policy document is essentially centered on Market Oriented Innovations and with a heavy biased towards Private Sector Participation. It is repeatedly stressed that this is a policy program with no inherent flow in it. The proposal follows the path to development through Commercialized Agriculture and Agribusiness, a globally accepted strategy at the present times. The forgoing criticism arises though, from the fact that the food crop agriculture in Sri Lanka is not yet commercialized to the extent stipulated there and the involvement of the private sector is only in domestic trade of primary commodities. Only a couple of large corporations are involved in agricultural research and development of agribusiness is still not in the hands of a broad group of entrepreneurs spread all over the country. Under these circumstances a heavy dependence on Sri Lankan private sector for innovations seems to be of questionable validity. There may be suggestions of "Market Driven" innovations aiming at some commercial interests of large firms: But their contribution towards "Scientific Innovations" catering to country's agricultural productivity and the small farmers in rural Sri Lanka is questionable. The proposals in the World Bank document would be of more relevance to Sri Lanka once she has emerged from the predominantly rural and poorly productive agriculture prevailing today: hopefully in a decades time or so.

2.2.1.3 Public Investment In Financial And Human Capital In Agricultural Research

Domestic Food Crops sector of the economy of Sri Lanka employs and sustains a majority of the population but impinges on critical areas of poverty, food security and some related social issues of the sort. In view of the relatively low productivity of the food crops sector, Investing in Research and Development (R&D) in it has been clearly recognized as one principal strategy of developing Sri Lankan economy. As a result, various governments have strived to attain growth and sustainability in food crops sector of Sri Lanka, often through modified policy package on agricultural R&D depending on the times and contexts they faced. The times and contexts had been clearly marked by different development paradigms as well as political priorities adopted by the respective governments. Such variations in public policies and strategies gave rise to the observed changes in public investment in agricultural research from time to time. This is the main subject discussed in the following section.

The historical developments in science, scientific agriculture, agricultural research and agricultural research policy in Sri Lanka have already been explored in various sections of this paper, mostly in qualitative terms. Hence, they are not intended to be repeated here unless essentially needed. Instead, the following account is restricted to a quantitative analysis of the public investment in agricultural research on food crops through the research system of the DOA, the exclusive government arm on the subject.

Data and the Sources

The time period considered for the present review and analysis is restricted from 2000 to 2017 because of the limited length of the available data time series. The main body of data used in this study comprises the series of 'annual expenditure on agricultural research' extracted from the "Performance Reports" published annually by the DOA. This series provides expenditure estimates on R&D for various Research Institutes and

Regional Research Centers separately, as well as in aggregate for the DOA. In addition, the benefits of R&D in the Department of Agriculture (DOA) disaggregated by its various Institutes and Centers are also published in the "Performance Reports", but to a limited extent.

Although such data are available for periods prior to 2000, it is important to note that they are not presented under the currently operational Institutes and Centers established after the "Restructuring of DOA" effected early in early 1990s. Further information was also gathered, where possible, from literature published by some Sri Lankan and international institutions as well.

<u>Policies on Food Crops Sector and on the DOA</u>

As a prelude to an analysis of public investment in agricultural R&D, a scanty picture of agriculture in the total economy of Sri Lanka is presented in Table 1 and Figure 2.1. Accordingly, the GDP of Sri Lanka has been growing for the last 23 years at an average rate of 4 percent per year but the agricultural sector has been growing at a very slow rate. Nevertheless, it is important to note that established research and extension institutes in the food crop production sector were in existence in Sri Lanka as component parts of the Department of Agriculture (Pain, 1981; Schokman, 1981). As was mentioned earlier, the structure of the DOA underwent a profound change as a result of the "Restructuring" took place in early 1990s resulting in her present organizational structure depicted in Chart 1. Accordingly, the DOA at present comprises 10 technical Institutes and Centers as her central elements and 15 Regional Research Centers spread all over the country as peripheral units.

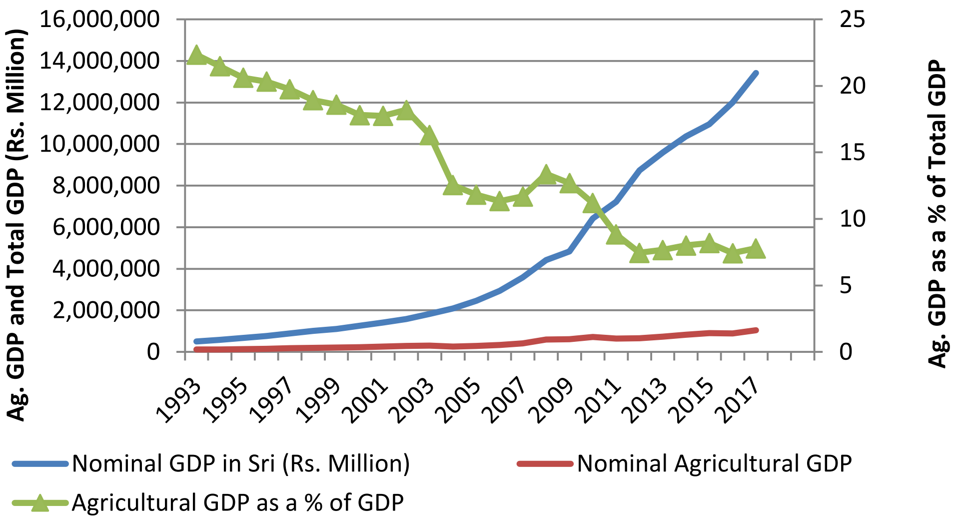


Figure 2.1: Agricultural GDP, Total GDP in real terms and Agricultural GDP as a Percentage of Total GDP

Source: Annual Reports, Central Bank of Sri Lanka

Even though the current analysis concentrates on the period starting at 2000, a scanty review of the period prior to 1977 characterized by 'the paradigm of closed economy' is included here, to serve as a comparison against the ensuing major analysis over the period 2000 – 2017. In the years prior to 1977 the import substitution and food self-sufficiency were implemented by the state with much force as the principal policies (IPS, 2008). The DOA, which consisted of the three main technical divisions of research, extension and seed production, was the chief mechanism available to the government for carrying out its primarily 'inward looking' agricultural program of the day. Hence the DOA was rather generously financed by the national treasury for achieving the most coveted economic goal at the time: of 'self-sufficiency' in food. Arguably, this resulted in most favorable terms of state resource allocation for research and extension in Sri Lanka's agriculture, although reliable quantitative data on this aspect could not be availed of. In addition to direct government allocation of funds for research and extension the inward looking agricultural policy was supplemented through agricultural support prices, input subsidies and different degrees of domestic product market interventions and protectionist trade policies.

The aforementioned inward looking and import substitution agricultural took a sharp turn following the overall economic liberalization policy adopted by Sri Lankan government in 1977. Yet, about 30 years since this land mark policy change no consensus exists that Sri Lanka has attained a successful outward looking agricultural sector (IPS 2015). Trade protection was drastically reduced depressing domestic agricultural prices discouraging agriculture in the short run. Ad hoc changes on import duties and quantitative restrictions further aggravated the situation by increasing price uncertainty facing domestic producers. In the long run, government budget on research and extension was curtailed and the growth in productivity started stagnating consequently (Samaratunga, 2009). Only the regulatory policies in relation to plant protection and the production of seed and planting materials progressed. But in the presence of the above problems not much of a positive impact on productivity and national output has resulted in. Relatively liberal trade policy is argued to be an overall pro-poor measure that brings benefits through increased efficiency in agriculture. Nevertheless, reduced emphasis on agricultural research and extension could in no way be justified in view of its negative impact on long run productivity growth in agriculture and not to mention was made on the economic welfare of over 30 percent of the rural population depending on it for livelihood (Weeraheva 2017).

On the other extreme, Figures 2.1 and 2.2 depict that food crop agriculture accounts for only about 15 percent of the annual Total GDP while only 0.15 percent of agricultural GDP had been allocated for research and extension on Food Crops on average, for the period 2000 to 2017. This is an extremely unsatisfactory situation compared to other Asian countries and developed countries have recorded such spending of 0.63 percent and 2.6 percent respectively in 1995 (Beintema et al 2008). Further, the present absence of a strong policy stance on productivity improvement and the persistent policy void on promoting domestic agriculture have only lead to the adoption of subsidies on fertilizer and enhanced price supports as the only "Production Promoting" policies. The dominant fertilizer subsidy policy of the last two decades and the relatively weak technology improvement policies such as the land-use policy, irrigation policy and inconsistent trade policies and their impacts are discussed elsewhere in this report.

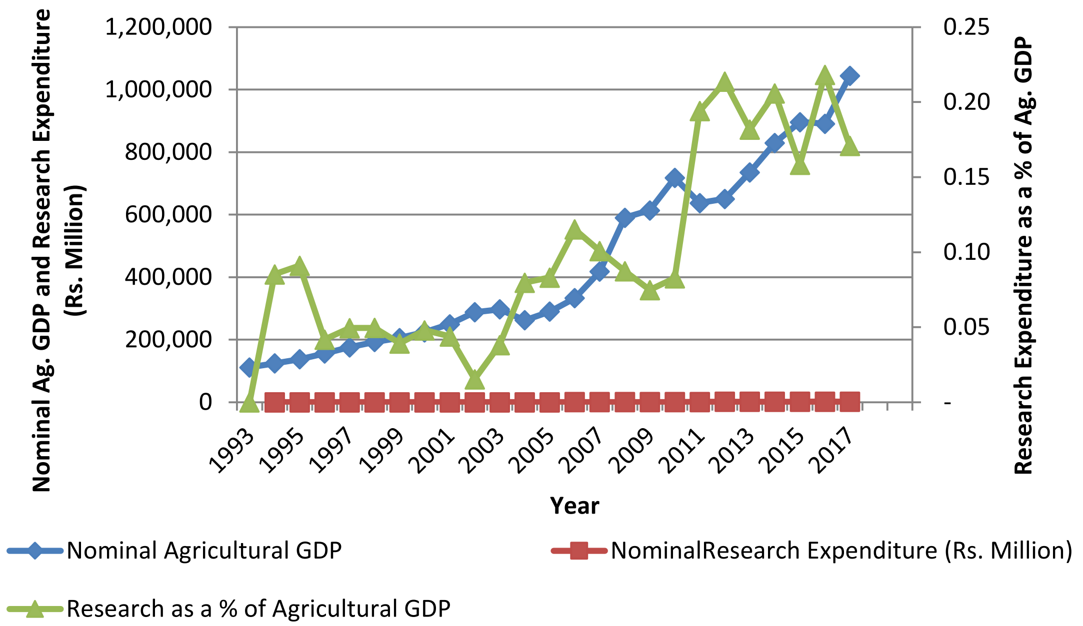


Figure 2.2: Agricultural GDP, Research Expenditure in Nominal terms and Research Expenditure as a Percentage of Total GDP

Source: Central Bank of Sri Lanka, Annual reports DOA, Budget estimates

Present Funding Arrangements for Agricultural R&D

As was mentioned earlier funding for agricultural R&D had been provided to various government institutes directly from the early days by the National Treasury under her annual voted expenditure. Alternatively, the plantation crop research institutes received their capital and operational expenditure from CESS funds administered by the treasury. This practice came to an end in 1987 at the enactment of the National Agricultural Research Policy (NARP) and the establishment of the Council for Agricultural Research Policy (SLCARP). The Sri Lanka Council for Research Policy (SLCARP) is the umbrella organization that oversees the country's public agricultural R&D system. Instead of the former practice under which R&D funds were directly disbursed by the Public Treasury, a new system was established under which SLCARP first scrutinizes all claims for agricultural R&D and then authorizes the disbursement of funds by the Treasury. The recipient institutes of R&D funds has currently been formed in to a group named the

‘National Agricultural Research Institutes (NARIs)’ which consists of 13 organizations including the CARP Secretariat and a relatively smaller higher education sector (SLCARP, 2012a).

The NRIs accounted for 85 percent of Sri Lanka’s public agricultural R&D expenditure in 2009 while the funds for the non-plantation sector stagnated around SLRs.400 million (World Bank, 2007). Private sector’s agricultural R&D investment data in Sri Lanka is hard to come by. Private sector engagement in agricultural R&D is mainly limited to export crops, rice, vegetable seeds and floriculture which, even in aggregate, is negligible in its volume compared to public sector R&D expenditure (Girihagama et al., 2012).

As mentioned earlier the total funding allocated by NARP for research on food crops in Sri Lanka is thoroughly inadequate for the task at hand. DOA is the sole organization which focuses on increasing productivity in the food crop sector, raising incomes of the farm households and strengthening export led agricultural growth in Sri Lanka. It also engages itself in a number of agricultural activities outside research such as production and distribution of seeds plus planting material and in-service agricultural education. Nevertheless, only the four Crop Research Institutes receive funds earmarked for research from the National Treasury. And yet, an Institute could retain only a portion of the total allocation it receives for her own research program while the rest is distributed among the Regional Research Centers coming under the institute’s purview. Direct disbursement of research funds, with or without the prior approval from SLCARP, from the treasury was the major modality of providing funds to the research institutes of the DOA right throughout in the past. However, after the establishment of SLCARP an additional scheme that provided a limited amount of project specific funds was also provided to the research institutes through a competitive bidding process for a limited period but this system has seized to exist recently.

The present structure of the DOA, as depicted in Chart 1, reveals its current tendency to organize her research activities along the lines four selected crop groups as Vegetables (HORDI), Field crops (FCRDI), Rice (RRDI) and Fruits (FCDI). This is a result of the somewhat controversial “Restructuring” of DOA in mid 1990s. The structure of the research facility of the DOA prior to “Restructuring”, however, was different and based on academic, or professional, disciplines as Botany, Agronomy, Chemistry, Entomology and Plant Pathology. The principal scientists were based in the Central Agricultural Research Institute (CARI) at Gannoruwa. The Research Officers (ROs) were located in numerous Research Stations spread all over the country and they were technically reporting to their respective Principal Scientists at the CARI. The particular crops researched on would depend on the agro-climatic regions where the research stations were located. Which of these two systems were more efficient or productive is an interesting question – but deemed outside the purview of this study.

Investment in R&D and related returns

A clarification on the terminology used in this section is in order right at the outset. The first term of the common abbreviation R&D is Research, which usually connotes “basic” or “Scientific” investigations that lead to scientific “Discoveries” or industrial “Innovations”. Yet, such novel discoveries need the activity called “Development” such as product development, before they are applied at production or “industrial” level. This is the basis of the common abbreviation R&D found in literature as a precursor to “Innovation” in any industry.

However, in relation to small farmers’ agriculture, research takes place, in most cases, in Research Stations and most of these turn out relatively simple “innovations” that can be directly applied at farmers’ fields. After the research phase, therefore, what is needed is not further in-house development but the conveyance of the new knowledge or new material to the farm level: a process which, in common parlance of agriculturists, is called Agricultural Extension. Consequently, the precursor before innovative agriculture in the smallholder farmers’ sector in Sri Lanka can be more aptly called R&E rather than conventional R&D. Therefore, R&E will be used hereinafter in this paper instead of R&D.

In fact, all research institutes of the DOA today comprise a small Extension unit to facilitate the “Transfer” of the “Technology” they generate. This may be a result of the former “Research” institutes of the DOA being transformed into “Research and Development” institutes following the restructuring in mid 1990s. Furthermore, the research institutes of the DOA prior to restructuring did not engage in extension activities. The research findings and recommendations used to be channeled through the Education and Training Division to the Agricultural Officers and other extension personnel of the Extension Division, all in the DOA. This channel of generation and dissemination of agricultural technological information used to be an institutional arrangement spanning all the 22 administrative districts of Sri Lanka.

Nonetheless, this uniformity of coverage in R&D services was disturbed as a result of the agricultural extension service being classified as a “devolved function” which would be administered by the nine “Provincial Councils”: the semiautonomous political and administrative divisions introduced under the Constitutional Reforms of 1987. The implication of this was the disintegration of the agricultural research-extension channel prevailed hitherto. Instead, nine individual “Provincial Agriculture Departments” responsible for providing extension services to the respective provinces emerged, but without any research capacity to support their extension programs.

Even though some repetition is involved the following paragraph may be warranted in order to put some aspects of the present research system in perspective. The “Research and Development Institutes’ of the DOA embarking on their own extension activities (to the extent possible) in later years were perhaps necessitated by the void created by these circumstances. As was mentioned earlier, DOA is holding the monopoly of research on food crops in Sri Lanka and therefore the recipient of the lion's share of funds allocated to agricultural research in the country. The other major resource deployed on food crops research is the sizeable fleet of trained man power. It was pointed out earlier that out of all agricultural research institutes in the NARS, DOA employs the largest work force.

In the event of investing public resources heavily in the field of agricultural research it is imperative that the government should also have prior knowledge on the rate of economic and/or social returns to such investments in order to justify their allocation. Unfortunately though, undertaking systematic economic and social evaluations of this nature on crop research undertaken by the DOA (in four crop groups, each containing many individual crops), is a daunting task. This is further compounded by the fact that the four research institutes are undertaking developmental (particularly extension) activities to some extent. As a consequence, such studies relating to the food crops sector in Sri Lanka are very rare and a few notable exceptions are due to Niranjan (2004) and Niranjan et al. (2001). These studies too are on the single crop of rice, for which an appreciably long data time series could be traced. The case of evaluating all research of the DOA is much more demanding and therefore remaining hitherto unexplored. However, the present study is to throw some light on this area that is in relative obscurity.

Research Expenditure of DOA

The first input needed for the present analysis is a data time series on research expenditure in as much detail as possible. The best available source of data, the annual "Performance Reports" of the DOA is limited to 23 years i.e. from 1994 to 2017. In fact, some data, particularly on Man Power, are restricted to an even shorter series from 2010 to 2017. Aggregate DOA level data on research expenditure so extracted are presented in Annex Table 2 and for expositional purposes in Fig.3.The aggregate research expenditure for the DOA is the summation of the expenditures of four individual Research Institutes viz. Field Crops Research and Development Institute (FCRDI), Horticultural Research and Development Institute (HORDI), Rice Research and Development Institute (RRDI) and Fruit Research and development Institute (FRDI). (Details of these individual institutes are discussed elsewhere in this paper).

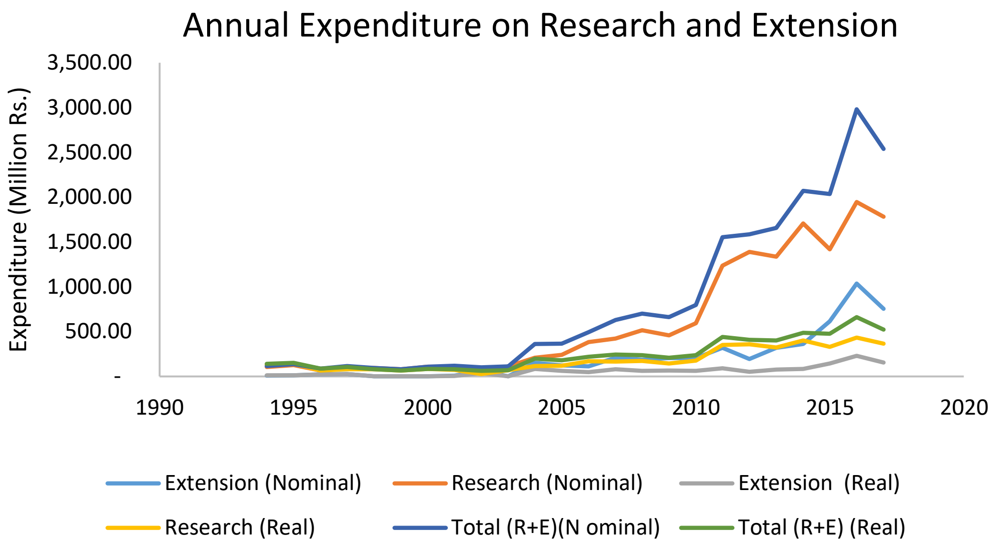


Figure 2.3: Annual Nominal and Real expenditure for Research and for Extension
Source: Central Bank of Sri Lanka, Annual reports DOA, Budget estimates

Annual data set out in Fig. 2.3 in both nominal and real terms, reveal that the aggregate research and extension (R&E) expenditure of the DOA, have been rising over the entire period under study, except for a nearly one third dip in 2000 – 2003 period. This looks encouraging at the first sight but the data reveal the disturbing truth that the increases in expenditure have not been keeping pace with the increasing rate of inflation, as implied by the real expenditure figures being constantly lower than the nominal figures. Furthermore, the gaps between the real and nominal expenditure figures have been widening right throughout the period indicating the constant devaluation of the DOA's annual research and extension budgets. The broadening gap between the research and extension expenditures also implies a growing bias in the DOA towards research over extension. Whether this a consistent policy of the DOA maintained over time is not clear, and in which case the economic logic behind such a policy should be formally justified.

Having observed that the expenditure of the DOA on R&E has been in an increasing trend the next important parameter to be determined is the rate of growth. Fig. 2.3 shows that the main period of growth in R&E expenditure was from 2000 - 2003 to 2016 and related data establishes that the annual (nominal) expenditure of Rs.113 million in 2003 had shot up to Rs.1945 million in 2016, which is a multiplication of the former by a factor of 17. A crude estimate of the average rate of year to year growth is an astounding 400 percent (or 4 times) per year. Needless to say this figure cannot be interpreted as an annual growth rate that can be sustained over an extended period of time as the expenditure curves set out in Fig. 2.3 pertains to a short term growth phenomenon that approximates an exponential phase of a growth curve. Within this short period an even shorter sub-period from 2009 to 2012 within which the research and extension expenditure has grown at roughly 400 percent per year, could be found. This sudden surge of investment may be attributed to the urgency felt at the policy circles in the event of "Foodflation" of 2008 (see Samaratunga, 2008 for details), of accelerating food production in Sri Lanka. However, the growth rates implied by the figures quoted for the period in Girihagama et.al (2012) of R&D expenditure in the DOA are much lower. But this is to be expected since their study covered the period from 1990 to 2008, which was the period of stagnant investment in agricultural R&D in Sri Lanka (see Fig.3). Stagnation of public investment in agricultural R&D in Sri Lanka is attributed mainly to constraints caused by the drain of the budgetary resources due to the 29 year war. But Samaratunga (2009) argues that it was the neglect at the policy levels of the investment in R&E owing to the declining world food prices and the consequent prospect of meeting Sri Lankan food demand with imports. Further, he argues that the liberalization policy of 1977-78 turned the interest of both the polity and the general citizenry away from developing agricultural productivity. In fact, this laid back attitude pervaded the agriculture sector in the wake of liberalization and averted a timely drive of diversifying agriculture that could exploit the new export opportunities opened up by trade liberalization.

On the subject of R&E expenditure, the next important issue is the adequacy of investment. Going back to Figure 2.2, it could be ascertained that in the decade of 1990s the investment in R&E had been a tiny fraction of Ag.GDP, which itself was a negligible percentage of total GDP. The expenditure on R&E grew to a noticeable level with the growth of Ag.GDP and the increase of R&E as a percentage of Ag.GDP is referred to as an increase in Agricultural Research Intensity (NRI). This percentage expenditure (NRI) fluctuated widely, yet the maximum it reached was 0.22 percent of Ag.GDP. This level of investment is dismally low and inadequate for sustainable development of agriculture according to agricultural development literature which suggests that a decent level would be about 2 percent of Ag. GDP (Gert-Jan Stads et al., 2005). However, Sri Lanka is close but below her neighbors in this respect since in India and Bangladesh this percentage is 0.4 and 0.32 percent, respectively (Girihagama et al.,2012). Yet Sri Lanka cannot be complacent in this respect since the present NRI of 0.22 percent is far below that is recommended level in National Agricultural Research Plan (2012), of 1.5 percent.

The data on R&E expenditure presented above are the aggregates of data pertaining to the four individual Research Institutes that constitute the research of the DOA. These four Institutes are uniform in administrative structure but they vary on their research activities and the crops they research on. Nevertheless, data on such individual activities are not available and only the Institute totals of expenditure could be traced. These data are presented in graphic mode in Figures 2.4, 2.5, 2.6, and 2.7 for FCRDI, HORDI, FRDI and RRDI respectively. All these institutes share similar trends with the aggregate R&E expenditure of Sri Lanka (Figure 2.3).

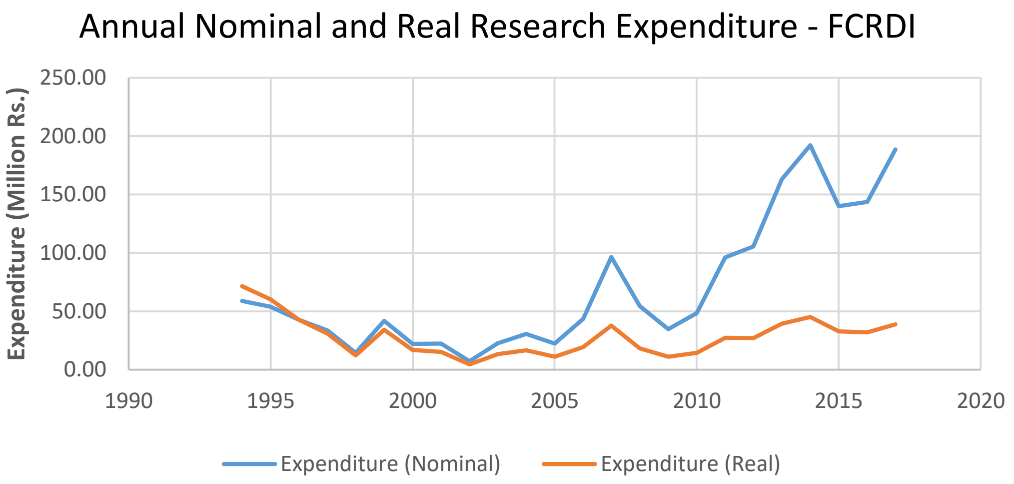


Figure 2.4: Annual Expenditure on Research and Extension at FCRDI in Nominal and Real terms

Source: Central Bank of Sri Lanka, Annual reports DOA, Budget estimates

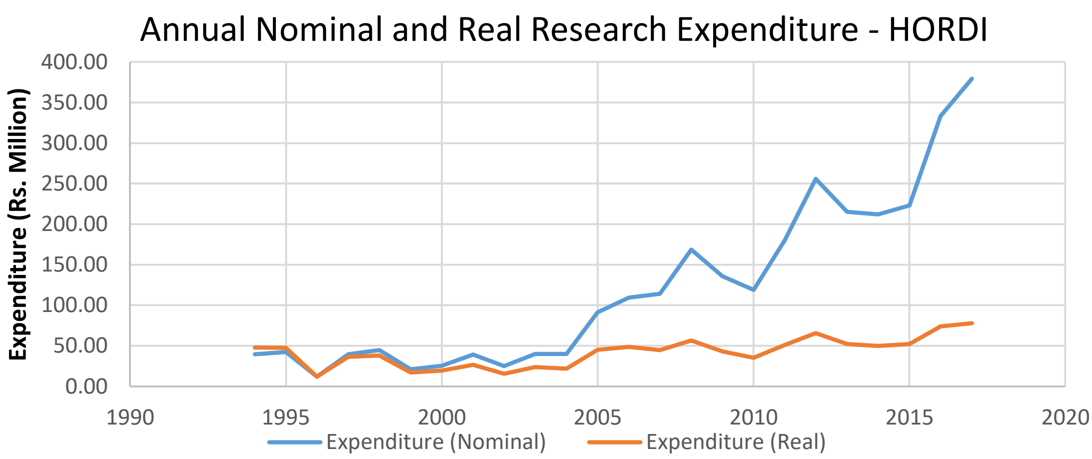


Figure 2.5: Annual Expenditure on Research and Extension at HORDI in Nominal and Real terms

Source: Central Bank of Sri Lanka, Annual reports DOA, Budget estimates

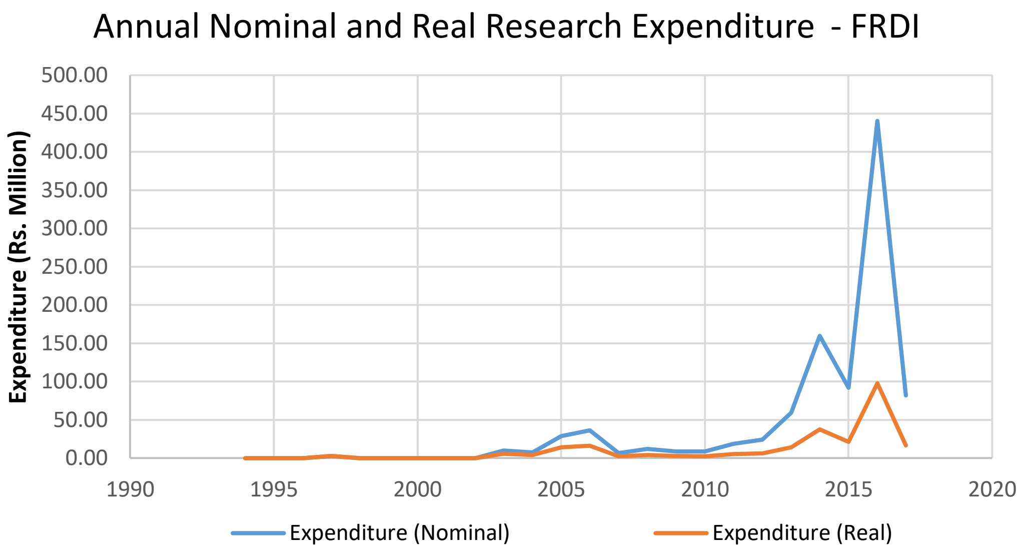


Figure 2.6: Annual Expenditure on Research and Extension at FRDI in Nominal and Real terms

Source: Central Bank of Sri Lanka, Annual reports DOA, Budget estimates

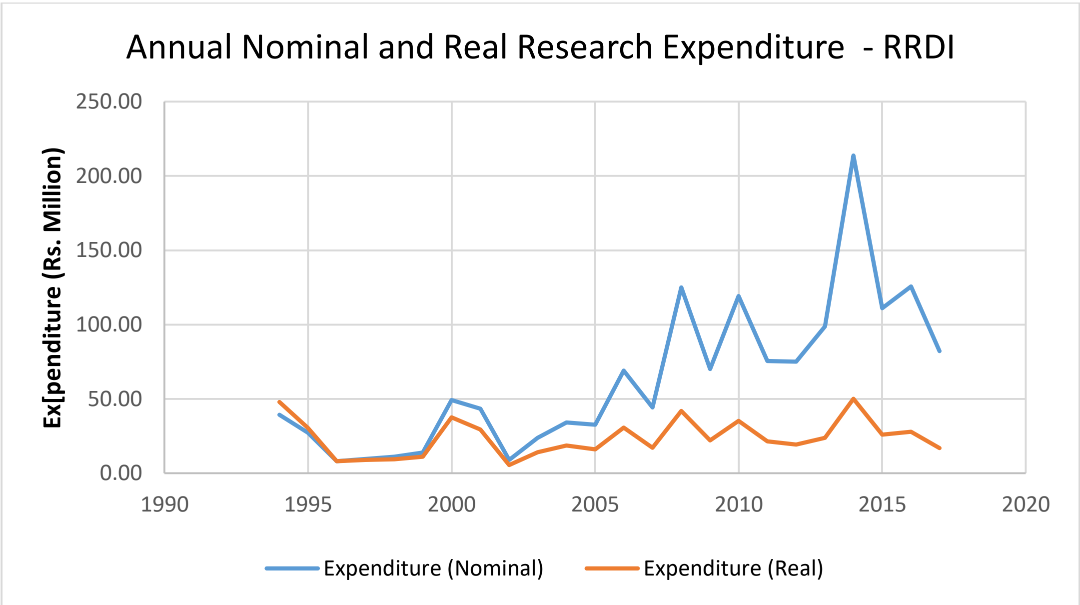


Figure 2.7: Annual Expenditure on Research and Extension at RRDI in Nominal and Real terms

Source: Central Bank of Sri Lanka, Annual reports DOA, Budget estimates

One peculiarity could be found in the case of FRDI which records research expenditure only from 2006 (Figure 2.6). This is because FRDI was newly instituted in 2006 by separating the fruit crop research component from HORDI. From this point onwards HORDI handles only the vegetable research component but interestingly her research budget has not recorded a declined as a result (Figure 2.5).

Apart from capital expenditure, the other factor the state employs in R&E is the trained man power. On the whole the DOA employs 43 percent of Sri Lanka's agricultural scientists but it accounted for just 26 percent of public agricultural spending in 2009 (Girihagama et al.,2010). As such, the following discussion on food crops R&E is chiefly centered on the whole of DOA and its activities.

Data in this respect is available only from 2010 onwards and they are presented graphically in Figure 8. Trained man power resource is divided into two categories as Grade 1 and 2 in this analysis. Grade 1 consists of the officers belonging to "Sri Lanka Agriculture Service" i.e. University Graduates in agriculture or pure science. Grade 2 comprises the supporting services viz. research assistants, laboratory technicians, laboratory assistants and agricultural instructors who hold diplomas in agriculture or similar qualifications but do not hold university degrees. Figure 8 clearly shows that both these categories have increased in strength over time. But the Grade 2 carder has increased three folds from 2010 to 2017 whereas the Grade 1 carder has grown by less than two folds. This reveals a growing worsening in the balance between Grade 1 and Grade 2 carder strengths. Moreover, the Grade 1 carder which is responsible for new innovations etc. has grown only by 250 over the last 7 years. In the light of the national plan (NARP) of increasing the NRI to 1.5 percent this expansion of high level man power seems inadequate. Another side of engaging and upgrading man power for R&E is the program of post graduate training and non-degree training opportunities. Data on this area pertaining to DOA operations were not recorded in this study and it remains a future need for improvement. However, Girihagama et al.,(2012) report that the Full Time Employed (FTE) man power per every one million farmers in Sri Lankan agricultural research system has been on an increasing trend from 2000 to 2009, recording the highest level of 154 FTE per one million farmers, in 2009. It is imperative to note however that this pertains to the NARS which comprises many institutions outside food crop production sector, which is the main focus of this paper.

<u>Benefits from R&E on the Food Crops Sector</u>

Unfortunately in Sri Lanka the benefit side of research (or R&E) is very poorly recorded and the Performance Report published by the DOA provides an account of new crop varieties released annually and a descriptive record of research and extension activities undertaken each year. Only the varieties released can be clearly quantified and the descriptive accounts provided on the other activities are not readily applicable in a quantitative analysis. They may be subjected to an analysis of qualitative data, but this is a protracted procedure and therefore was not attempted in this study.

The data on crop varieties released annually, despite year to year fluctuations, presents a most encouraging observation that there is an increasing trend in total number of crop varieties released per year. This could be treated as an indication of an increasing trend in "returns to investment" in R&E. Release of rice varieties is the most consistent in introducing new varieties over the years but its dominance over the other crop groups have declined over the years. Lowest but equally consistent varietal releases pattern can be seen in relation to Other Field Crops (OFCs) as well. A remarkable observation made is the growing dominance of Fruit crops and Vegetable crops in the varietal release program of the DOA and this is an encouraging development in the light of the present national interest in enhancing exportable agricultural products. On the whole the varietal release program of the DOA can be treated as a success story.

Although the release of varieties over time provides a certain benefit from the R&E activities it is imperative to mention that releasing a variety per say is only a part of the process that leads to the realization of real economic (and social) benefits to the society. Final economic benefit to the society depends on the net social returns obtained by cultivating the said variety by the entire society. This depends on many parameters such as the area cultivated to the variety and the level of production which finally results in the desired economic impact of supply shift. If adoption of a variety by the society takes time, the rate of adoption becomes an important factor in comparing the merits amongst new varieties. There is additional information such as demand and supply elasticities of the commodity concerned as well. (see for example Niranjan, 2004). As such, proper analyses of the impact of resource and time allocated for any R&E project is a highly demanding task.

Finally, as mentioned earlier as well, only a very few studies of this nature are available in relation to Sri Lankan agriculture. Niranjan (2001 and 2004) are prominent among them but they again are limited to rice. These studies show that the impact of rice research in Sri Lanka has been positive and they indicate National Agricultural Research Benefits (ANRBs) in aggregate terms to be 46.01, 54.39 and 58.22 million Rupees in in 3 different trade scenarios, in response to 37 percent increase of research expenditure on rice. The Internal Rates of Return (IRR) computed by Niranjan (2004) range from 174 (in trade protection) to 162 percent (in free trade) and according to these results it is concluded that investment in rice research had been economically profitable: and Sri Lanka had, therefore, been underinvesting in rice research. Yet the fact remains that this is in relation to rice only whereas the present study covers a range of crops viz. Rice, numerous Subsidiary Field Crops (SFCs) and numerous Vegetable and Fruit crops. Thus, any attempt to generalize the above findings for the entire food crop sub-sector is not warranted. The implication of this is that similar studies should be conducted in other types of crops as well in order to help the policy makers in prioritizing crop research investments in Sri Lanka.

Agricultural Research & Political considerations

A National Agricultural Research Policy (NARP) was formulated in the early 1980s to foster a public national agricultural system that ensures demand orientation, client orientation and high quality in its research and dissemination. However, the resulting agricultural research system is also essentially government-centered, and not successful in commercializing agriculture and promoting regional specialization and vertical diversification. Enhancing agricultural research and technology by increasing budgetary and human resources allocation, with a focus on much broader aspects like livelihood improvement, rural development, food security and agro based industries is a necessary condition for policy reforms in technology generation. Within the present context of globalization, adaptive research too emerges as very important in buying or acquiring foreign technology and transferring successfully to different locations in the country (IPS 2015).

In spite of these merits of buying and burrowing of agricultural technology there are some important issues that should be given serious consideration at the same time. The reliance on international trade and development is a widely advocated strategy of the modern day, especially by international development agencies as well as trading organizations. Previously discussed World Bank document is one good example. It stresses on Market Led research and development and even the Innovation culture proposed there is based on commerce, may be more than on science. The Top-Down approach to technological innovation is viewed as an 'unsuitable' approach for Sri Lanka. This implicitly suggests that generation of top level scientific and technological innovations is an activity almost entirely reserved for advanced countries and large multinational corporations. This could result in, particularly in the case of biological resources and crop varieties, these countries and corporations being the monopolies holding exclusive property rights on them. In this event the researchers in less developed countries would be relegated to the state of 'adaptive researchers' responding to the market demand for imported crop varieties and technologies. The morale of local scientists would deteriorate under such a setup where opportunities for "up-stream" research and top-down application of agricultural technology are seriously thwarted. Putting the scientific community of a country in such straight-jackets cannot be considered a progressive step towards the development of science and technology. Furthermore, the merits of some research programs in Sri Lanka of, sometimes denigrated, top-down format were discussed in detail in a previous section.

On the other hand, the imported 'improved' crop varieties produce higher yields but with the application of large doses of agrochemicals (which are also imported). This is in stark contrast with the present move towards agro-chemical free agriculture and to a lesser extent, organic agriculture. These are national policy priorities explicitly identified in

"National Policy Framework – Vistas of Prosperity and Splendor" (2019), the national policy statement of the newly elected President of Sri Lanka. This may imply moderate input agriculture based on improved and cross-bred indigenous crop varieties through agricultural research in Sri Lanka. Another aspect of dependence on imported biological technology promoted by commercial interests is the gradual displacement of local crop varieties resistant to pests and diseases and compatible with Sri Lankan food habits. (There are some unconfirmed claims that the local varieties are more nutritious). The almost disappearance of Sri Lankan tomato variety called "Goraka Thakkali" due to the popularization of thick-skinned salad varieties with better shelf quality. The crux of the argument, however, is that the true 'economic or social costs' of the loss of indigenous crop varieties to the nation has not been properly evaluated and Sri Lankan agriculture is being driven by imported crop varieties and allied technology based on the 'financial' gains and the commercial interests of certain parties.

As such, even after taking all precautions, there remains an array of interrelated questions with adopting modern inputs and technologies, such as the potential benefits and risks. Therefore new policies and institutions are needed to achieve benefits without incurring undesirable costs. What should be the roles of the private and the public sectors in effecting such policies and hence, how the modern technology and the new institutions can help poor people escape poverty and to make the agricultural development more inclusive is a valid question in the agricultural sector in Sri Lanka. Moreover, private sector participation in technology development in sections of the market where positive research results exist, the possibility of securing the appropriation of their private benefits to the proprietors through a legal property right system is government's responsibility. Nevertheless, this is to be practiced with protective measures for research results as well via carefully designed patents and intellectual property rights (IPR). Consequently, the state has to play a role in preventing exclusion of certain strata of farmers and preventing the country from being overly dependent on foreign technologies that can be controlled by alien economic or political powers.

2.2.2 Agricultural Extension in the DOA of Sri Lanka

Agricultural extension service is the vehicle that carries agricultural technology developed in the research institutes all the way to its final users, mainly the small farmers in rural areas in developing countries like Sri Lanka. According to Arthur T Mosher, a pioneer in the study of rural extension in developing countries, the rural extension workers, in addition to being the vehicle of technology perform a multitude of roles as the encouraging companion, the rural errand boy, the business advisor and the like, within the farming community. As such, the rural extension agents' service is intertwined with almost every link of the agricultural development network of a developing country. May be as a result, different aspects of agricultural extension have been discussed to varying degrees in different sections of this paper. Some repetition therefore is unavoidable in the following account of the agricultural extension service but every attempt is made to keep it to a minimum and make this discussion short.

2.2.2.1 History and development of the extension service

The distant history and development of DOA's extension service have already been touched upon briefly in the beginning of this paper (A detailed description of this subject is presented by Arasasingham, 1981). Therefore, only a few selected and yet important developments of recent times that had serious impacts on extension and thereby on agriculture at large, are elaborated in the following narrative.

After a long series of qualitative changes in the functions and quantitative changes in the staff strength of the extension service over a long period of time, a major change took place in the DOA with the appointment of a Deputy Director of Agricultural Extension along with the establishment of an exclusive Division of Agricultural Extension (DAE) in 1964. Following this, District Agricultural Offices were established in each of the 22 administrative districts of the country and these Offices were headed by 22 District Agricultural Extension Officers (DAEOs). The district offices at the time had 6 to 17 Agricultural Instructors (AIs) and 20 to Krushikarma Vyapthi Sevekas (KVSs) (the village level agricultural extension workers), depending on the size and the farmer population of the respective districts (Arasasingham, 1981). This development is the beginning of an exclusive division dedicated to agricultural extension service in the DOA. Within the districts DAEOs were in overall charge of the administration of the extension staff while holding numerous other responsibilities on planning and execution of the agricultural program of the district as well. As a result, they seldom provided technical guidance to their staff (Arasasingham, 1981), a negative attribute inherent in the organizational setup at the time.

The extension service at this time was centered on individual and group meetings conducted by the KVSs at farming villages, under the supervision of AIs. This program was supplemented with Varietal and Method demonstrations conducted mainly by AIs.

Both AIs and KVSs had responsibilities other than extension such as distribution of rice seeds.

This organizational and functional scheme relating to agricultural extension of DOA continued without a significant change until the countrywide implementation of the "Agricultural Extension and Adaptive Research Project" (AE&ARP). This project was blueprinted, technically guided and totally funded by the World Bank during the period 1980 to 1984. Leaving the Adaptive Research component out, the basic plan behind the implementation of the Agricultural Extension component of the AE&ARP is as follows.

- Training and Visiting (T&V) system was adopted as the basic method of extension at farm level. Under this system a given number of farmers per each KVS range were designated as 'contact farmers' and visiting each of them according to a fixed fortnightly schedule was compulsory to the KVSs. The contact farmers were responsible to spread the extension messages delivered to them by the KVSs among a group of 'follower farmers' assigned to each of them. Accordingly, the extension messages delivered by the KVSs were supposed to spread among the entire farmer community within their respective ranges.
- The development of the extension messages the KVSs would deliver in their fortnightly visits are done by the AIs, Subject Matter Officers (SMOs), Subject Matter Specialists (SMSs) and Agricultural Officers (AOs), mainly in the District. The messages depend chiefly on the stage of the crop in the field and the agronomic and other needs of the crop at that stage. Answering any special questions from the farmers on any problems such as the emergence of an unknown pest outbreak is also the responsibility of this group. (Help may be obtained from the Research and Education and Training divisions if and when necessary).
- Upgrading of technical knowledge and skills of extension personnel is rendered through In Service Training Programs conducted on a regular program by the Education and Training division.
- Regional Technical Working Group (RTWG) conducted for each Agro-Ecological Region before the beginning of each season is the forum that brings researchers and extension personnel together, to act as a two way information conduit. In addition to edification of the extension staff with new technological advances in research institutes, encouraging Bottom-Up research planning is one major purpose of this mechanism.

In order to fulfill the large requirement of field level extension agents the exiting small contingent of KVSs was expanded to over 2000. This system was later severely criticized by the World Bank (2007) itself (citing a local analyst), stating that "the system was very complex; most of its elements worked independently and adopted the traditional Top-Down modality".

On the contrary, nevertheless, the AR&ARP, at least in principle, had a significant potential for improving agricultural productivity at that time during which individual farmer contacts was the extension method needed by the predominantly rural agriculture of Sri Lanka. It is true, however, that the program did not realize its full potential, sometimes due to usual bureaucratic inefficiencies resulting chiefly from the high level officials acting more as administrators rather than technical frontrunners and sometimes, due to project design problems leading to resource misallocations within the project itself. One glaring example was that only a very few KVSs owned even bicycles: even they were their private property but not provided by the project or any public authority for duty related purposes. The KVSs had to travel long distances to cover their circuit of contact farmers within the allocated periods of time. The ratio of farmers to KVSs has been, reportedly 3000:1 in the beginning of the system. (But this ratio declined later with the previously mentioned recruitment of a large number of new KVSs). However, author knows from personal experience that the majority of KVSs in the Dry Zone attempted to cover such long distances they had to cover on foot, and often failed. This was a clear loophole of the project design in which a large number of field vehicles (Four-Wheel Drives) were provided by the project for the use of higher officials.

Damaging though, these are organizational inefficiencies and defects in the initial plan. Nevertheless, deficiencies of this nature could be remedied in substantial proportions with the help of experiences accumulating over time and with dedicated leadership of the authorities concerned.

2.2.2.2 Downfall of the extension system

The extension service that had been operating, at least with some degree of success under the AE&AR project (and the T&V extension system) experienced its downfall with two sweeping political ‘reforms’ introduced in mid 1980s and early 1990s. Both these events and their impacts on agricultural research and extension were discussed in several previous sections. But brief accounts on the political events and their implications, especially relating to agricultural extension, are presented blow, in spite of the repetition involved, in the interest of the continuity of this section.

The two political events and their implications on agricultural extension in Sri Lanka are as follows.

1. The first episode was the official proclamation in 1987of ‘devolution of power’ of the central government of Sri Lanka to newly established “Provincial Councils” in the nine provinces of the country. Agricultural research was identified as a non-devolved function and therefore held with the Central government while agricultural extension was devolved to be administered by the Provincial Councils. The practical operation of ‘devolved’ extension activities started in1989 only in 8 provincial departments as the

Northern Provincial council was not properly functioning due to the ongoing civil strife.

On the other hand, extension functions in the so-called “Inter-Provincial Areas” (the areas under large irrigation projects that traverse the boundaries of two or more provinces) were retained with the central government and managed by the newly formed “Extension and Training Center” (ETC) under the DOA. ETC started with about 224 staff members including directors, supervisors and field extension workers assigned to mainly rice growing interprovincial areas. The ETC of the DOA continued with the T&V extension program in the inter-provincial areas with some subsequent modifications.

However, the details of extension programs carried out by the “Provincial Departments of Agriculture” (PDOAs) are not clear. Approximately 875 extension staff worked in the eight provinces and the farmers to extension officer ratio has been 3000: 1 but reportedly this has been as high as 7000: 1 in some areas (World Bank, 2007).

In addition to all the above there existed the “Mahaweli Authority of Sri Lanka” (MASL) which was solely responsible for extension in the productive settlements under the Mahaweli River Diversion Scheme. Except from participating in RTWG meetings of the DOA, MASL operated totally autonomously without any linkages with either research or extension agencies. Consequently MASL was perhaps the agricultural organization least affected by the aforementioned political reforms in Sri Lanka.

The above story clearly shows the breakdown of the personal-contact based agricultural extension system of Sri Lanka. In addition, the segregation of the extension system from the research system demolished the research-extension link operating through RTWG mechanism and the calamitous results of this were explained earlier. Also, the failure of the attempt to replace the RTWGs by PTWGs, and the reasons for that, were explained earlier.

2. The second major blow to the agricultural extension service of Sri Lanka was, as pointed out earlier, the transfer of the entire KVS carder engaged in field level extension to Janasaviya program, an activity totally outside agriculture. The features of this program and the implications on agriculture were discussed earlier in more detail and therefore not repeated here. Suffice it to say here that this event rendered the entire agricultural extension service of the country devoid of a single field level agent. That was the end of agricultural extension based on individual contact modality in Sri Lanka.

   Following the above pervasive changes an apparently related development came about with the establishment of a new ministry entitled the “Ministry of Agrarian Services and Development” (MAS) and renaming of the formerly Department of Agrarian

Services as the "Department of Agrarian Services and Development" (DASD) mainly to provide subsidies and other services to the farmers. Along with this a new permanent carder of 9600 village level agents, rather oddly designated as "Agricultural Research and Development Assistants" (ARDAs) was established for whom the required educational qualification was only GCE ordinary level education. Even though the ARDAs are supposed to devote three days per week to agricultural extension activities they were not given any post-recruitment education or in-service training in agriculture. This much is enough to show the mismatch between the needs of the rural agricultural sector and the placement of ARDAs to serve those needs.

After these sweeping changes effected in agriculture in general and in agricultural extension in particular, some new trends could be observed emerging in DOA extension programs. This may be as an attempt to comply with the new extension methodologies spreading around the word on the one hand and, on the other hand, as an attempted remedy to deal with the inadequacy of a sizeable extension work force in the field.

The first was the beginning and gradual growth of the use of computers in all areas of DOA activities. This is an obvious result of the global trend of declining prices and consequent spread of Information and Communication Technology (ICT). But in the case of extension, the arrival of computers and other ICT facilities led to the second 'innovation' of increased use of mass communication using printed matter, audio-visual material as well as other multimedia products to make-up, at least partially, for the dearth of village level extension workers. These modern applications definitely increased the efficiency and output of the high and middle-level officers and technicians while improving the quality of extension aids produced, and hence their effectiveness. The third new extension modality introduced was group extension activities. One outstanding example was the Rice Yaya (tract) Program implemented by the ETC in interprovincial areas. A 'technology package' consisting of eight mandatory practices was introduced to all the farmers of an entire Yaya (tract) and the farmers' adherence to the mandatory practice was monitored throughout the season. The Yayas were rotated seasonally until an entire village or a larger area is fully covered. Another group extension method adopted was the "Field School" approach for educating a group of farmers on a selected technology or a technique. These relatively recent extension methodologies may have achieved the desired results to varying degrees, but systematic studies of their effectiveness and the allied benefit-cost ratios could not be found for making firm conclusions on their viability.

2.2.2.3 Social change and potentials for agricultural extension

With the passage of time several social and economic parameters in Sri Lanka's predominantly rural agricultural sector have changed significantly. Some, but not all, of these changes may have positive implications towards better extension service.

Simultaneously, but specifically in the last three decades approximately, the field of technology has seen many advances that have definite positive impacts on modern agricultural extension. The following brief review attempts to examine these developments and their possible impacts on agricultural extension in Sri Lanka.

Within the last five decades there has been a series of demographic changes in the rural sector, of which the major one being a population growth. This has led to a reduction of farm size (in some areas) and an increase in agricultural labor force. Hence the extension programs of early decades, even in 1970s, did not hesitate to introduce labor intensive practices, such as transplanting of rice, while introduction of farm machinery was given only limited or zero attention. But a marked change was observed in, roughly, the last three decades during which the population grew at a lower rate but the demographic composition changed resulting in a higher percentage of younger strata in the society. At the same time the level of educational attainment in these younger members increased substantially. From an agricultural point of view this could be seen as a progressive phenomenon as the level of education of the farmers is often positively correlated to adoption of new technology. This makes the returns to investment in extension as well. But another concomitant social change particularly in current decades is that these educated younger members of farm families tended to leave agriculture to look for employment in industry and services sectors. The promising picture anticipated above in agriculture has faded away due to shrinking of agricultural labor force has already been created. Consequently, a change in extension methodology and extension priorities indicated a need to change.

On the contrary, the advent of modern ICT unambiguously opened new vistas for improved agricultural extension. The social developments of the last two or more decades were also encouraging as, even in the farming community, mobile phones and more recently smart phones were becoming increasingly common. The response of the DOA to this emerging scenario was an increase in her investment in ICT for the purpose of improving extension in the rural sector. However, had the younger members of the populace who are the heaviest users of ICT devices remained in agriculture, the returns to this investment could have been much larger. Quite early in this period the DOA upgraded her Audio-Visual Center in order to expand the use of audio-visual extension aids in group extension activities and in mass communication through radio and television media. An extension hot-line was also introduced to provide speedy solutions to farmers' agricultural problems. Personal Computers and Tablets also were provided, first to higher level extension personnel, as well.

This drive towards modern extension culminated in the establishment of the "National Agricultural Information and Communication Center" (NAICC) headed by a Director, in 2007. The former audio-visual center and the printing press are also placed under this new Center. New extension initiatives have been set up under the Center and the designing and popularization of Agricultural Extension Apps for speedy dissemination of extension information is a prominent one. Information on area specific fertilizer recommendations, crop forecasts and early warnings etc. are presently available through these Apps. Plans have also been made and the implementation begun to provide Agricultural Instructors (AIs) all over the country with Tabs so that agricultural problems at field level could be immediately transmitted to the new "Crop Clinic" that provides quick solutions. This is presently functional only in a few provinces due to the fact that the program was planned and to be coordinated by the DOA in the central government while the provinces have to fund it in their districts. This could be an example for the frictions and conflicts possible between the Central and Provincial administrations.

Finally, since the extension service is the major institution that is responsible for technology dissemination at the grass root level, and this task is still not satisfactorily completed, there are some popularly held criticisms on it, some of which are even shared by professional commentators. The most popular one is that the agricultural extension services in Sri Lanka is supply driven and limitedly focused on farmers' needs and aspirations. The second critique is that public extension service in Sri Lanka is crop wise institutionalized or compartmentalized. The argument raised here is that extension is provided by many different specialized institutions whereas the farmers in Sri Lanka cannot be distinguished strictly by crops and enterprises such as exclusive paddy farmers or livestock farmers (IPS, 2015). Thus a new institutional arrangement for an extension system that suits integrated small farming systems including fruits and vegetables stands out as a policy priority in Sri Lankan agriculture.

Thirdly, both policy and institutional reforms are deemed necessary to bring R&D and extension under one umbrella while the role of public-private partnerships in the process of technology generation and transfer should be strengthened. Agricultural extension is under increasing pressure to become more effective and more responsive to clients' needs and less costly to the government. Despite various attempts to improve effective dissemination of agricultural technology, the process of such reforms still remains incomplete, according to the public eye. It is also stressed that technology dissemination through extension has to be customized by strengthening existing extension approaches with adequate investments in budgetary and human resource provisions. The state has to play a specific role in ensuring inclusion of small-holder farmers in the adoption process some new technologies which they might exclude themselves of, due to technical difficulties or high costs of adoption involved.

2.2.2.4 New proposals for improving agricultural extension

The newest proposals and recommendations to improve the agricultural extension system of Sri Lanka are found in the same World Bank document of 2007 discussed earlier in relation to the research system. Some structural proposals for the extension system are very similar to those discussed before in relation to the research system and hence not reiterated here. However, some of the propositions made in relation to extension are technically related to those made with respect to the research system. Such issues are discussed here in ways consistent with the opinions expressed in the discussion on the research system.

WB document proposes group extension based on organized “Producer Groups” of farmers as an extension modality with great potential in Sri Lanka. It also observes that Sri Lanka is ahead of every other country in South Asia in forming such farmer groups. Yet, at the same time caution is also expressed that the extension system is still supply-driven instead of market-driven in the provinces where “Community Based Organization” (CBO) model is at work. As CBOs lack the ‘production-function’ according to the WB report, it is indicated that they can end up being political, more interested in seeking subsidies and other services from Government.

Based on observations made on a program implemented by Western Province PDOA and another program initiated by a group of large corporations (based in Colombo), the WB document presents two impressive examples of applying successfully the group extension approach. WPDOA case is identified by WB as “market driven, well organized and pursuing a five-ear strategic plan validated by farmers”. The WP extension service routinely runs farmer trainings on agribusiness management, entrepreneurship and a host of other agro-based as well as nonagricultural household industries. The other success story is a program run by a group of hybrid maize seed companies. They provide technical assistance to groups of farmers (whose location is not provided) as well as coordinate with feed manufacturers to arrange buy-back contracts and, sometimes, arrange credit and crop insurance facilities for the farmers. Both these examples are true success stories; one as a group extension program for small farmers but the other as a private commercial enterprise that employs farmers’ labor and land resources. This is a profit making business enterprise primarily serving the interests of a large private business entity rather than a model of agricultural extension aiming at, in addition to farmer income, a host of development issues such as food and nutritional security, food diversity, efficient resource use in complex farming systems etc. Therefore, implications of these success stories on designing and planning an effective agricultural extension policy and an institutional framework for entire Sri Lanka would call for further reflection and critique.

Relating to the WPDOA program one could easily find some special reasons for its success, of course in addition to the competence and commitment of the staff involved. WP is the smallest and most urbanized province in Sri Lanka with the best road infrastructure and transport facilities. Therefore, an intensive and regular farmer training program, such as the one indicated above, is possible in WP with a limited staff. Specific features of the program such as trainings provided in agri-business management and entrepreneurship are not feasible everywhere in the country as PDOAs do not have adequate numbers of staff trained in these disciplines. In WP however, even in an absence of such expertise in-house, it is quite convenient to secure the services of private trainers because of the highly urban setting. If private sector participation, which is a highly valued feature of modern extension quite often, is needed (this is not indicated in the given case) such participation can be conveniently secured due to the same urban setting in WP. Further, enterprises promoted in the said program as ornamental flowers and landscape and interior design have an economic potential only in highly urbanized areas.

Considerations of this nature lead to the conclusion that the highly successful extension program highlighted in the WB document is rather a special case but not a general case for Sri Lanka. Hence the suggestion by the WB that WPDOA's extension program should be followed as an example by all provinces does not seem to be well placed. It is quite clear to a person who is aware of the intricacies of Sri Lanka such as the geographical, infrastructural, socio-economic and agricultural diversities offered by the nine provinces, or the 25 districts, would feel hesitant to accept a sweeping generalization of an ideal based on an incongruous special case.

Recommendations on structural issues of extension system

The WB document presents four major structural issues acting as stumbling blocks in the effective operation of the extension system of Sri Lanka. It is encouraging to note all these agree with the observations and findings reported earlier in various sections of this paper. For the continuity of the discussion they are briefly presented below as well.

- Devolution of agricultural extension to the provinces has created a 'functional disconnect' between the ETC (within the DOA) and the PDOAs in the provinces. This prevents the whole country from working according to a common strategy.
- There is an imbalance of talent and resources between the ETC and PDOAs and also, there is an 'attitudinal problem' that makes working together difficult. Although the ETC has considerable talent and resources at hand and capable of providing a lot of technical support to PDOAs, it does not take place optimally because of the attitudinal problem as to who should be in charge.
- All research departments and institutes fall under the jurisdiction of MOA and they are funded by the central government. Extension being a devolved function, individual plans are drawn up and funded by the respective PDOAs in the provinces. This gives rise to 'built-in administrative hurdles' to be overcome in bridging the research – extension gap.
- Under the present system the only prevailing link between research and extension is the biannual PTWG meetings that currently concentrate on the production plans for the coming season but do not provide a platform for planning and implementing a long-term agricultural development strategy.

Recommendations for national and provincial institutes for extension

The recommendations given in the WB document for a national plan and an institutional framework for extension are quite similar to her scheme proposed in relation to research. Therefore, some details are not repeated here.

In order to maintain coherence with programs for research and innovation, the plan and programs proposed for extension presupposes the existence of the NAIC explained earlier. Under this or parallel to this, the proposed “National Agricultural Extension Center (NAEC)” serves as the apex body on planning and programing extension activities. This could, by closely working with the counterpart research centers, review “Strategic Research and Extension Plans” (SERPs) and innovation proposals submitted for funding by “Provincial Agricultural Innovation Councils” (PAICs).

PAICs are another set of provincial level organizations proposed in this scheme. The role of PAICs is to ensure collaborative work between research and extension workers in developing SERPs and their successful implementation with NAIC funding. Priority is given to projects or programs that would link research with extension and/or link extension with private firms or NGOs.

The creation of the aforementioned NAEC is justified in the WB document in detail and summarized below.

- Creating a center of excellence in extension strategy, approach and methods which also acts as a repository of a wide variety of relevant information would be directly useful for all parties involved in agriculture.
- Conducting systematic monitoring and evaluation of all extension programs and activities is a necessity for meeting national goals and objectives.
- NAEC would possess a sizeable IT system that would link the province, district and divisional level institutes and provide them with current technical and market information.

In spite of the validity of these justifications, there are some concerns that require further attention. In setting up of the proposed NAEC the role of already existing ETC is not even mentioned despite the fact that it is the largest national institute which is most well equipped with both physical and human resources needed for extension. Further, the proposed plan of action includes reviewing SERPs in close collaboration with research centers. The SERPs, on the other hand, are supposed to be prepared by PDOAs of provincial governments and research institutes/centers of the central government, in collaboration with each other. The research - extension divide under the present system of government was discussed in detail several times previously. As such, assuming such a close collaboration would occur without a pervasive reorganization of the current system seems to be a serious lapse.

On the other hand the proposal on establishing an IT system that networks all central, provincial and regional institutes is not a novel idea. As explained before the DOA has already established the NAICC which could be easily upgraded to serve the said purposes, rather than establishing an entirely new system.

A proposition

The foregoing review of the extension system and the preceding review of the research system of Sri Lanka unequivocally lead to one glaring revelation that Sri Lankan agriculture for the last three and a half decades has been persistently beset by the systemic disconnect between research and extension. While both components suffered from its cataclysmic consequences, the extension system isolated in the provincial system and sundered from the essential support of research and training has to face the brunt of the problem. It was revealed earlier that the cause of this obstacle was a mishandling of a political imperative in mid 1980s, without giving due regards to the inherent peculiarities of agriculture.

Yet, the mistakes of the past need not be perpetuated: and they ought to be changed for the betterment of the situations. Therefore, the alternative that is logical and appropriate would be to remove agricultural extension away from the list of ‘devolved subjects’ and place it under the ETC of DOA.

This proposition is certain to be labeled as radical, if not outlandish, particularly owing to its political implications. There would be stiff resistance from provincial councils as they would not like to relinquish their authority on such an important subject. Nevertheless, with persuasive representations to the top political leadership, it is imperative that this change may be effected in the interest of the entire agricultural sector and thereby the entire population of Sri Lanka.

2.2.3 Irrigation Policy and Public Expenditure on Irrigation Infrastructure

Irrigation water for cultivation is most prioritised policy of the government even prior to independence to achieve the food security of the country. Public expenditure programmes for construction, rehabilitation, operation and maintenance of irrigation infrastructure were the main emphasis that the state placed on the development of the domestic food crop sector after independence.

New construction, rehabilitation, operation and maintenance of irrigation infrastructure

Through irrigation development it is expected to expand the cultivable area, to increase cropping intensity (both maha and yala cultivation) and to increase the quality of land. Construction of large reservoirs received attention of all governments. The public investment program allocated about 13 % of its investment for irrigation infrastructure development during pre Mahaweli period while it rose to more than 30% during *Mahaweli* construction. Increasing public investment in irrigation came to a peak during the time when the largest ever multipurpose irrigation project, Mahaweli was undertaken in 1979-1985 period. Some 128,250 Ha of land in the dry zone brought under cultivation with irrigation water. Investment in minor (Village) works has remained more or less static and has continued to be the smallest category and was only 3 per cent of total investment during 1980's. Investment in irrigation declined rapidly in the 1990s with the completion of the Mahaweli programme and most of the major irrigation works (Figure 2.8). Expenditures have focused on O&M, rehabilitation and water management with foreign funds and local funds. It dropped to 13 per cent by 1990, and thence to 2-3 per cent from the mid-1990s of the public investment program.

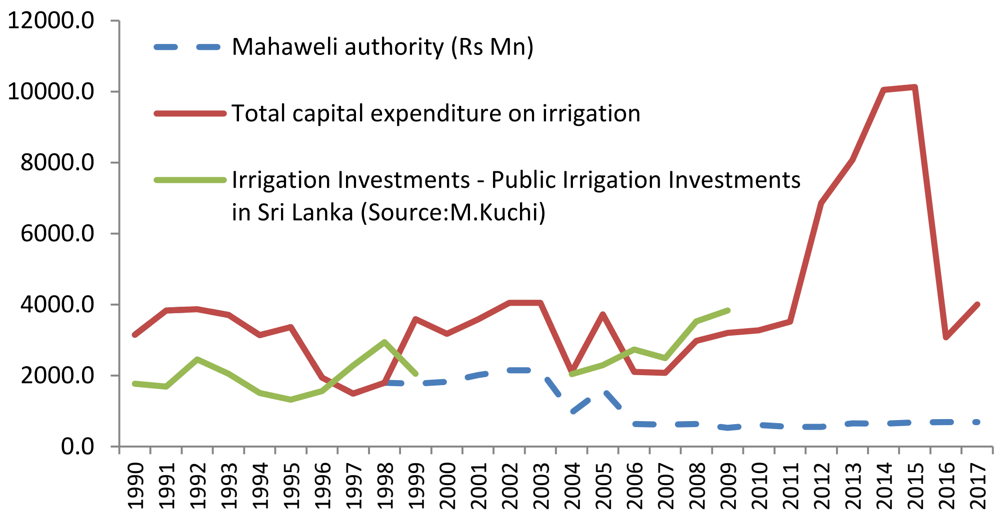


Figure 2.8: Irrigation Investments since 1990

Source: Central Bank of Sri Lanka, Budget Estimates, Kikuchi (2002)

From 2006 onwards, again attention was paid to invest mainly on new reservoir constructions aiming at productively using of the available water resources (Figure 2.8). In this background the public investment in 2009 was made for the construction of multipurpose irrigation schemes and trans-basin diversions, targeting to utilize water to address the emerging demand from agriculture as well as non-agricultural sectors. Also funds were mobilized for rehabilitation of existing irrigation schemes and dams and other works. Mainly domestic funds were diverted for the construction of new reservoirs such as Moragahakanda and Kaluganga reservoir, Menik ganga, Deduru Oya, Rambukkan Oya reservoirs etc. Major Irrigated area under cultivation increased from 1980's at a rate of 1.13% per annum (Figure 2.9).

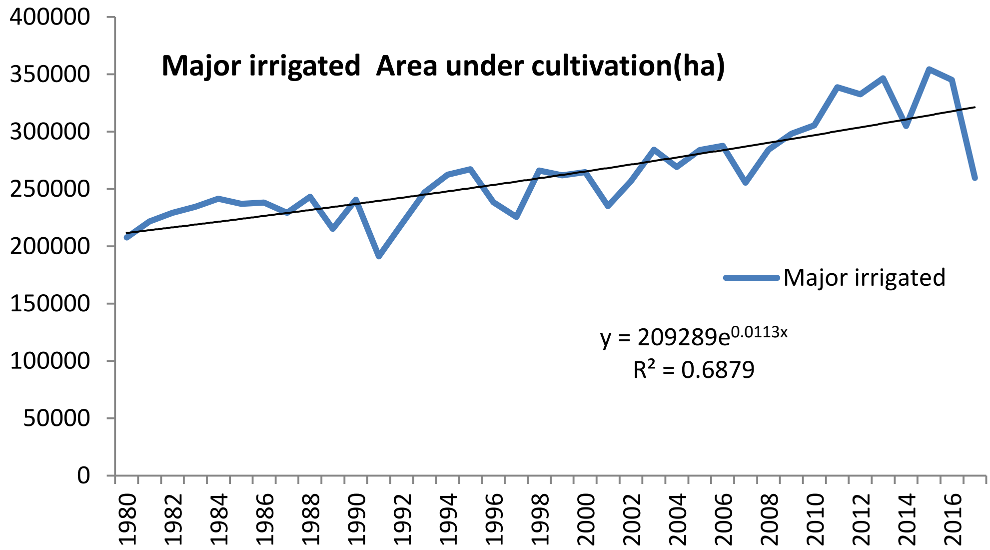


Figure 2.9: Major Irrigated area under cultivation 1980-2017
Source: Department of Census and Statistics

Currently several government agencies are involved in the construction, operation and management of irrigation systems. Of the total irrigated area, about 400,000 ha are under major schemes which are considered more than 80 ha of command area. Of that 3/4 th of the area is administered by the Irrigation Department and ¼ th is by the Mahaweli Authority. About 200,000 hectares of irrigated land under minor schemes (below 80 ha) is administered by the Department of Agrarian Services and it is estimated that minor schemes may number over 15,000, of which only half are operational. There are several minor schemes that have been abandoned, while new ones are always being constructed or abandoned ones rebuilt. Since irrigation development and management is a devolved subject, at the provincial level too there are provincial irrigation agencies for irrigation development and management and agrarian services. There are many agencies responsible for irrigation that is causing duplication and inefficient use of manpower and institutional resources.

Irrigation systems are jointly managed in major schemes with the management responsibility given to the farmer below the distributary level. In the minor schemes the management responsibility is entirely with the farmers. O&M is still being largely financed by the government, although farmer contribution in the form of labour is forthcoming. Allocation for O&M by the government is declining and therefore level and quality of O&M is on the decline. Irrigation water is a free public good to the farmers. Although it was attempted to levy a charge for water, basically to recover operation and maintenance costs (O&M costs) by introducing the cost recovery program that commenced in 1984 in the Mahaweli areas, this program has remained suspended at present.

Currently there is no policy on water allocation from major water courses or water bodies for various purposes. The government through the Cabinet of Ministers decide on water allocation for various purposes on a situation by situation basis or when an issue arises with respect to water allocation. The situation is really critical during the years with less rainfall.

Other irrigation infrastructure and machinery: Agro-wells, pumps and other structures

In major and minor schemes alike, farmers use pump water mostly for irrigating other food crops (OFCs). Besides lifting groundwater, farmers use pumps for lifting water from rivers, canals or tanks (dead storage in particular) to irrigate their crops. More than 70 percent of lined dug-wells are found in minor irrigation schemes. Unlined dug-wells are found only in major irrigation schemes, while tubewells are found mostly in minor schemes. Since 1989, the government has been making major efforts to promote lined dug-wells in both major and minor irrigation schemes in the dry zone through extending a subsidy to farmers. Both in major and minor schemes, the distribution of agro-wells between the command and the highland is about 30:70—more agro-wells are set up in the highland than in the command.

Lined dug-wells have been promoted by the government and non-profit making organizations through subsidies. In contrast, the unlined dug-well and the tubewell have been diffused entirely under farmers' own initiative.

It was especially after 1989 when the government commenced the well subsidy program that the investments in agro-wells and pumps rose sharply. The investments in agro-wells and pumps showed rapid increases again in the mid-1990s. However, the rate of increase seems to have been declining since then. Such trends have been brought about mainly by the deceleration of the increase in lined dug-wells and pumps.

2.2.4 Fertilizer Policy in Sri Lanka

Chemical fertilizer became a predominantly important agricultural input with the green revolution in the world and Sri Lanka took initiative to use chemical fertilizer for high yielding varieties to improve the productivity. Therefore, fertilizer policy was first focused on promoting the chemical fertilizer use among paddy farmers. In 1957, high yielding varieties (improved old varieties) which are responsive to chemical fertilizers were introduced to Sri Lankan paddy farmers (Wickramasinghe et al, 2010). This was a new technology for paddy farmers and therefore, a need aroused to promote the high yielding varieties and chemical fertilizer use. In order to encourage chemical fertilizer use, a fertilizer policy was formed with the aim to provide subsidies for fertilizer, guaranteed price for the output (paddy), improve the availability of fertilizer and awareness of fertilizer use among farmers through extension. Over the years, government has assisted the farmers through two different approaches in an alternative manner in cutting down the fertilizer cost. First is by introducing a subsidized fixed price for the fertilizers and the gap between the subsidized price and the market price is paid by the government. Since these fertilizers are mainly imported (95 percent), the volatility in international prices were absorbed by the government. The second approach offered a fixed amount of cash or a fixed proportion of the cost and the rest is borne by the government. Institutional setup has also been developed over the time to deliver an effective subsidy scheme. Currently the movement is towards organic fertilizer and integrated soil management systems with the concerns on health of the population and the environment.

Evolution of fertilizer policy

Pre-liberal era (1948-1976)

The first fertilizer policy was introduced in 1962. It was a fertilizer subsidy programme initiated to promote the use of chemical fertilizer in paddy farming. A direct subsidy was given by reducing the market price of fertilizers. Urea, Muriate of Potash (MOP) and Triple Super Phophate (TSP) were subsidized. The programme expected that the farmers will tend to use chemical fertilizer and they would achieve profit maximizing level of production. During that period, supply and distribution of fertilizer was handled by three private firms.

In 1964, government entered fertilizer trade establishing Ceylon Fertilizer Corporation (CFC). It involved in importing, mixing, storing and distribution of fertilizer to cater the demand from paddy and other food crops sectors.

CFC took over the sole authority of importing fertilizer by 1971 based on the policy on government intervention in international trade. This is the time in which stringent closed economic policies were introduced. Therefore, private sector participation in wholesale sector was contracted to nearly 25 percent of the fertilizer use.

By 1975, the subsidy policy was extended to other food crops in an effort to increase the fertilizer use efficiency. The aim was to prevent outflow of subsidized fertilizer from paddy to other food crops. A uniform rate of 33 percent was offered for all the crops and continued until trade liberalization.

Liberalization of the economy (1977-1987)

With trade liberalization in 1977, government allowed seven other private and public corporations to enter the importation of fertilizer. CFC handled 60 percent of the imports and the rest was distributed among seven other corporations.

Fertilizer subsidy policy was handled by the treasury up until 1978. Thereafter, the National Fertilizer Secretariat (NFS) was given the authority to administer the subsidy scheme. A uniform rate of 50 percent of the CIF value was imposed as the subsidy rate since November 1978. Custom duty (12.5 percent) and business turnover tax (5 percent) were exempted for fertilizer.

In 1979, the subsidy rate was further increased for urea (50 percent to 85 percent) and for other fertilizers (50 percent to 75 percent). NFS came into operation in 1979. It involved in coordinating all the activities related to fertilizer importation, distribution and utilization. The main task of NFS was to increase the fertilizer use efficiency.

Subsidy rates were fluctuated during the period of 1979 to 1983 considering the volatility of fertilizer prices in the international market. For urea it varied between 85 percent to 60 percent and for NPK mixtures it varied from 75 to 40 percent.

Thereafter, the fertilizer prices remained stable during the period 1983 to 1987. During this period, macro-economic stabilization is observed and domestic reforms were not prominent.

Structural adjustment policy (1988-1990)

In 17th December 1988, regulation of fertilizer act No 68 of 1988 was formed. It was an act "to regulate the importation, manufacture, formulation and distribution of fertilizer and to provide for matters connected therewith or incidental thereto" (Laws of Sri Lanka, 2014). With the increasing involvement of private sector, NFS was given the authority to issue licenses for above activities under this act.

In 1988, government had to impose a budgetary restriction of 600 million LKR for fertilizer subsidy scheme due to the soaring fertilizer prices in the international market. In the same year, certain fertilizers were excluded from the subsidy scheme (rock phosphate[1]

[1] Rock phosphate is the only fertilizer produced domestically.

and sulphate of ammonia). Urea, TSP, MOP and NPK mixtures were eligible for the subsidy scheme.

A decision was taken to abolish the subsidy scheme since 1st January 1990. This was the era the government began to revolute power to provincial councils and privatization of public corporations took place. Further, a nationwide poverty alleviation programme was introduced to provide an income subsidy for those who fall below the poverty line.

Since 1994

In 1994, the fertilizer subsidy scheme was reintroduced considering the soaring Urea prices. A fixed price rate was given for urea, SA, MOP and TSP.

Lowering distortions including subsidies and non-tariff barriers were discussed under these WTO regulations. In 1996, the subsidy on SA was abolished and since 1997, the subsidy was offered only for urea. From 1998 to 2003, a 50kg bag of urea was given at.350 LKR. Urea price was increased to 800 LKR, 600 LKR and 550 LKR in 2004,2005 and 2006 respectively.

With the new fertiliser subsidy2005, farmers were given the three main fertilisers at 350 Rs per 50 kg which is the lowest price recorded for all three fertilisers after withdrawal of the study in 1990. By having such a low price for all three fertilisers; Urea, TSP and MOP, it was intended that farmers would adopt the recommendation given by the department of agriculture. By issuing only the recommendation, it was on the other hand intended that farmers those who use more than the recommendation would stick to the recommendation.

In 2016, fertiliser subsidy scheme was revised with the provision of a cash grant in place of the provision of fertiliser. The government converted the fertiliser subsidy to an allowance of Rs. 25,000 per hectare up to a maximum of two hectares per paddy farmer per annum in place of the provision of a 50 kg bag of fertiliser at Rs. 350. Further, the government extended the fertiliser subsidy for tea, coconut and rubber as well in 2016 under which a cash grant of Rs. 15,000, Rs. 9,000 and Rs. 5,000, respectively was provided per hectare per annum. Other field crops (potato, onion, chili, soy bean and maize) received 10,000 LKR/Ha/Year. Cash grants were executed through state banks. Those were People’s bank, Bank of Ceylon, National Savings Bank and Regional Development Bank.

2018 A decision was taken by the Cabinet of Ministers, in March 2018, to terminate the cash grant of the fertiliser subsidy programme and replace it with the provision of fertiliser to farmers, to avoid issues that arose in implementing the cash grant policy. Accordingly, an approved amount of fertiliser was provided to farmers at a concessionary price of Rs. 500 per 50 kg bag for paddy and Rs. 1,500 per 50 kg bag in respect of other crops (such as potatoes, onions, capsicum, corn and soya) from the Yala season in 2018 onwards. The programme was initiated from Yala season in 2018. Provision of high quality fertilizer was an objective under the theme "Poison Free Country".

Parallel to this subsidy scheme, the theme “A Wholesome Agriculture - A Healthy Populace - A Toxin Free Nation" was promoted from 2016 to 2019. Under that, promotion of production and utilization of organic fertilizer, bio-fertilizer and gradual reduction of chemical fertilizer use through Integrated Plant Nutrition Systems (IPNS) was promoted. Provision of soil and plant testing facilities for site specific fertilizer application, assuring timely availability of chemical fertilizers in adequate quantities, prevention of misuse of fertilizer subsidy scheme, promoting application of straight fertilizers and promoting production of fertilizer using locally available raw materials were the other objectives of the fertilizer policy.

According to the current national policy framework; Vistas of Prosperity and Splendour, introduction of an integrated soil fertility management system and promoting organic farming were given attention. In 2020, cabinet released approval for issuing fertilizer free of charge for paddy farmers who possess minimum of 2 ha of lands. Urea and super phosphate were approved under this scheme.

Recommendation reforms for paddy cultivation

Different fertilizer recommendations were introduced for paddy farmers time to time as a result of continuous research for paddy sector. It began in 1956 and recommendations were given in 1959, 1964, 1971, 1980, 1990, 1993, 1996, 2001 and 2013.

Fertilizer mixtures were introduced to supply balanced nutrients. In 1950, three fertilizer mixtures were introduced for dry zone, wet zone and sandy soil in North and East provinces. In 1971, more mixtures were introduced based on different factors such as availability, farmers’ response, nutrient accumulation, fertilizer use efficiency, pollution, yield levels and water availability. There were seven mixtures available namely; for dry and intermediate zone, wet zone, wet zone iron toxic soils, wet zone boggy soils, dry and intermediate zone soils, wet zone poorly drained soils and wet zone poorly drained iron toxic soils. In 1980, three mixtures were introduced. Those were for dry and intermediate zone, wet zone and a mixture for whole areas.

In 1990, direct fertilizers were promoted to reduce the unwanted nutrient application. Under that, ammonium sulphate and urea were recommended as the nitrogen source. Triple Super Phophate (TSP) and Single Super Phophate (SSP) were recommended for phosphorous source. Muriate of Potash (MOP) was recommended for potassium source.

Considering the fertilizer use efficiency of different nutrient sources, fertilizer sources were changed time to time. For nitrogen source, ammonium sulphate was recommended in 1950 and in 1964, prilled urea was introduced. In 2013, granular urea was recommended. For phosphorous source, rock phosphate was recommended in 1950. Thereafter, in 1956 rock phosphate was recommended for wet zone and TSP for dry zone. In 1964, rock phosphate was recommended for all rice fields. Again in 1964, rock phosphate or bone meal was recommended for wet zone and TSP for dry zone. In 1980, TSP was recommended for all rice fields. For Potassium source, MOP was introduced in 1950. In 1990, 3.5 tons of rice straw was recommended for one-hectare paddy field to supply the potassium requirement. In 1993, straw and MOP together were recommended for iron toxic soils. In 2013, use of both straw and MOP was recommended for all types of paddy fields.

Time of application of fertilizer is critically important for the efficient fertilizer use particularly to prevent unnecessary leaching. In 1950, nitrogen fertilizer was recommended to apply as a basal application. In 1956, it was recommended to split the application as basal and a top dressing 30 days before flowering. In 1964, recommendation was changed to use as three top dressings. In 1971, two recommendations were given. One basal application and three top dressings were recommended for 3 months variety and one basal application and four top dressings were recommended for 4 months varieties. In 2001, it was recommended to use one basal application and three top dressings for all varieties. In 2013, four top dressings were recommended for nitrogen fertilizer.

For potassium fertilizer, in 1964 it was recommended to apply as a basal plus a top dressing two weeks before planting. In 1990, it was recommended only to apply as a basal application. In 1996, it was recommended to apply as a basal plus two top dressings for iron toxic soils. In 2001, it was recommended to apply in basal application plus one top dressing at planting. In 2013 it was recommended to apply as two top dressings at 4 weeks and 6 weeks after planting. For iron toxic soils, it was recommended to use in basal application plus three top dressings. Posphorous application was recommended as a basal application. Zinc sulphate was introduced in 2001 to apply as a micronutrient source per one season for all the paddy fields. Currently, research is in progress for nano-fertilizer production, organic fertilizer production and micro-nutrient application to assess the requirement of micronutrients. A considerable level of private sector involvement is evident in introducing recommendations for fertilizers especially introducing micronutrients.

Expenditure on fertilizer subsidy

Sri Lankan government continued to offer the fertilizer subsidy over the past 57 years regardless of the budgetary burden it caused. Figure 2.10 shows the expenditure of government for the fertilizer subsidy from 1985 to 2018. The contribution as a percentage of GDP remains 0.2 over the last four years.

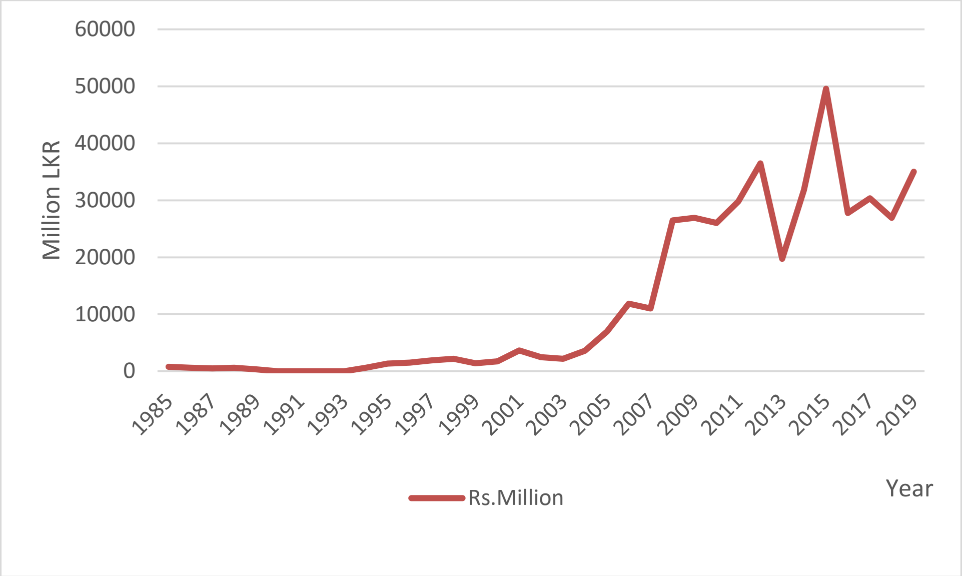


Figure 2.10: Expenditure on fertilizer subsidy over the years (nominal value)

Source: Annual reports of Central Bank of Sri Lanka

2.2.5 National Seed Policy

This policy encompasses mainly the institutions, regulations and public expenditure programs for production and marketing of quality seed and planting materials. Providing quality seeds enhances the efficiency of resource use. However the effectiveness of the policy instruments is the relevant policy issue.

Larger proportion of seed is supplied to the farmer through informal sector until now. The seeds which belong to the formal seed sector include those certified by the seed certification Services (SCS) of Department of Agriculture (DOA). Formal sector seed supply was a monopoly of the government. With the opening up of the economy after 1977, agricultural policy continued to evolve broadly in the direction of gradual government withdrawal from the production of seeds and was directed towards opening up the other field crops sector to trickle down the development of the seed technology in the rest of the world through imports. Promotion of private sector and farmers in seed production, facilitation of safe import of quality materials, removal of impediments in quarantine procedures are some of the important policy directive changes towards this direction.

Seed import liberalization, privatization of government seed farms, enacting the Seed Act as a regulation policy are the major changes brought with the liberalisation of the seed sector. Currently the formal seed sector is comprised of both government and private sector seed production and seed imports. Therefore this sector has to comply with local, national, and - in some crops - global dimensions. The informal seed system is normally localized at the farm or community level and has relatively little organization.

Evolution of seed policy

The first formal arrangement of the seed sector was reported with the establishment of the Department of Agriculture (DOA) in 1912 by the British. They assigned the responsibility of producing seeds and planting materials of major food crops to the Central Agricultural Research Institute. Seed sector became an organized sector by 1950s with these developments and the introduction of the hybrid seeds for the paddy sector.

In 1960s, in response to the green revolution polices of developing countries, research and development in high yielding varieties was encouraged by the Sri Lankan government. By 1972, nearly 71 percent of the farmers were adopting high yielding varieties (Dhanapala 1999). However, still the government had a monopoly for the seed market until liberalization policies were implemented. It is observed that up until late 1980s, the Department of Agriculture remained the sole supplier of seeds. Private sector was allowed to import certain seeds in particular exotic seeds since 1984. Further initiatives in private sector participation in seed industry was hindered by the highly subsidized prices for seeds, lack of access to basic seeds, technology and the policy environment.

In 1990, private sector participation was allowed in seed production and supply considering the rising demand for quality seeds. Seed Certification and Plant Protection Centre (SCPPC) of the Department of Agriculture was established in 1990 to assure a quality seed supply with the private sector participation in the market. Three government owned seed farms were privatized in 1993. Meanwhile, a committee comprising private and public sectors was formed to review the seed importation and government seed pricing.

Further, imports of all seeds and planting materials were duty free in 1995 to keep the prices low. By 1996, nearly 90 percent of the farmers were using high yielding varieties (Henegedara 2002).

A National Seed Policy (NSP) was brought forwarded and approved in 1996 with the objective of establishing a viable seed industry for the country. NSP was expected to assure the availability of quality of seeds and planting materials for the farmers. This policy consists of matters related to varietal development and release, provision of basic seeds and planting material, commercial seed production, processing, marketing and utilization, importation, coordination and development assistance, certification and quality promotion and other support activities. This policy aimed to provide guidelines to promote the private sector participation in quality seed production. Thereafter, commercial seed production and marketing were mainly handled by the private sector and the government intervention was gradually declined. In 1998, Hingurakgoda seed farm which was owned by the DOA was privatized and the preliminary work related to privatization of Pelwehera seed farm was completed. A grant of 100 million LKR was provided to seed production centres in Maha Iluppallama, Batalagoda, Ambalantota, Bata-Ata and Nikaweratiya.

Plant Protection Act No 35 of 1999 was enacted repealing the Plant Protection Ordinance which was introduced in 1924 with several amendments. The act was aimed to protect the domestic plants and animals from introduction of pest and diseases from abroad. It controlled and managed the importation of those materials. Therefore, seed and plant material importation had to comply with the newly introduced quarantine regulations which can be considered as another milestone in the seed sector. Director General of Agriculture is given the administrative authority of this act and the Department of Plant Quarantine is the executing body.

In 30th July 2003, Seed Act No 22 of 2003 was enacted. It was “AN ACT TO REGULATE THE QUALITY OF SEED AND PLANTING MATERIALS; AND TO PROVIDE FOR MATTERS CONNECTED THEREWITH OR INCIDENTAL THERETO”. The Director General of Agriculture is the in-charge of general administration of this act and discharges the functions assigned to him by this act. The National Seed Council was established under this act. It comprises of Secretary to the Ministry, Director General of Agriculture, Director of the Seed Certification Department of Agriculture, the Executive Director of the Sri Lanka Council for Agricultural Research Policy (SLCARP), Director-General of the Sri Lanka Standards Institution (SLSI) and four of other members are appointed by the minister to represent seed producers, users and importers (private sector). The secretary to the ministry is appointed as the Chairman of the council. The functions of the council are given under eight subheadings. It covers "

a) preparation of guidelines and principles to ensure production and distribution of high quality seeds and planting materials.
b) Periodic reviews for planting materials and seed production
c) Advise the minister and other relevant authorities in matters pertaining to production and supply of seeds and planting materials to farmers
d) Periodic reviews of quality of seeds and planting materials
e) Minimum limits such as germination viability, genetic purity, appearance, damaged seeds, water content and pests for seeds and planting materials available in the market
f) Minimum labeling requirement for seeds and planting materials available in the market
g) Quality and size of containers of the seeds and planting materials for different species
h) Protection of new varieties through necessary actions"

Seed Certification Service

Under the Seed Act No 22 of 2003, Director- seed certification is given the authority of following responsibilities.

(a) "exercise the exclusive right to certify seed and planting materials grown in Sri Lanka;

(b) issue seals, stickers, stamps and labels with the mark or seal of the Seed Certification Service;

(c) prohibit any locally produced seed of any crop variety or hybrid from being described and sold as "certified seed" of that crop variety or hybrid if has not been produced in accordance with the rules for production of certified seed published and administered by the Seed Certification Service of the Department of Agriculture and in the case of imported seed. prohibit any seed of any crop variety or hybrid being described and sold as "Certified Seed" of that crop variety or hybrid unless the Seed Certification Service of the Department of Agriculture has recognized the official system of seed certification in the country of origin of that seed;

(d) monitor the production and processing of seed and check that the standards for certification are met;

(e) enter premises and inspect seed conditioning and storage facilities:

(f) check registers of seed movement and identity;

(g) implement the standards for seed certification as may be determined by the Council;

(h) use approved procedures in field inspection, seed testing, monitoring, seed conditioning, collecting seed samples and affixing, certified labels to seed lots that qualify for certification;

(i) ensure that certified seed are packed, sealed and labelled in the prescribed manner;

(j) take samples of locally produced and imported seeds and check conformity with prescribed standards;

(k) establish and publish standards for seed certification; and'

(l) maintain and publish a list of producers and suppliers of certified seed and planting materials" (Seed Act No 22 of 2003).

All the seed handlers are required to register under the Director-in-Charge of the Seed Certification in Department of Agriculture (DOA)[2]. A monitoring procedure follows and renewals and cancellations are decided by the Department of Agriculture. Seed certification service is offered under the department for locally produced seeds and for imported seeds. Local seed production is monitored until it reaches the farmer. Imported seeds are checked with the country of origin and checked in the department's laboratory. A list of certified seeds and planting material suppliers and producers is maintained and published by the department of agriculture. The act states the regulations and penalties in violating the procedures. However, the act is lack of a compensation method when the seeds do not provide the promising results for the farmers (Hirimuthugodage, 2014). It is identified that no-gazetting of the regulations of the seed act has become a barrier to make necessary action in regulating the sector.

Seed Certification and Plant Protection Centre (SCPPC) of DOA

The SCPPC of DOA involves in administration of operational functions of the Plant Protection Act No. 35 of 1999, Control of Pesticides Act No.33 of 1980 and Seed Act No. 22 of 2003. Therefore, it assists in regulatory and legislative aspects of the above acts.

[2] The center is called the Seed Certification and Plant Protection Centre (SCPPC) of DOA.

The centre is headed by a director and there are 5 additional directors under the director ACPPC. It provides the services on

a) "Supervising the quality assurance of locally produced seed & planting material.
b) Supervision and making pesticide recommendations & safe use of pesticides in different growth stages of crops.
c) Supervision of exchange of plant genetic resources among countries.
d) Supervision the implementation of plant protection act and establish international phytosanitary agreements.
e) Coordination and supervision of plant protection activities in Sri Lanka".

In terms of seed certification, the SCPPC has an additional director for seed certification service. There are 35 units including 4 seed testing laboratories, 6 post control testing farms and 24 seed certification regional offices scattered island wide. It provides services by introducing bar code system for seed label, GPS mapping system for mother plant, cold room facilities for all Seed testing laboratories and introduction of molecular detection methods for seed health testing.

A National Agriculture Policy (NAP) was formed in 2007. The policy aimed following aspects for the seed industry.

a) "Produce and supply high quality seeds and planting materials of commercial varieties in a competitive environment with the participation of state and private sector
b) Maintain seed security by having buffer stocks of certified seeds of recommended varieties
c) Strict enforcement of government certification and quarantine regulations with regards to seeds and planting materials
d) Enact laws to ensure that the seeds and planting material available in the market are of good quality
e) Discourage the importation of crop varieties having terminator gene"

In 2010, based on the new policy regime "The Emerging Wonder of Asia"; modernization of 10 underutilized seed farms to cater the demand for other field crops was planned during 2010-2015.

The current policy framework Vistas of Prosperity and Splendour has identified "Expansion of agriculture production by providing good seed and planting materials" as a strategy under agriculture sector. The activities of the strategy include the following into consideration in production of seeds and planting materials (MOF, 2020).

- Introduce a "domestic seeds policy" to produce quality seeds at international standard

- A standards certificate will be made compulsory to import seeds
- Promote private sector to produce quality planting material on a large scale
- Establish a seeds bank under the Ministry of Agriculture to ensure seed safety

Seed production and supply mechanism in Sri Lanka (Formal seed sector)

Seed supply in Sri Lanka similar to other countries of the region consists of a formal and an informal sector. Nearly more than 90 percent of the seeds were supplied by the informal sector (FAO, 2000). For paddy sector, nearly 20 percent of the requirement of Certified Seeds is produced through the formal process while the rest is informally produced using Registered Seeds and Certified Seeds. Figure 2.11 shows a diagram representing the typical seed supply system of a country in transition stage. Only the formal sector can be regulated through polices and laws although informal sector seeds are sold in the market. Therefore, we consider the information pertaining to the formal seed sector in Sri Lanka.

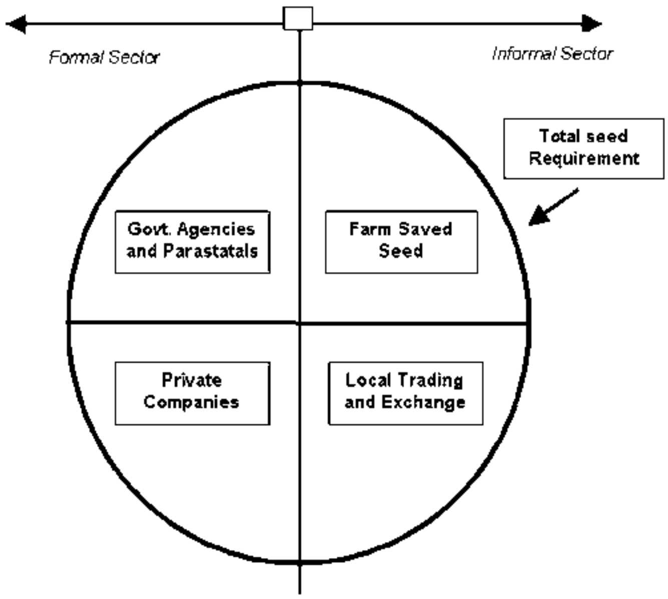


Figure 2.11: Components of the seed supply system (Turner, 2002)

The supply mechanism is implemented and administered by the Seed and Planting Material Development Centre (SPMDC) under the DOA. Since its establishment, the SPMDC has taken several measures to improve the mechanism of supplying high quality seeds and planting materials to the domestic cultivation. The center is administered by a director and there are four additional directors for which three are for different crop categories namely; paddy and Other Field Crops (OFC); Vegetable seed and planting material; Potato and one additional director assigned for development activities of the

SPMDC. There are 16 DDA (seeds) offices maintained all over the country. There are 27 farms of SPMDC which produce basic seed and certified planting material. Moreover, 3 Special Units (Vegetable Seed Centre, Bean Seed Centre and Seed Potato Stores) and 32 Sales Centers are also maintained.

The mission of the SPMDC is "to assure the supply of high quality seeds and planting materials at reasonable prices to the farming community of Sri Lanka" (DOA, 2018).

The center has following objectives.

- Production of basic seed and planting material in government farms and distribution
- Production of certified seeds under contract growing and distribution
- Management of government farms
- Seed enterprise development and co-ordination
- Maintenance of buffer seed stocks
- Coordination of seeds and planting material supply

Seed paddy

The local production of seeds go through the following process are considered as quality seeds to be sold at the market (Figure 2.12).

Figure 2.12: Seed paddy multiplication process, SPMDC of DOA

Breeder seeds are produced and supplied by the Rice Research and Development Institute (RRDI) located in Batalagoda and its substations. These seeds are used to produce foundation seeds. FSP is used to produce registered seed paddy (RSP)[3]. Currently, FSP and RSP of 27 paddy varieties are produced by 10 government farms (DOA, 2018). RSP is used to produce certified seed paddy (CSP) which is ready to be distributed among farmers to produce consumption paddy.

Nearly 500,000 ha of land is cultivated in Yala season and 780,000 ha in Maha season. Altogether, nearly 1,280,000 ha of paddy extent is cultivated annually. In order to cultivate the above extent, 6,400,000 bushels[4] of CSP is required. The estimated RSP requirement is nearly 160,000 bushels. In 2018, the production of RSP was 65 percent of

[3] FSP and RSP categories are called basic seed paddy.
[4] 1bu = 20.5 kg

the requirement (104,231 bushels) due to the drought conditions. However, achieving 25 percent of the RSP requirement is considered as a healthy level or acceptable level for the sector.

Considering the demand for quality seed paddy and resource limitations in government owned farms to produce the total requirement, SPMDC conducted the collaborative seed programme with the participation of several agencies including private sector organizations. Under this programme the Registered seed is supplied to the contract growers as well as to private seed growers including private sector organizations. In return they provide CSP to the SPDMC. Sometimes they sell directly to the farmers without selling to the SPDMC.

CSP is mainly produced by the private sector using RSP. Nearly 20 percent of the requirement of CSP is produced through the formal process while the rest is informally produced using RSP and CSP. The SPMDC targets to purchase 60,000 bushels of CSP annually through Contract Seed Production Programme to maintain a buffer stock. In 2018, 50709 bushels have been purchased by the SPMDC.

Seed paddy is issued by the 15 DDA (seeds) offices and the sales centers attached to those offices. During the two seasons of 2018, seed paddy sales was around 152,269 bushels through these centres.

Foundation Seed is mainly issued to the farm programme of SPDMC and little amount is issued to the contract growing programme to get registered seed.

OFCs

SPMDC produces and supply all the necessary basic seeds (foundation and registered) requirement of OFCs excluding maize and groundnut. Nearly 25 percent of the certified seeds are supplied by the SPMDC. Hybrid maize seeds are imported and 5 percent of the maize seed requirement is domestically produced and those are open pollinated varieties. Around 15 percent of the groundnut seeds are domestically produced and the rest is imported.

Breeder seeds are supplied by the Field Crop Research and Development Institute and its sub stations. There are 11 OFCs and thirty-six varieties (black gram, green gram, cowpea, soybean, maize, groundnut, sesame, finger millet, chili, onion and sun hemp). Breeder seeds are used to produce foundation seeds and only the government farms are involved in producing foundation seeds (Figure 2.13). The capacity of government farms is not adequate to produce the total seed requirement. Therefore, private sector is also contributing in registered seed production through the “contract seed production programme”. All the certified seeds are produced by the private sector. Occasionally, germination tested seeds are purchased when the demand surpasses the supply. In 2018, nearly 820 mt of seeds have been produced and 482.7 mt of OFC seeds have been distributed due to the unfavorable climatic conditions (DOA, 2018).

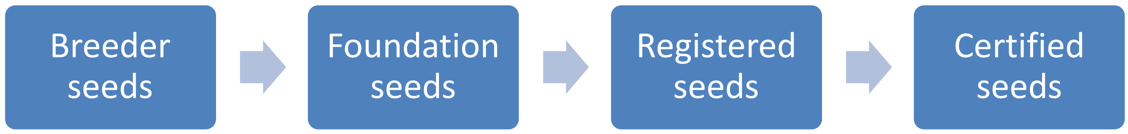


Figure 2.13: Production of OFC seeds, SPMDC of DOA

Production & Supply of Vegetable Seeds

SPMDC produces 70 varieties of 18 local vegetable crops (DOA, 2018). There are 6 hybrid varieties among those. Breeder seeds are supplied by the Horticultural Crops Research & Development Institute (HORDI). Basic seed production (foundation and registered) is conducted by the government farms. In 2018, 4448.75kg of basic seeds were produced for 26 varieties of 15 vegetable crops. Standard class seeds are produced by the government farms, private sector organizations and contract seed production system. In 2018, the standard seed production was 17740.08 kg which is nearly twofold of the previous year. Hybrids seeds are produced for tomato, cucumber, bitter gourd and brinjal. The amount produced in 2018 was 256.95kg. Distribution of seeds is done though the SPMDC sales outlets & registered dealer network. In 2018, the amount distributed was nearly 17166.41kg (DOA, 2018). Dealer network consists of “Agrarian Service Centres (ASCS), Cooperative societies, Farmer organizations, Provincial DOA and private registered seed merchants” and the network has been strengthened in 2017 by increasing the number to 300 members (DOA, 2017).

Production & Issues of Seed Potato

Seed potatoes are produced by only the government farms in Nuwara Eliya district. The seed production program has been improved to provide seeds (G1 seeds) to farmers which facilitates the own seed production (DOA, 2018).

Production & Supply of Planting Material

There are 22 DOA farms and 4 research farms involved in producing planting materials such as budded plants, rooted cuttings, seedlings and suckers of fruit crops and other plants. In 2018, total planting material production was 1,089,317. It is slightly a low figure compared to 2017 due to drought conditions.

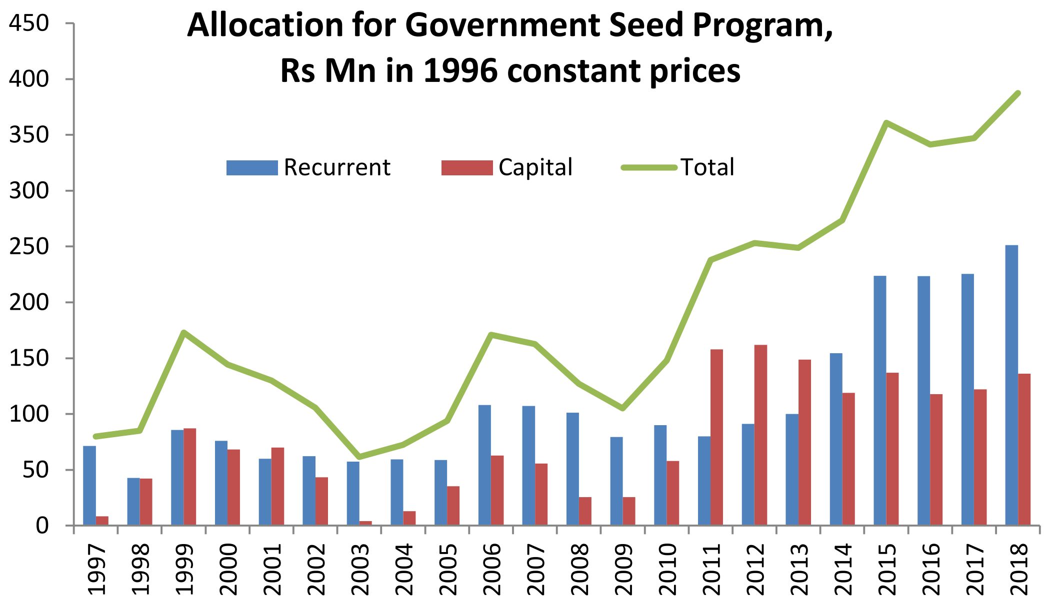


Figure 2.14: Recurrent, capital and total expenditure allocation for the government seed program

Source: Central Bank of Sri Lanka, Budget estimates

Table 2.1: Achievement of targeted OFC seed production in 2018

Crop	Annual National seed requirement for a normal season (according to NFFP 16-18) (kg)	Targeted Percentage production of SPMDC	Produced amount of seeds in 2018 (kg)	Produced amount as a percentage of national seed requirement
Maize	2,226,148	5	49,154	2.2
Chili	18,081	25	2907	16.0
Soy bean	1,074,575	25	120,598	11.2
Cowpea	399,960	25	64,483	16.1
Ground nut	1,869,300	15	275,575	14.7
Green gram	691,478	25	197,415	28.5
Sesame	211,640	25	15,206	7.2
Finger millet	61,745	25	17,317	28.0
Black gram	356,480	25	78,483	22.0

Source: SPMDC,DOA, 2018

2.2.6 Policies on Farm Machinery and Mechanization

Mechanization in Sri Lanka started as far back as late 1940’s with the introduction of the Massey Ferguson 4 wheel tractor and the usage was limited to a few large scale plantations. Tractor use in land preparation in irrigated rice farming began with the formation of state run tractor pool for hire, hire services by cooperative societies, preferential import duties and low interest credit. Four wheel tractors were popular that time. Use of two wheel tractor began in late 1960’s with the introduction of Sri Lankan designed British land master in 1960’ which later manufactured by Japan, China and India. It was affordable to individual farmers to own it. After 1970’s other field crop sector also started using tractor power in land preparation. Since the economic reform in the late 80s, the private sector rapidly emerged as the major player in meeting the demand for greater farm/tractor power uses.

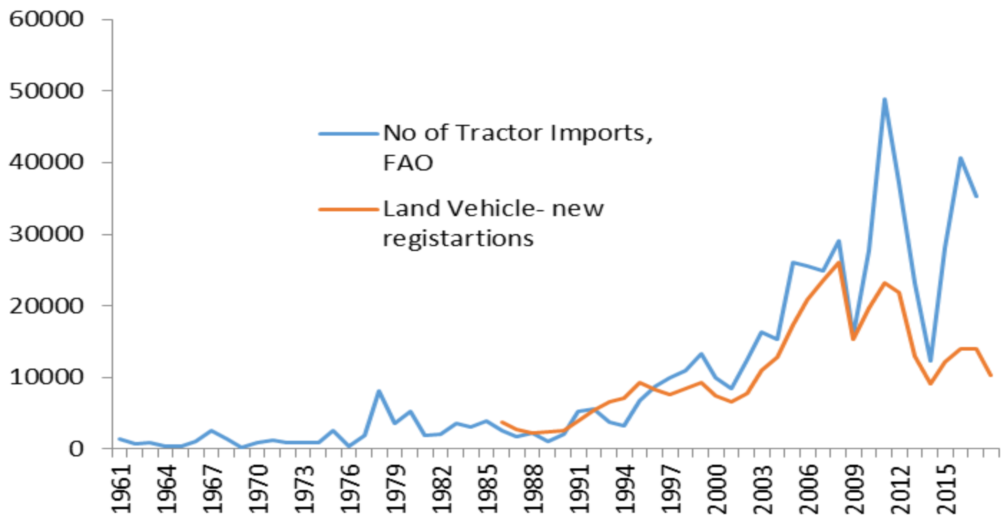


Figure 2.15: No of tractors imported and new registration of land vehicles

Source: FAO, Central Bank of Sri Lanka

Tractor imports were significantly increased after 1994 when the government waived duty on machinery and equipment imported for use in the application of new and innovative technologies in agriculture (Figures 2.15 & 2.16). One other major influence for this trend was the introduction of tractors from neighboring India at lower costs compared to the European counterparts. The supply and import of agricultural machinery were exempted from VAT. In 2004, tariff on machinery reduced to 3% from 5%. Highest imports of 2 wheel tractors/ pedestrian controlled tractors are reported in 2008. After 2008, again 4 wheel tractor became more abundant in the fields (Figure 2.17). When the import tariff structure was simplified in 2010 machinery became under zero tariff. For tractor imports nearly 100 Mn US dollars of foreign exchange had been spent in 2011. In 2013, government introduced VAT on tractors and implements for the first time in the history of this industry. This added to the selling price which was transferred to the farmer.

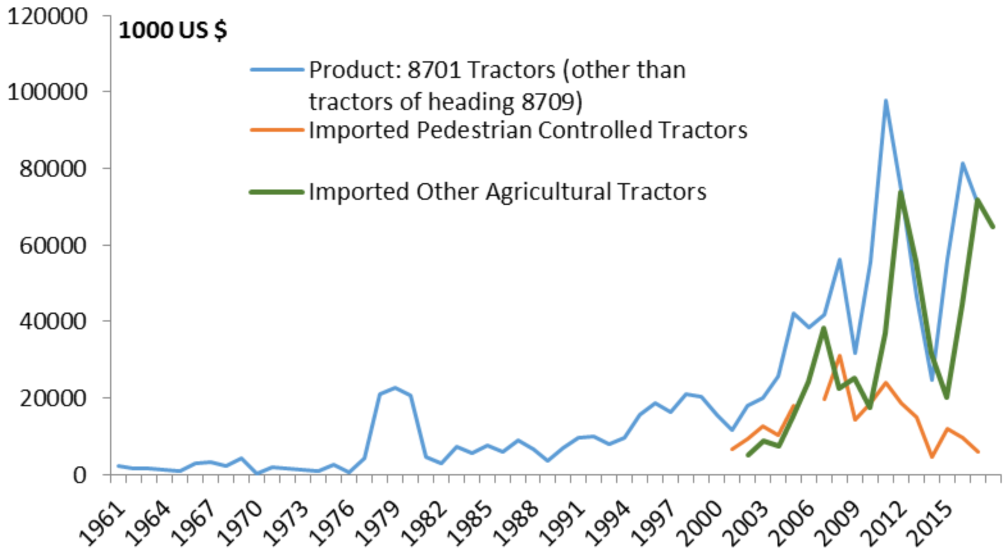


Figure 2.16 : Tractor imports by product in quantity, 1961-2018
Source: FAO, Central Bank of Sri Lanka

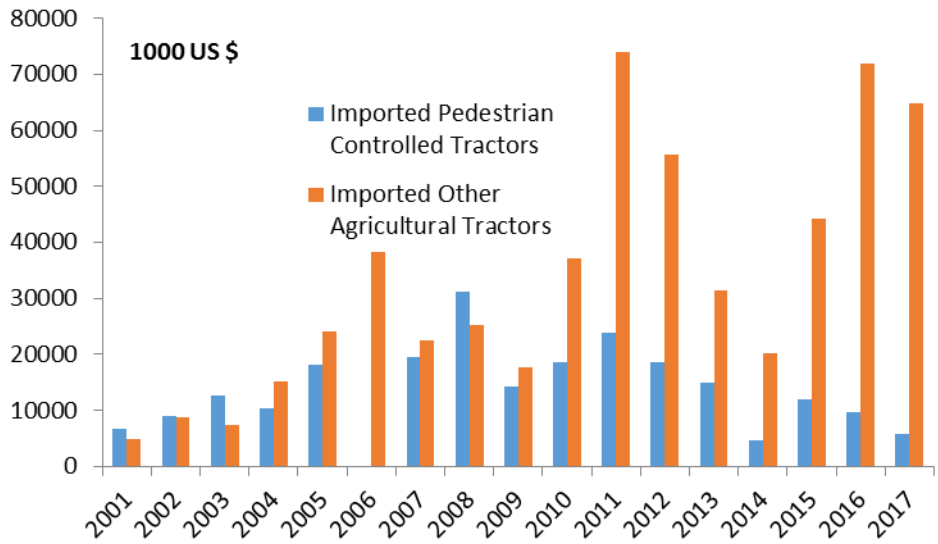


Figure 2.17: Tractor imports by product in value terms, 1961-2018
Source: FAO, Central Bank of Sri Lanka

The next important introduction of machinery in paddy farming was the threshing machine either propelled by tractor or as a separate machine. In 1970's The Farm Mechanization and Research Centre (FMRC) introduced a 2 wheel tractor operated thresher designed by FMRC. Later harvesting machinery were introduced. Today, four wheel tractors, threshers like agrimec, combine threshers and combine harvester are used for threshing. Most of the farmers in rain-fed areas used agrimec and four-wheel tractors for threshing as the size of cultivated land plots in rain-fed areas being very small and combine thresher or combine harvester not being able to be used in swampy paddy lands in rainfed areas in the wet zone. With the introduction of larger combine-harvesters, individual machine owners emerged as the primary suppliers of hiring services. The initially introduced large combine harvesters were widely adopted in the irrigated dry zone with large tracks at its initial phase of its adoption. Later mini combine harvesters suits to average farm size started to be available in the fields.

As shown in the import values in the table below (Table 2.2), imports of combine harvester with thresher are on the increase in the last few years preferably adopting combine harvester for the purpose of threshing mostly in the irrigated large tracks.

Table 2.2: Import value of harvesting and threshing machinery

	Import Value in '000 US $			
	Combine Harvester-thresher	**Threshing Machinery Thresher**	**Harvesting machinery for agricultural produce**	**Harvesting and Threshing machinery Total**
2001	371	0	257	628
2002	138	13	182	333
2003	164	1	111	276
2004	944	412	83	1439
2005	3855	2102	261	6218
2006	3832	3281	513	7626
2007	3293	1906	337	5536
2008	6481	4657	467	11605
2009	4052	1855	792	6699
2010	14261	1294	176	15731
2011	24555	2843	253	27651
2012	17677	196	204	18077
2013	12338	109	235	12682
2014	4129	8	125	4262
2015	16498	69	316	16883
2016	33773	11	957	34741
2017	8399	14	199	8612

Source: ITC, FAO

Apart from imports of farm machineries, designing, manufacturing and adjusting imported machineries to local needs are important components of this industry. FMRC is the responsible government agency that has been inexistence for long years. FMRC The Farm Mechanization and Research Centre (FMRC) task lies in the introducing of effective agricultural mechanization technologies for the crops grown which are compatible with the socio-economic and field conditions prevailing in various regions of the country. The FMRC tests, designs and develops appropriate technologies to suit local conditions. The commercial production of farm machinery is not mandatory to FMRC and therefore the private sector machinery manufactures who are registered at the DOA produce these machines in accordance with the FMRC designs followed by the tender procedures of the DOA.

Mostly farm implements are imported and distributed by private agri-business firms in the corporate sector since it involves large investments. Moreover these firms have their own plants for making required changes for better adoption of these machineries in the field. These firms also have taken steps to introduce new machineries to the farmers based on experience in other countries.

Also there are local private sector manufactures those who design, manufacture and sell machineries at local level. Mostly these are agriculture implements for various farm activities.

Government policy also emphasises to support development and manufacture of agricultural machinery, and the promotion of agricultural mechanization through public and private sector participation. The 2012-2015 National Agricultural Policy provides clear directions for implementing a comprehensive package providing credit and tax concessions for machinery, equipment and extension services for farmers engaged in such activities in agriculture.

When mechanization in OFC sector is concerned, machinery power is used for land preparation for entire fields except there are topographical limitations for adoption. Several types of machineries have been accustomed to suit the operation related to weeding, seeding, harvesting, threshing etc with some success.

Farm Implements Designed and Invented by FMRC

Two Wheel Tractor Operated 3 Tine Plough/Tiller, Seeders, Threshers, Water Pump, Inter-Cultivator

Farm Implements Imported and Distributed by Private Agri-Business Firms

Rotavator, Motorized Weeder, Four Wheel Tractor, Seeder

Farm Machinery Developed and Sold by Local Manufacturers

Two Wheel Tractor Operated Disc Plough, Four Wheel Tractor Operated Seeder, Altered Combine Harvester for Maize Threshing, Paddy Agrimec Altered for Threshing of Finger Millet, Seed Master, Rotavator Altered for Earthing Up, Modified FMRC Maize Thresher, Altered Combine Harvester for Maize

Other than machinery and agriculture implements, adoption of irrigation equipment is also important in mechanization of agriculture. In particular, the increasing use of motor pumps is a significant contribution to the development of small-scale irrigation. The Government of Sri Lanka promoted the rapid adoption of water pumps through interventions such as the development of groundwater wells for agriculture; provision of subsidies and credit facilities for purchasing micro-irrigation equipment; and government policies on tax, tariffs and extension support. In 2006, the government introduced a reduction of 50% of the tax payable on the profit for 5 years for companies importing drip irrigation equipment (through amendments to the Inland Revenue Act No. 10 of 2006).

Table 2.3: Timeline of Changes in Mechanization

	1940-	1950	1960	1970	1980	1990	2000	2010	2015
4wt	Introduced/imported since late 1940's and continue to today. Earlier mostly European makes, presently mostly, Indian, Chinese machines. For both ploughing and threshing (wheel treading) of paddy lands. Since 1980, It has been used to plough OFC fields as well.								
2wt				Sri Lankan Designed British Land Master introduced in later 1960's. Thereafter Japanese, Chinese, Indian makes became very popular. Used for ploughing, transportation, threshing etc.					
Threshers (rice)/winnowers				2wt driven threshers for paddy introduced in 1970's. FMRC designed and locally manufactured.					
Threshers (OFC)							From early 2000, green gram and maize threshing machines introduced.		
Combine Harvesters								Introduced for paddy after the war ended	
Water pumps				Mainly driven by 2wt engines introduced in 1970's and has been used extensively since 2000 for OFC's.					

Source: Abeyratne, F (2017)

Time line of changes in mechanization is given in table above (Table 2.3)

In 2000, the Government of Sri Lanka initiated a subsidy program to encourage the installation of micro-irrigation (MI) with agro-wells. Owning a water pump was an eligibility criterion for receiving the subsidy. The program facilitated the adoption of micro-irrigation systems by over 900 farmers. From 2005 to 2010, the Ministry of Agriculture promoted drip irrigation systems, which included a solar panel, solar-powered water pump and drip irrigation kit. The Department of Agriculture established another program in 2013, with the objective of expanding the adoption of drip and sprinkler technology in the dry and intermediate zones of Sri Lanka.

Currently all pumps are subject to taxes, including 15% VAT, 2% Nation Building Tax (NBT) and 5% cess. The government provides support to local water pump assemblers through the reduced general custom duty. (Aheeyar, M et al 2019); Providing tariff concessions for agricultural machinery and the open economic policies adopted by successive governments encouraged the private sector to import water pumps from China and other countries. Low-cost pumps in turn increased the ability of smallholders to access agricultural technologies. Yet, the relatively high cost of pump and irrigation technology packages, alongside the lack of capital or access to loans for investment, are major constraints to the adoption of these packages for many smallholder farmers. Additional policy mechanisms, such as targeted subsidies, concessional loan schemes, etc., may be needed.

Today, Sri Lanka has a largely mechanized agriculture sector next to Bangladesh in South Asia. Machinery use in land preparation and harvesting is common in most food crop faming. Labour use in agriculture has come down. There is a large scope opened to mechanization in several management practices including seeding, weeding, lift irrigation due to scarcity of labour and banning of agro chemicals for weeding. Importers are of the view that imported machines are cheap and durable. Therefore policies should be directed to add value through he forward linkages of modernization of agriculture through mechanization.

2.2.7 Road infrastructure

A proper road network is crucial for connecting input and output markets. Therefore, among many infrastructure facilities, road network has a considerable impact on rural agriculture. Ancient Sri Lanka had a road network connecting the religious places and ports from the capital cities of the ruling kings. Historically, Sri Lanka's road network development was initiated during the colonial period mainly to transport commercial plantation crop products to the ports and to facilitate the other activities such as administration and defense of the country. A railroad network was developed during this period and a canal system was developed during the period of Dutch as a means of transportation. Thoroughfares ordinance No.10 of 1861 is "an ordinance to amend and consolidate the law relating to public thoroughfares in Sri Lanka" which is an indication of some formality in the road network development activities of the country (Thoroughfares Ordinance, 1862). Prior to the introduction of motor vehicles in 1940, roads were constructed to move the animal drawn carts (RDA, 2020). Thereafter, road transport became the most widely used transport mechanism.

Road development in Early 20th

The road network of Sri Lanka was maintained and developed by the Public Works Department in 1950s (RDA, 2020). In 1959, Sri Lanka had 19, 104 km long road network out of which 12, 000 km was access roads (Kumarage, 2003). Considering the significance of the road development activities, by mid 1960s the responsibility of the Public Works Department was confined to public roads and buildings excluding its responsibility on other dimensions such as water supply and drainage and housing. Identifying the importance of road development and maintenance, a new Department of Highways was formed in 1969. The new department was solely established for the development and maintenance of class A, B, C, D and E roads. There were approximately 28,000 km road network in 1969. Bridges were handled by a separate "Bridges Division" maintained under the Public Works Department.

In 1971, most of the functions of the Highways Department were transferred by forming two organisations namely; the Territorial Civil Engineering Organisation (TCEO) and the State Development and Construction Corporation (SD & CC). Additionally, to the road development and maintenance, the TCEO had the responsibility to improve and maintain the irrigation works including village tanks, irrigation canals and to assist local authorities to improve local roads and bridges. The State Development and Construction Corporation (SD & CC) was formed to construct the bridges and other civil engineering work. The functions of the Highways Department were confined to planning, design and supervision of major roads and bridges.

Road Development during 70's and 80's

In 1978, the functions of TCEO were transferred back to the Department of Highways. Road Development Authority was formed under the Ministry of Highways in 1983. It is formed by the RDA Act No 73 of 1981. Initially the functions of RDA were to implement certain construction works. Thereafter, its functions were expanded and the functions of the Department of Highways were transferred to the RDA in 1986. RDA was given the sole responsibility of developing and maintaining all the roads and the bridges. The estimated road length was 28,000 km including all the four categories of roads A, B, C, D and E.

In 1989, with the 13^{th} constitutional amendment; provincial councils were formed. Under that, C, D and E roads and the bridges came under the authority of corresponding provincial councils. Approximately 17,000 km of roads were in C, D and E classes.

Sri Lanka's road classification shows three main categories namely; national roads, secondary roads and access roads. National roads consist of A & B types of roads which are managed by the Road Development Authority. The secondary roads belong to class C and D roads which are called provincial roads and managed by the provincial councils. Third category of roads is the access roads and class E roads come under this category. Those are managed by local authorities which includes Pradeshiya Sabha, municipal or urban councils depending on the administrative area. There are some access roads managed by different institutions such as Forest Department, Irrigation Department, Mahaweli Authority, Wildlife Department, Fisheries and Aquatic Resources Department and plantation companies. The length of these roads was estimated to be 68,843 km in 1990 and around 1000 km are estimated to be added annually (Kumarage, 2003). These roads are built through voluntary work (Shramdana), provincial council funds and acquisition of private roads as public roads. Those roads (access roads) mostly remained unpaved in rural areas while kept paved in urban areas. However, proper inventories are not maintained for these roads. Mostly, those roads were built in an ad-hoc manner and considered of poor quality due to the limited maintenance and use of poor engineering techniques (Kumarage, 2003).

Thoroughfares (Amendment) Act, No. 9 of 1988 and Thoroughfares (Amendment) Act, No. 81 of 1988 were came into effect to amend the Thoroughfares Ordinance.

1991 onwards

Sri Lanka's road network consists of National Highways (A & B class roads and expressways), provincial roads (C & D class roads), unclassified local authority roads and other roads, including those maintained by state sector agencies (CBSL, 2017). Highways and Expressways are maintained and developed by the RDA. Provincial and local governments maintain C and D roads. Table 2.2 and Figure 2.1 show the road network of Sri Lanka from 1990 to 2018. It illustrates that total road network has increased from 25, 738 km in 1990 to 31,144 km by 2018[5].

"Maga Neguma" programme initiated in 2004 which supported the rural road development has significantly contributed to this provincial road network expansion. Nearly 60 percent of the roads in Sri Lanka come under 'C' (40 percent) and 'D' (20 percent) categories. A considerable improvement in class 'C' roads is observed since 2009 which is soon after the end of civil war of the country.

[5] Record keeping on class 'E' roads has been excluded since 2006.

Since 2009 to date, development of road transportation was considered a key priority compared to the other means of transportation such as rail, air and sea transportation. The National Thoroughfares Act No 40 of 2008 came into effect to provide " planning, design, construction, development , maintenance and administration of an integrated public road network in Sri Lanka; to provide legal framework necessary to facilitate private sector investment and participation in road construction, development and maintenance; to assist the provincial councils and local authorities in the development in the development and maintenance of roads; to promote and facilitate community based organisations engaging in the construction, maintenance and management of roads and public roads; and to provide matters connected therewith or incidental thereto" (National Thoroughfares Act, 2008).

Road rehabilitation especially in Northern and Eastern provinces, construction of rural roads under 'Maga Neguma' programme, construction of highways and flyovers were the goals of the government. In 2009, the re-opening of A9 road significantly facilitated goods and passenger transportation to Jaffna. Measures were continued to rehabilitate national roads in the Northern and Eastern provinces. The estimated cost was 123 billion LKR. Rehabilitation of 1,174 km of roads was planned under the Trincomalee Integrated Infrastructure Project (TIIP) under which Northern Spring and Eastern Revival programmes are driven (CBSL, 2009). Road density per square kilometer in Sri Lanka was 1.6 km which is a comparatively high figure compared to the other countries in the region. RDA spent 78,186 million LKR in 2009 which is nearly 47 percent increase or roads and bridges.

Major road development projects continued were Southern Expressway Project, Colombo-Katunayake Expressway Project, Colombo Outer Circular Highway Project and Colombo – Kandy alternate highway project. Four flyovers were completed and four more were planned. The longest bridge in the country connecting Trincomalee and Kinniya was opened during 2009.

2010: Road development was given prominence under the "Randora" infrastructure development programme. In order to support the government policy on road development, "The national road master plan" was developed. It considered construction, development, maintenance and rehabilitation of highways, expressways and bridges. Rural roads were covered under the 'Maga Neguma' programme which was initiated in 2004. Weak Bridge Programme (WBP) has identified 169 bridges and 15 of those were rehabilitated while construction of 32 bridges was commenced. Similar to 2009, linking the North and East with the other areas of the country continued. Conflict Affected Area Rehabilitation Project (CAARP) to reconstruct 190 km of roads in the Northern and Eastern Provinces, North Road Connectivity Project (NRCP) to construct further 170 km of national roads in the North Central and Northern Provinces and rehabilitation of 140 km of provincial roads in the Northern Province come under that objective. The Sanguppidi Bridge was opened reducing the distance to Jaffna by nearly 80 kilometers and thereby cutting down the travel time by nearly three hours (CBSL,2010).

2011: The government's objective on linking the regions was continued through Northern and Eastern road development projects and 'Maga Neguma'. The Southern expressway was opened for traffic which is an important milestone of the transport sector in Sri Lanka (CBSL, 2011).

2012: The Trincomalee Integrated Infrastructure Project (TIIP), which was initiated in 2008 was completed in 2012. Other projects were continued. Rehabilitation of A020 road from Anuradhapura to Rambawa and the B268 road from Mannipay to Kaithady were completed in 2012 (CBSL, 2012).

2013: Construction of new roads and rehabilitation of existing roads were continued in 2013 as well. Based on the National Road Master Plan (2007-2017), development of expressways and highways under 'Randora' programme and development of rural roads under 'Maga-Neguma' were successfully continued. Colombo - Katunayake Expressway (CKE) and other extensions to the expressways, flyovers and rehabilitated Padeniya - Anuradhapura road were opened for traffic during 2013 (CBSL, 2013).

2014: Several road development projects were continued based on the National Road Master Plan. Assistance was received from ADB, UK, France, Japan and Korean Economic Development Cooperation Fund (EDCF) for several projects. Meanwhile, Northern Road Rehabilitation Project (NRRP), the Conflict Affected Region Emergency Project (CAREP) and the Northern Road Connectivity Project (NRCP) were continued (CBSL, 2014).

2015: Road development was given top priority to facilitate the economic activities and regional connectivity. Extensions for expressways were continued and flyovers and bridges were constructed. Existing projects were continued while a new agreement was signed with the Kuwait Fund for Arab Economic Development (KFAED) to reconstruct 25 bridges on national highways. Government commenced a rural access road improvement programme called 'Integrated Road (i-ROAD) Investment Programme' with the help of ADB. 'Maga Neguma' rural road development programme also continued during the year.

2016: Road development work continued in 2016 as well giving road development a high priority. There were several projects funded through bilateral and multilateral arrangements. Japan, France, Austria, Saudi Arabia, the United Kingdom, Kuwait and the OPEC Fund for International Development (OFID) were among those. Further, World Bank funded for improving the climate resilience of road infrastructure through the Climate Resilience Improvement Project (CRIP).

2017-2018: Regardless of the tight fiscal conditions in 2017 and 2018, the road development projects were continued giving priority. The total length of the expressway network by 2018 was 170 km and it is expected to achieve 350 km by 2021. Currently, it is expanded to Hambantota and Katunayake -Kadawatha- Kerawalapitiya. The road network is expected to expand to Kandy and Ratnapura (RDA,2020).

Currently, Ministry of Highways and Road Development is the apex body of road network of Sri Lanka. Road Development Authority is responsible for the maintenance and development of national highway network. It includes class A and B roads and expressways. Provincial and local governments maintain C and D roads. As table 2.4 and figure 2.18 shows, C class road network has expanded considerably and mainly in agricultural provinces.

Table 2.4: Road length in km by class of road in Sri Lanka from 1990 to 2018

Year	A	B	C	D	E	Expressways	Total
1990	4,116	6,331	9,640	5,150	501		25738
1991	4,116	6,465	9,453	5,200	516		25750
1992	4,216	6,671	8,917	5,280	516		25600
1993	4,220	6,722	8,961	5,296	381		25580
1994	4,220	6,854	8,765	5,300	381		25520
1995	4,220	6,908	8,457	5,346	554		25485
1996	4,221	6,926	8,457	5,346	554		25503
1997	4,221	6,926	7,900	4,643	771		24461
1998	4,222	6,926	7,756	4,564	891		24359
1999	4,221	7,241	7,824	5,926	1,076		26288
2000	4,222	7,265	7,315	5,425	1,735		25962
2001	4,337	7,571	7,536	5,720	1,662		26826
2002	4,339	7,670	7,682	5,763	1,700		27154
2003	4,339	7,670	8,136	5,765	1,913		27823
2004	4,339	7,679	8,136	5,771	1,935		27860
2005	4,314	7,706	8,257	6,074	1,968		28319
2006	4,219	7,553	9,565	5,412			26,750
2007	4,219	7,655	9,575	5,418			26,867
2008	4,219	7,670	9,552	5,546			26,988
2009	4,216	7,704	11,231	5,855			29,006
2010	4,219	7,800	11,316	5,783			29,119
2011	4,219	7,800	11,424	6,356		95	29,895
2012	4,219	7,945	11,304	6,287		95	29,850
2013	4,219	7,949	11,669	6,726		121	30,684
2014	4,215	7,993	11,837	7,193		161	31,398
2015	4,215	7,995	12,497	6,385		170	31,262
2016	4,215	7,995	12,497	6,385		170	31,262
2017	4,215	7,995	12,565	6,190		170	31,135
2018	4,215	8,005	12,565	6,190		170	31,144

Source: CBSL (A),(2006,2019). Economic and Social Statistics of Sri Lanka

Figure 2.18 shows the current composition of roads and provincial distribution of road network. The lowest road length is observed in Eastern province while it is the highest in North-Western province. In all the provinces, C and D class roads constitute more than 50 percent. Expressways are confined to Western and Southern provinces.

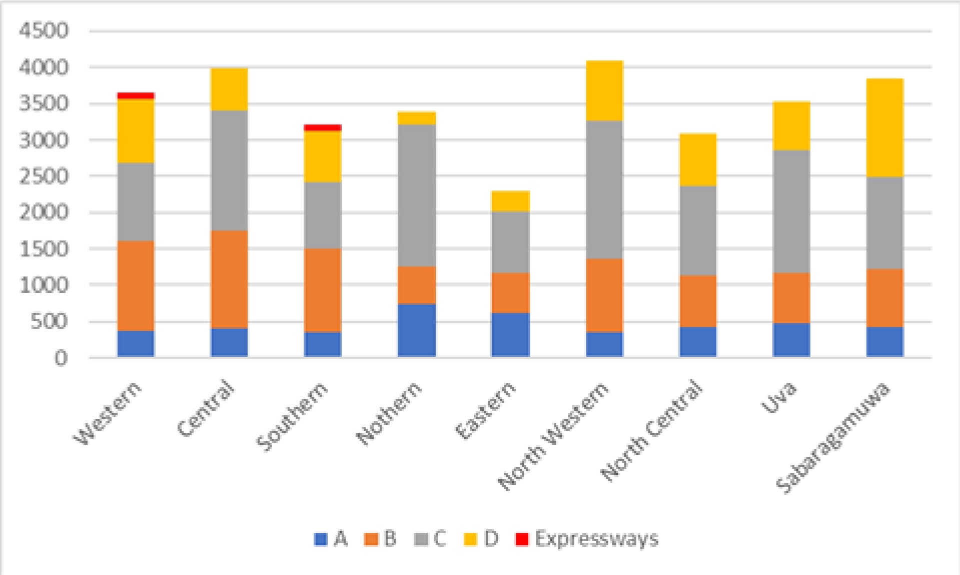


Figure 2.18: Provincial composition of road network in km
Source: Economic and Social Statistics of Sri Lanka, CBSL (A),(2019).

Investment in rural road development under "Maga Neguma" programme which was initiated in 2004 increased to about more than Rs Mn 5000 by 2014 significantly contributing provincial road network expansion (figure 2.19).

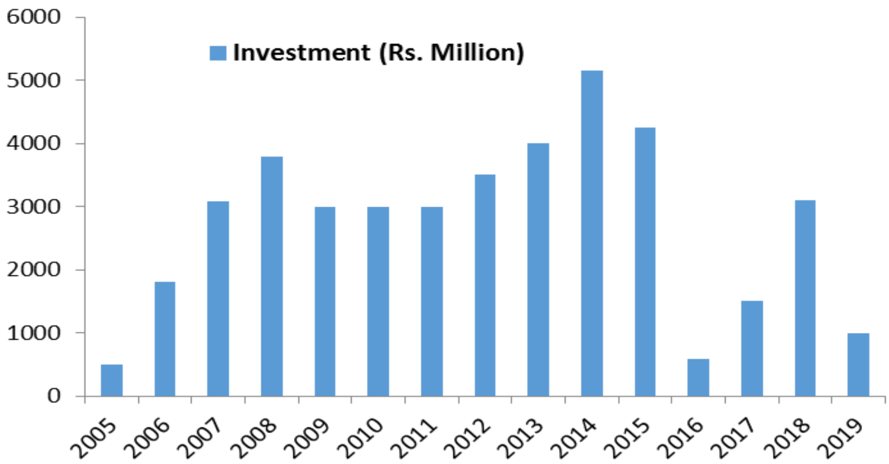


Figure 2.19: Investment in rural road infrastructure under *Maga Neguma* Program
Source: Budget Estimates, Ministry of Finance

2.2.8 Agriculture Credit and Finance Policies

Need for credit and financial facilities for agriculture was evident with the informal financial markets operated before the formal financial market came into operate. However, the existence of informal arrangements is still prominent due to many reasons such as its flexibility in repayment and accessibility. Majority of the farmers in Sri Lanka (more than 85 percent) are small scale farmers or subsistence scale. When their main income source is agriculture, it is hard for them to save the input costs for the next season. This was exacerbated when they shifted from traditional agriculture to modern agriculture with the green revolution. That is basically a movement from cultivation of traditional varieties to hybrid varieties for which input cost especially the fertilizer and agrochemical cost is quite high and essential to apply (CBSL, 1998). Therefore, a formal financial market and credit facilities were built-up time to time assist the agriculture sector. The Land Commissioner's Department is considered as the first source of institutional credits in rural agriculture (CBSL, 1998).

Evolution of agricultural credit and finance polices

Pre-liberal era (1948-1976)

Institutional arrangements for agricultural credit were began since 1947. It commenced with three loan schemes namely; the short term cultivation loans disbursed by the Department of Food Production, the medium term loans disbursed by the Co-operative Agricultural Production and Sales (CAPS) societies for purchasing machineries and the long term credits provided for CAPS societies to purchase vehicles and to construct storage facilities (Sanderatne, 2002). These schemes were continuously expanded by increasing the coverage of the societies and the money allocated. For example, the amount disbursed from 1947 to 1953 increased from 4.36 million LKR to 15.86 million LKR. The functions of the CAPS societies were further expanded during 1956/1957 period converting those societies to multi-purpose cooperatives. The credit amount increased to 21.9 million LKR. However, the credit disbursed was declined to 10.6 million LKR by 1963 due to loan defaults.

A new scheme was introduced in 1963 which is named Expanded Credit Scheme. It considered share of capital in the cooperative, area cultivated and loan repayment in granting loans for the burrowers. The scheme has disbursed 34.6 Million LKR by 1964.

The New Agricultural Credit Scheme was introduced in 1967 replacing the previous scheme. Under this scheme, cooperatives had to obtain funds from the government and to lend those to farmers. Central Bank of Sri Lanka is involved in financing cooperatives and small-scale agriculture through the establishment of the People's Bank in 1963. Thereafter, in 1974 Bank of Ceylon also joined the new agricultural credit scheme and Hatton National Bank joined with a limited scope (Sanderatne, 2002). Central Bank lent money at a lower rate to the banks and cooperatives involved in this credit scheme. The credit limit for paddy was increased depending on the type of practices and purpose. Crops other than paddy such as chili, red onion, potato, vegetables, big onions, ground nuts and maize were included in the scheme.

Agricultural and Industrial Credit Corporation Ordinance of 1943 was amended in 1970 by the Agricultural and Industrial Credit Corporation (Amendment) Act (No. 5 of 1970). This act regulates and authorized to lend money to undertake cultivation or processing related agriculture investments. The amendment allowed the corporation "to borrow, or accept deposits of, money from the Government, the Central Bank of Ceylon, or from any other source approved by the Monetary Board of such Bank, on such terms and conditions as may be determined by agreement between the corporation and the Government, or such Bank, or such other source, as the case may be".

Comprehensive Rural Credit Scheme was introduced in 1973 to provide credits through the rural banks operated by the cooperative societies. The scheme supported obtaining loans or purchasing inputs and other agricultural activities. Further it extended the support for other credit needs such as consumption, emergencies and housing.

Liberalization of the economy (1977-1987) and onwards

Comprehensive Rural Credit Scheme initiated in 1973 existed up to 1986. In 1977/1978 Maha season, the loan amount was increased by nearly 62 percent due to relaxing of the eligibility criteria for receiving the loans. Thereafter, the disbursed amount was considerably declined with the loan defaults. This scheme existed until 1985 and in 1986, the scheme was replaced by the New Comprehensive Rural Credit Scheme (NCRCS). This scheme was not crop specific and was more flexible giving farmer the freedom to choose. Credits were provided for consecutive three years and the Central Bank facilitated repayment difficulties for crop losses due to natural calamities by rescheduling the loans and refinancing facilities were provided at an annual interest rate of 1.5 percent for the banks. Banks were given the authority to make the decisions on providing loans based on repayment history and a proper monitoring and evaluation procedure was introduced. Loans were based on area of cultivation and when the repayment history is satisfactory, the banks were able to grant cultivation loans without a guarantee up to a maximum level specified. People's Bank, Bank of Ceylon, Hatton National Bank, Indian Overseas Bank, Regional Rural Development Bank, Thrift and Credit Cooperative Societies involved in the scheme with the Central Bank's guarantee on 50 percent of defaults (Sanderatne, 2002). A Credit Guarantee Fund has been established by the Central Bank of Sri Lanka for this purpose. The Rural Credit Advisory Board was formed to meet and discuss the issues pertaining to rural credit and rural development.

Thereafter, NCRCS continued up until today with several changes time to time.

Figure 2.20 shows the nominal value of loans granted under NCRCS for paddy and other crops over time. Chilies, red onions, potatoes and other subsidiary food crops come under ‘other crops’ category.

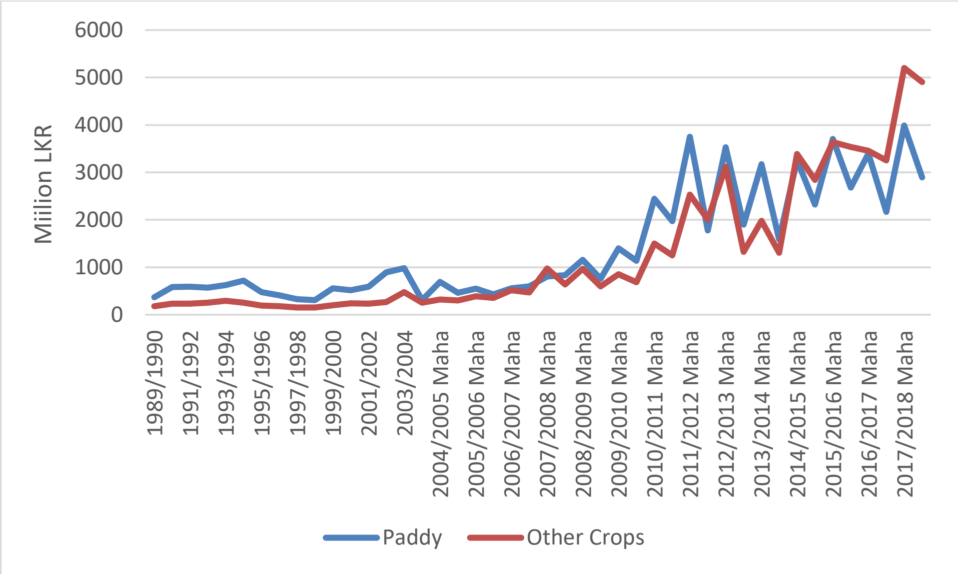


Figure 2.20: Nominal value of credit granted for paddy and other crops under NCRCS
Source: CBSL annual reports 2009, 2018

Loan recovery was a major issue in implementing the credit schemes for agriculture over the years. Figure 2.21 shows the loan recovery rate for paddy and other crops over the time for NCRCS.

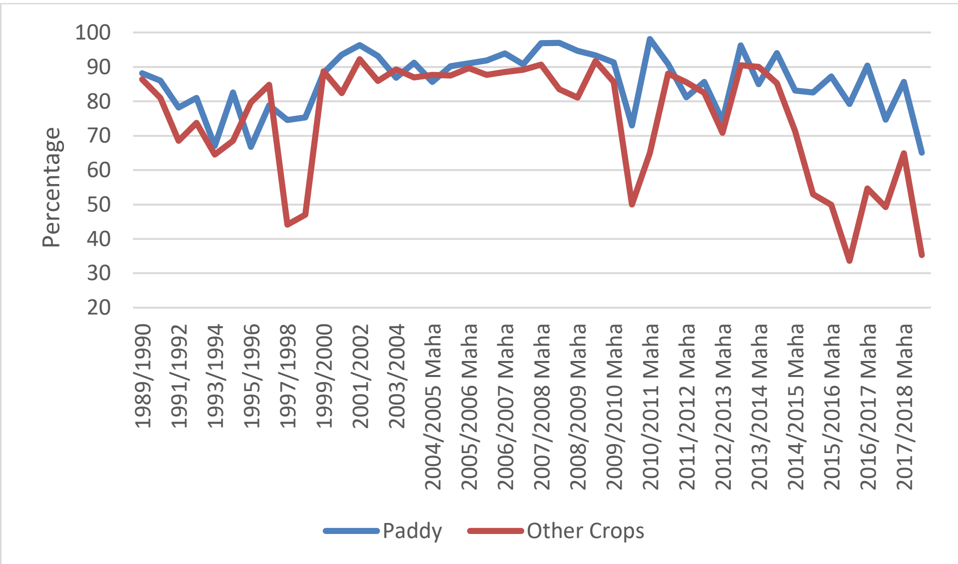


Figure 2.21: Loan recovery rate for paddy and other crops under NCRCS
Source: CBSL annual reports 2009, 2018

Currently, CBSL implements “Sarusara”- New Comprehensive Rural Credit Scheme (NCRCS) which is funded by the GOSL, through Licensed Commercial Banks and Licensed specialized Banks as an interest subsidy scheme and a credit guarantee scheme as well (CBSL, 2018).

International Fund for Agriculture Development (IFAD) had funded the National Agribusiness Development Programme (NADeP) completed in 2017 and another 5 refinance loan components under Smallholder Agri-business Partnership Programmes (SAPP) in 2018. The funds of these programmes were handled by the CBSL through Licensed Commercial Banks and Licensed specialized Banks. The policy existed up to 2020 had the objectives of strengthening the rural credit institutions which assists in farmers’ financial activities, introducing a simple procedure and a concessionary interest rate in obtaining agricultural and agribusiness loans, to establish a mandatory share of agricultural credits in state banks and to utilize the Govi Setha fund effectively for agricultural credit (Ministry of Agriculture, 2019).

The current policy of “National Policy Framework Vistas of Prosperity and Splendour” states its expectations to introduce a simple low interest agricultural credit scheme to farmers (MOF, 2020).

2.2.9 Agriculture Insurance Policies

Sri Lanka was the first developing country in Asia to have launched an 'all-risk' insurance of the paddy crop on a limited experimental scale with Food and Agriculture Organization (FAO) assistance (Ray, K.,1981). In 1956, the Sri Lankan government recognized agricultural insurance as a mechanism to increase agricultural productivity and to offer relief and protection to the socially and economically beleaguered segment of the population. During the same year, the country sought the assistance of the FAO in the preparation of the operational framework of an agro-insurance scheme. The first experimental crop insurance scheme (CIS) in Sri Lanka was introduced in 1958 for rice cultivation. This scheme covered about 28,000 acres of paddy in selected areas of six districts and was administered by the Department of Agrarian Services.

Progress of agricultural insurance in Sri Lanka can be traced back to the following periods:

1958/59 to 1960/61

This scheme was implemented on an administrative basis and it covered six different districts to study the problems in each region for a period of 4 years in order to gain knowledge and to test the farmers' reaction. The administration of the crop insurance scheme was carried out by the Commissioner of Agrarian Services with the assistance and co-operation of other departments whose activities had a bearing on or relevance to the cultivation of paddy.

This pilot project which commenced in 1958/59 covered 28,000 acres in six districts, which was approximately 3% of the total physical extent of land cultivable with paddy and this operated for 3 years.

Under this pilot scheme, the collection of premium was in principle, to be after the harvest in order to make it less onerous for the farmers.

Crop Insurance Act No. 13 of 1961

This Crop Insurance Act passed by the Parliament provided the necessary legal framework for the operation of a regular CIS, which commenced from 1961/62 maha season. This Act provided the necessary legislative authority for the operation of a crop insurance scheme, which could be considered as the second phase of development.

The Act vested the minister in charge with authority to specify and expand the areas of operation of the scheme where deemed feasible. The insurance of paddy crop was made compulsory in the area specified by the Minister under the Act, and hence all persons having interest in paddy cultivation within such areas were automatically insured under the scheme.

1962/63 to 1972

The Crop Insurance Act No. 13 of 1961 became operative and the area under insurance gradually increased to around 200,000 acres. This operated until 1973.

1973 to 1983

The third phase of development of agricultural insurance began with the repeal of the Crop Insurance Act No. 13 of 1960 and the enactment of the Agricultural Insurance Law No. 27 of 1973, which took effect in April 1974. The agricultural insurance scheme was subjected to various experimental changes in administration.

The Agricultural Insurance Law No. 27 of 1973

In 1973, the Act No. 13 of 1961 was replaced by the Agricultural Insurance Law No. 27 of 1973 which came into operation in April 1974, making provisions for a more comprehensive and compulsory scheme.

The objectives of Act No. 27 are as follows:

i. To operate a comprehensive agricultural insurance scheme for the benefit of paddy crop farmers;
ii. To undertake research studies necessary for the promotion and development of agricultural insurance.

This scheme was to be implemented in 3 stages as follows:

i. Insurance of the paddy crop in the country;
ii. Insurance of livestock and selected subsidiary food crops;
iii. Insurance of non-traditional food crops.

The scheme was partly subsidised by the Government, which funded the administrative costs.

The Act provides for compulsory insurance of the paddy crop and any person having an interest in the paddy crop in any area coming under the purview of the Act is deemed to have entered into a contract of insurance with the Board against the loss of such crop.

The enactment of the new law effected the following major changes:

a) It established an autonomous body called the Agricultural Insurance Board (AIB) to administer and operate the agricultural insurance system in Sri Lanka.
b) An insurance scheme embracing the entire country was introduced.
c) The law provided for compulsory insurance of paddy crop and granted authority to the AIB for the prosecution of defaulting farmers.

d) The premium had to be paid in advance during a payment period fixed for the season by the AIB.
e) The law provided for expansion of the scheme where voluntary insurance of specified crops and species of livestock to be undertaken.
f) An agricultural insurance fund was established to manage the financial operations of the scheme.

1983 to 1987

The next phase of the scheme began in 1983, with certain important policy changes and operational changes. The main policy changes effected in respect of paddy insurance are appended.

a) An interest-free, long- term government loan of Rs.50 million was obtained to build up a readily accessible loss reserve to meet any deficit between premia collection and indemnity payable. This grant was invested to generate interest, which was utilized to meet the deficit.
b) Curtailing producers' indemnity payment like ‘prorating’ was abolished both at individual level and area-wise group level.
c) Indemnity payments were expedited to reach the farmers in time before the next season’s cultivation.
d) The paddy insurance rules and regulations were revised to entertain genuine claims relaxing some rigid technical conditions and requirements.
e) An incentive for non-claimants was provided by way of free insurance after five seasons of continuous no-claim period.

The Agricultural and Agrarian Insurance Act No. 20 of 1999

Agricultural Insurance Board (AIB), which functioned with fairness from the government consolidated fund since its inception in 1974 was brought within a broader framework by the Agricultural and Agrarian Insurance Board Act. No 20 of 1999 which came into effect from August 16, 1999 with a view to establishing the scheme on a self-finance basis.

The new Act made the following provisions:

a) To broaden the scope of the AIB and establish the Agricultural and Agrarian Insurance Board (AAIB) to provide insurance for agricultural and horticultural crops and medicinal plants, livestock, fisheries and forestry, agricultural equipment and implements, the storage and preservation of agricultural and horticultural produce and produces of medicinal plants and fisheries and forest produces.
b) To provide medicinal benefits and social security schemes for agriculturists; and

c) To repeal the Agricultural Insurance Law No. 27 of 1973, thereby permitting private insurers to undertake crop insurance

All powers and duties conferred or imposed on the Agricultural Insurance Board established by the Agricultural Insurance Law, No. 27 of 1973, by the Farmers Pension and Social Security Benefit Scheme Act No. 12 of 1987, the Fishermans Pension and Social Securities Benefit Scheme Act, No. 23 of 1990 were repealed.

With the implementation of the new scheme, the activities hitherto handled by the Agricultural Insurance Board (AIB) were transferred to the newly established Agricultural and Agrarian Insurance Board (AAIB). Since the monopoly of the AIB in respect of agricultural insurance was eliminated by the new Act, other insurance companies involved in the sector have the opportunity to pursue agricultural insurance.

The Agricultural Insurance Law was repealed and the Agricultural and Agrarian Insurance Board (AAIB) was established under Agricultural and Agrarian Insurance Act. While continuing its former business, steps were taken by the new AAIB to design new insurance schemes for seed farms, model farms, seed stores, livestock, fisheries,^ floriculture and coconut.

The insurance schemes designed by the AAIB on the request of the Perennial Crops Development Project for perennial crops, Department of Export Agriculture for export agriculture crops, Southern Development Authority for maize cultivation in the Southern region and the Tea Research Institute and Tea Small Holding Development Authority for smallholder tea plantation continued to be in operation during the year under review.

Ceylinco Insurance Company Ltd. (CICL), which is the only private insurer operating in the agricultural sector, expanded its services to various sectors including life insurance for farmers during 1999 after the enactment of the new Act.

2000 onwards

In 2000, AAIB has introduced new insurance schemes for (i) tobacco cultivation under the Ceylon Tobacco , (ii) agricultural projects under FSC system, (iii) seed paddy and model farming, (iv) tea nurseries and plants under the Tea Research Institute and the Tea Small Holding Authority and, (v) the scheme for sesame, Kurakkan and Maize crops.

AIB broadened its scope by introducing a technical method of loss assessment for crops such as onion and ground nut. Action has been taken to introduce new insurance schemes for foliage and cut flowers, medicinal plants, storage of agricultural products and medicinal products and a scheme for insuring agricultural machinery.

In 2003, the AAIB added two more crops, namely, banana and ginger under its crop insurance scheme. CICL implemented special insurance schemes, namely, the Post-

Harvest Crop Insurance Scheme for paddy and the Ceylinco -Seylan "Govi Rakawaranaya", which offered special life and health insurance cover to crop credit customers.

National Insurance Trust Fund was formed in 2006 based on the Act No.28 of 2006.

Crop insurance scheme was established in 2013 according to the budget proposal in 2012 for farmers who receive subsidized fertilizer under the "Kethata Aruna Pohora Diriya" programme. It is a compulsory Insurance scheme as a remedial measure to mitigate damages caused to cultivations due to droughts, flood and wild elephants and operated as per circular No.BD/EE/118/01/BP/2013,dated 21/06/2013, issued by the Ministry of Finance & Planning. Farmers contribute Rs. 150/= at the time of purchase of each chemical fertilizer bag of 50 kg as a premium (Rs.3/-per 1 kg of fertilizer) during each cultivation season. The insurance premium is charged at the time of purchasing fertilizer at the Agrarian Services Centres and Cooperative Societies which are selling subsidized fertilizer. In addition, a crop insurance levy of 1% of the annual profit is also collected by NITF from all licenced banks, registered insurance companies and financed companies. Insurance benefit is paid subject to a maximum limit of Rs.25,000/-per hectare(Rs.10,000/-per acre) in the event of a total loss. The Cultivation Loss Assessment Committee should assess the damages based on the stage of cultivation. After receipt of recommended claims from Agrarian Development Centers to NITF, claims are processed and payments are directly credited to the bank accounts of farmers.

The currently implemented risk layering model offers insurance to all farmers who cultivate paddy as follows (Table 2.4).

Table 2.4: Loss Compensation based on risk assessment for paddy farmers

Risk	Parameter	Loss Compensation
Self-Retention Layer	20% yield reduction	
Market insurance layer (subsidised premium attached to the fertiliser subsidy)	20% to 100% Yield loss is the loss parameter when compensation /indemnities are paid on the basis of total cost of production Rs. 40,000	**NITF Up to Rs.10,000**
Market failure layer		**Treasury Upto Rs. 40,000**

Source: Wickramasinghe, 2020

Crop Insurance has expanded for five other crops including, Potato, Big Onion, Chillie, Maize and Soya Bean, in 2017. (Will be paid compensation upto maximum of 10,000 rupees per acre for damages to crops in times of a calamity). "Compulsory Crop Insurance Scheme" was introduced in year 2018 by extending the insurance coverage for other commercial crops such as maize, soya been, big onion, potatoes and chilli and cover the actual loss of the crop damage in order to minimize the financial risk of the Government and compensate farmers without causing difficulties as well.

Also the government has decided to offer farmers insurance free of charge for six varieties of crops including paddy from the Yala season, 2018. (Onion, Potatoes, maize, Soyabean and Chillie, in the case of cultivation damage Rs.40,000 per acre or Rs. 100,000 per hectare will be paid as claim benefits)

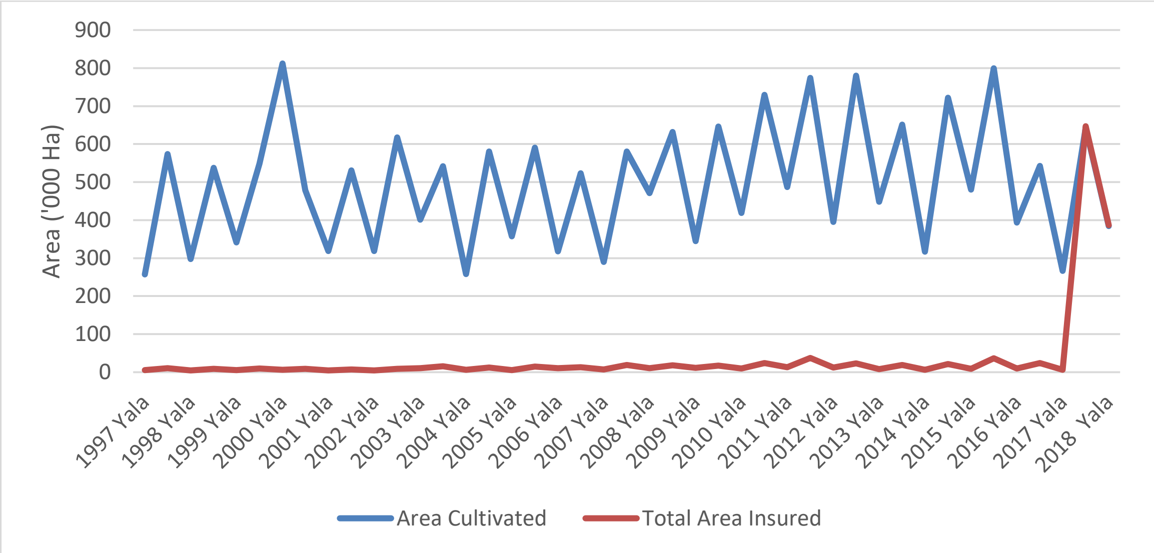


Figure 2.22**:** Performance of paddy insurance schemes over the years
Source: CBSL, (2009, 2018)

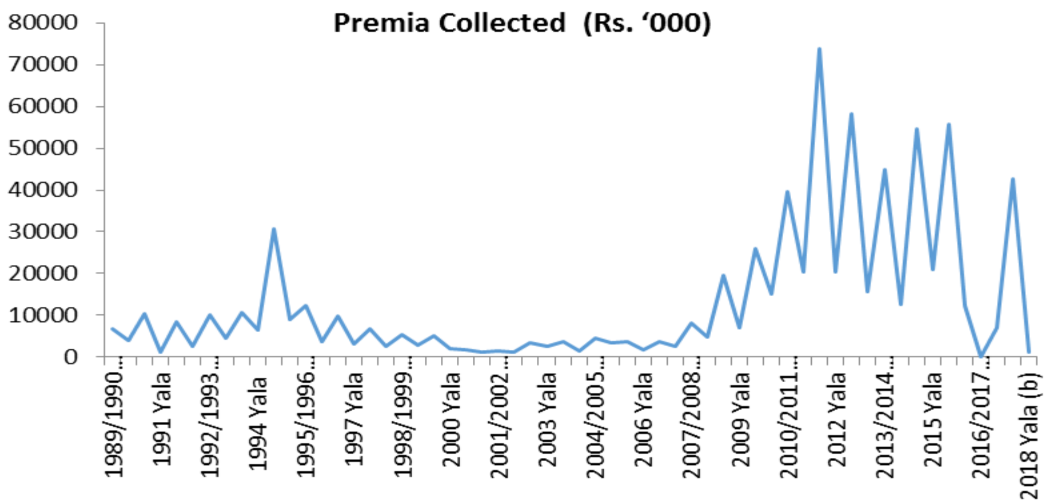


Figure 2.23: Insurance premium collected from 1989 to 2018
Source: Annual reports, CBSL various issues

Insurance premium collected has increased after 2005 when the insurance scheme was attached to the feriliser subsidy program of 2005. With this program entire paddy farmers were included to the insurance program. However, the indemnities paid in return for the crop losses have also increased (Figure 2.23 & 2.24).

Operations of the crop insurance programme for paddy sector shows that in the recent years AAIB continues pay larger indemnities against insured paddy crop making crop insurance alone as a risk sharing strategy against the climate disturbances an unsustainable policy.

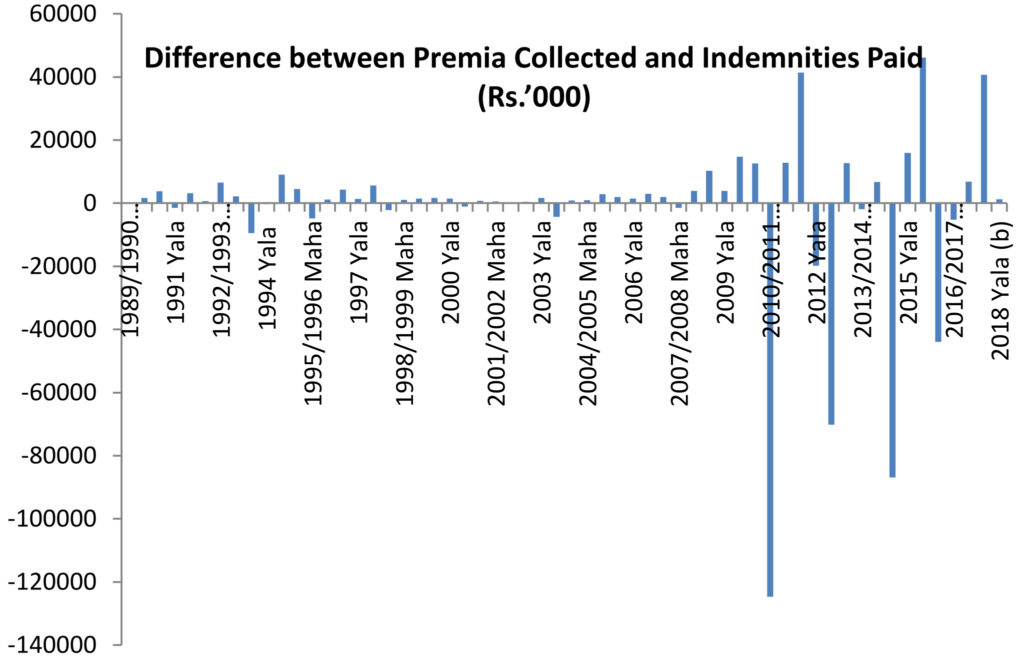


Figure 2.24: The difference between insurance premium collected and the indemnities paid from 1989 to 2018

Source: Annual reports, CBSL various issues

Table 2.5: Government expenditure in the crop insurance and important policy changes

Year	Current Transfer (Rs.Mn)	Remarks
1990	12.7	
1991	3.6	
1992	11.1	
1993	23.8	
1994	20	
1995	11.2	
1996	8.6	
1997	0	
1998	14.6	
1999	30	**The Agricultural and Agrarian Insurance Act No. 20 of 1999**
2000	31 .7	
2001	36.2	
2002	32.2	
2003	0	
2004	28	
2005	31	
2006	38	**Formation of National Insurance Trust Fund in 2006 (Act No.28 of 2006).**
2007	37.9	
2008	327	
2009	130.9	
2010	125	
2011	790.4	
2012	134.8	
2013	138	**Crop Insurance Scheme**
2014	2,100.30	
2015	2,276.00	
2016	2,690.00	
2017	2,760.00	**Expanded Insurance Scheme**
2018	2,835.00	**Compulsory Crop Insurance Scheme/ Free of charge**
2019	3,340.00	

Source: Annual reports, CBSL various issues

2.2.10 Public Expenditure Programs of the government and investment prioritization

Public investment programme and its share in Agriculture

Sectoral allocation of resources in the Public Investment Programme (PIP) has varied over time in accordance with measures taken by government to deal with prevailing economic and political conditions and also with total resource availability. The PIP, a rolling plan, is flexible and reflects changes in government policies and priorities from year to year. The PIP is divided according to economic sectors viz., Agriculture, Industries, Social Overheads, Economic Overheads and Human Settlements. It lists projects by sectors under three categories: on going, annuals and new projects. Those that do not fit into any sector are grouped under a heading "Miscellaneous". Resource requirements are indicated by the implementing agencies for a period of five years from the current year. The aggregate of requirements of all agencies gives total resource requirements.

Total resource availability is estimated from resource flows that are dependent on international trade effects on primary commodities, the vagaries of weather on agriculture and upon international assistance. Thus, these have a direct control over the size of the PIP. Domestic savings are inadequate to finance the investment programme and recurrent expenditure of the government, so foreign assistance is always needed.

The government priorities in 1984 were decided to:

(i) provide adequately for O&M allocations as a first priority.

(ii) exclude activities that could easily and efficiently be undertaken by the private sector.

(iii) embark on: - quick-yielding, production oriented projects which would reduce the balance of payments problem. - essential infrastructure needs in power, irrigation, transport and communications. - urgent needs in health, education housing and nutritional standards of the people.

The completion of the Agriculture Food and Nutrition Strategy Study later in the same year identified areas of the agriculture sector that were starved of investment, such as the plantation sub-sector, for which the Medium Term Investment Programme was implemented. However, the declining trend was not reversed. From the latter part of 1987, civil strife began to spread all over the country. As a result, revenue collection fell from an average of 21 per cent of GDP to 18.8 per cent in 1988. Export earnings declined further and private transfers from migrant Sri Lankan workers leveled off. To add to these difficulties, in 1989 the new government launched its lead programme on poverty alleviation, employment generation, nutrition and other social welfare measures to fulfil its election promises.

The PIP for 1989-93 (Table 2.6.) was formulated to take these constraints and changes into account. In its 1989 Policy Framework Paper, the government agreed with the IMF and World Bank to bring stability and to contain inflation.

The main reforms to be effected during 1989-93 included:

a) reduction of the PIP from 11 per cent to 9 per cent of GDP.

b) reduction of the overall deficit from 12.5 per cent to 8 per cent of GDP.

c) reduction of domestic borrowing from 6.4 per cent to 3.8 per cent of GDP.

However, to accommodate the government's new lead programme, subsidies and current transfers would increase during 1990-1991 but should level off thereafter. The Transport Sector Master Plan and the ongoing Power sector study were other areas that would compete for additional investments. Thus, a further shift of emphasis away from agriculture was envisaged.

Table 2.6: Sectoral Allocations in Public Investment Programmes from 1979-86 to 1996-2000 (percentages)

Period	79-83	83-87	87-91	92-96	96-2000
Capital Budget	100	100	100	100	100
	(n.a.)	(33)	(37)	(40)	(40)
Agriculture	43	45	22	17	10
Of which	(n.a.)	(45)	(53)	(47)	(41)
Mahaweli	23	27	12	8	3
Irrigation	(n.a.)	(53)	(52)	(31)	(29)
Non-Mahaweli	2	4	3	2	2
Irrigation.	(n.a.)	(43)	(60)	(56)	(52)
Industries	10	2	-	2	3
	(n.a.)	(8)	(6)	(7)	(66)
Human Settlements	10	11	9	18	14
	(n.a.)	(17)	(50)	(42)	(49)
Economic	30	26	41	51	40
Overheads	(n.a.)	(37)	(43)	(55)	(64)
Social Overheads	7	9	9	13	13
	(n.a.)	(15)	(22)	(23)	(17)
Miscellaneous	-	7	7	6	21
	(n.a.)	(0)	(7)	(-)	(4)

Note: Numbers in brackets are percentages of foreign assistance.

Source: Public Investment Programme, Ministry of Finance

Although areas starved of investment were identified in the National Agriculture Food and Nutrition Strategy Study, the absorptive capacity of the agencies within the agriculture sector did not improve to the point where they became real competitors for irrigation. Total Public Investment at the end of the 1980s was around Rs.30 billion. It was not expected to grow at more than 2 per cent per year in the 1990s, with the adoption of the new Policy Framework by the Government in consultation with donors. However, this control was not exercised in practice. Total public investment rose from around Rs.38 billion in 1991 to Rs.61 billion in 1996, with expectations of Rs. 114 billion in 2001.

Investment Priority Areas identified in the 2017 public investment programmme:

Irrigation water resources development

Trans-basin diversion
New reservoir development and construction
Augmentation of feasible existing reservoirs
Rehabilitation of existing tanks and reservoirs
Increase the water use and conveyance efficiency

Table 2.7: Investment Priority Areas

Priority Investments	2017	2018	2019	2020
Construction of Major/ Medium Irrigation Schemes	51,000	58,500	68,500	73,000
Rehabilitation of Irrigation Schemes	11,500	12,000	14,500	15,000
Operation & Maintenance activities / Water Management	5,000	6,000	6,500	7,000

Source: Department of National Planning

Assistance to Agriculture

- Promoting new hybrid and high yielding varieties of cash crops and establishing seed cultivation farms
- Introducing latest agricultural equipment and technologies in production and market value chain including post-harvesting
- Establishing large scale agro enterprises for value addition and product diversification
- Establishing a fully empowered Agro Marketing Authority – development of markets, infrastructure in value chain
- Introducing and popularizing Agro Financial Tools & Products
- Building agricultural roads and market places
- Strengthening agriculture extension services, introducing best practices
- Promoting production and use of eco-friendly agro-chemicals
- Strengthening research and development on new varieties, technology and new market trends
- Introducing e Agriculture to distribute information to the farming community
- Implementing agriculture crop insurance Scheme to compensate farmers for the losses due to floods, droughts and other natural calamities.

Table 2.8: Investment Priority Areas in Rs Mn

Area	2017	2018	2019	2020
Crop Production and Improvement	2,779	1,812	2,568	2,976
Agribusiness Development	2,232	4,359	5,517	6,318
Seed and Planting Material	480	577	755	913
Research and Development	546	603	370	414
Extension and Training	115	117	129	150
Development of Minor Irrigation System	4,500	4,050	5,300	6,100
Acquisition and Rehabilitation of Capital Assets	1,029	975	1,154	1,264

Source: Department of National Planning

CHAPTER 3

NATURE AND MAGNITUDE OF PRIVATE SECTOR INVESTMENT IN AGRICULTURE AND ITS DETERMINANTS

3.1 POLICY INCENTIVES FOR PRIVATE SECTOR PARTICIPATION

Of the main stakeholders engaged in agriculture; state, private sector, subsistence and commercial farmers and the international partners, the role played by the private sector more definitely the corporate sector is of significant importance as state withdrew from various functions that had been performing before liberalization of the economy. Policies were oriented creating an enabling environment for private investment in agriculture to earn a reasonable return on to their investment while achieving growth in agriculture sector.

Until mid-1980s, the public sector had the monopoly over the seed industry in Sri Lanka. An organized seed production and distribution program was initiated by the Department of Agriculture (DOA) after selection and breeding of improved paddy varieties in the late 1950s. In between 1960 to 1980, the industry matured within the state sector and in late 1970s, the National Seed Certification Service began functioning. Improved seed for all food crops was produced, imported and marketed exclusively by the DOA until 1984, when the first step towards privatization was taken.

Private sector was allowed importing and marketing of exotic vegetable seeds at that point. Until then, the highly subsidized seed prices, poor access to improved basic seeds and technology and a restrictive policy stifled any initiatives by the private sector to enter the seed industry. With the time of that, government encourages the private sector to invest in Agriculture other than trading.

As the first turn on, in 1994 the government sold off seed farm at Thalawa and a committee comprising public and private sector was established to review the system of importing seeds. In 1996, the government approved the National Seed Policy, which sought to increase the role of the private sector in development, production and marketing, while reducing the role of the state primarily to regulation. In 1998 and 2000 respectively, another two seed farms (Hingurakgoda and Pelwehera) were privatized. The Government produced only foundation seeds, which 2 were then issued to private growers for production and marketing. The majority of seeds used for paddy is actually retained by farmers themselves from their own crop. The Plant Protection Act, which envisaged a slackening of restrictions on the import of seeds, was approved by the Parliament in 1999.

By 1994, Sri Lanka had already gone through a liberalization process whereby most non-tariff barriers to trade had been removed. In addition, duty has been waived on a number of commodities for cost of living considerations. Imports of all seed and planting materials for agriculture are duty-free and the duty has been waived on machinery and equipment imported for use in the application of new and innovative technologies in agriculture. At recent past, in 2010, imports for agricultural machinery were provided in a zero duty rate.

Private sector has an excessive potential in investing in Agriculture. The following schematic representation indicates the opportunities for private investment in Agriculture, in Sri Lanka. Looking at the present picture, supply of inputs, development of physical infrastructure, transfer of technology and support services prevails more or less in the sector. However, these basic components of opportunities, should be accessed under the supervision of the public sector and should be monitored accordingly.

Supply of Inputs

- Seeds / Planting materials
- Bio-fertilizers
- Packaging materials
- Tools / machinery

Development of Physical Infrastructure

- Market centers
- Cold Storage / Warehouse
- Sorting-grading-packing centers
- Industrial sites

Investment Opportunities

Transfer of Technology

- Controlled Agriculture
- High demand / high valued crops / Livestock products
- Off season production techniques
- Processing and Value addition
- Integrated Production systems

Support Services

- Research and Extension
- Testing and certification
- Refrigerated transportation
- Storage / warehouse facilities
- Forward Contracts (web-based)
- Crop Insurance

3.2 THE CURRENT DEPICTION OF PRIVATE SECTOR INVESTMENT IN AGRICULTURE

There are numerous private entities active in investing in agriculture. Predominantly these private entities tend to invest in seed market, machinery and agro- chemical market. Some of the important companies in Sri Lankan seed market include, Tropical Seeds/OPEX Holdings, Best Seeds (a representative of East West Seed), CIC Agri Business, Hayleys Agriculture, Supreme Marketing Company, and Lankem Ceylon PLC-Agro. In view of the machinery industry, Hayleys Agriculture, Dimo Sri Lanka, Divi Shakthi, Helix Engineering (Pvt) Ltd, Dave Tractors (Pte) Ltd, Brown & Company PLC, Agfour Engineering, and Jinasena Agriculture are some of the pioneers.

In this study, it specifically aims at Hayleys Agriculture and CIC Agribusiness, for explaining the trend of investing in Agriculture and to explore the government sustenance and draw backs for investing in Agriculture.

3.2.1. Hayleys agriculture

Hayleys has grown from a small proprietorship in Sri Lanka's southern city Galle, into one of Sri Lanka's largest, most diversified public companies. The 140 year Hayleys chronicle traverses the tapestry of time, changing with it and taking shape from it.

Today Hayleys is a Sri Lankan multinational conglomerate renowned globally and locally in certain specialized areas of expertise such as Agriculture & Agri Business, Transportation & Infrastructure and Consumer & Leisure.

A quoted and truly broad-based company, in the 52 years since its incorporation Hayleys, has had a record of 26 scrip issues and 4 modestly-priced rights issues, together with dividend payouts averaging 25% in each of these years.

The Hayleys Agriculture, comprises by vast range of sectors.

<u>Sectors</u>

- Crop Nutrition
- Soil and Water Management
- Seeds and Planting Solutions
- Crop Protection
- Agri Mechanization

3.2.1.1. Nature of the investment and the present context

3.2.1.1.1. Agri Mechanization

Offer a range of machinery for agriculture mechanization from tractors and rice trans-planters to sprayers and combine harvesters and market products covering Paddy, Tea, Coconut and Dairy sectors.

- Heavy Machinery (Tractors and implements, combine harvesters, trans planters)
- Light Machinery (Knap sack sprayer, midst blowers, power sprayers, bush cutters, fogging machines, weeders)
- Tea Machinery (Tea harvesters, Tea bush pruners, Earth augers)
- Protected Agriculture (Locally fabricated net house, free fabricated greenhouse, insect proof nets, UV treated polythene, shade nets, mulch films, anti -birds nets, fencing nets, nylon blue nets, mesh nets, locally fabricated greenhouses and other accessories)
- Micro irrigation (Drip irrigation, sprinkler irrigation and other accessories)
- Dairy Machinery (Milking systems, milking machines, chaff cutters)
- Coconut Machinery (De-huskers and shredders)

Hayleys (Hayleys Agri Equipment Division), plays a vital role especially in Agriculture machinery, in Sri Lanka. As there are three main stages in the Agriculture process: Pre-harvest, Harvest and Post- harvest, Hayleys focus their devotion in pre- harvest and harvest, predominantly in Open Field Crops such as Paddy and Maize. For land preparation, equipments such as tractors, Crop establishment rice trans-planters and harvesting equipments, the harvesters (Primarily for paddy). For other sectors; dairy, tea and coconut. Primarily regards to the paddy; the company concentrates on crop establishment and crop harvesting, as the land preparation is common. (The land preparation is irrespective to the crop). Government tenders are the common channel of occupying the opportunity to supply the machinery. According to the Head of the Agriculture Machinery Division of Hayleys Agriculture; Mr. A. Rajap; Hayleys has supplied about 600 trans-planters for past few years. Hayleys train farmers to establish the nursery and to use the mechanized trans- planter, while promoting the Dapoc nursery substituted for manual broadcasting. Mechanized transplanting has many advantageous trend over manual transplanting particularly in saving labor cost, increase in yield and production at low cost. Hence the situation prevails so, there are some issues denoted with that can be reckoned as risks for the farmers, such as water issues (scarcity , precipitation patterns, issuing of water from the authorized bodies) and the reluctance of farmers by themselves to establish and maintain a nursery. Relying on some collaborative research works implemented with RRI, Batalegoda, it was found that, transplanting has a trend of increasing the yield at least 10%, absolutely for 4 months and, 3 ½ months varieties; while 3 months varieties susceptible for the planting stress. There is an opportunity to use the mechanized weeder for weeding, when the row planting is done, instead of using sprayers. Observing the dynamics of using trans planters , in some areas it has been identified that some pockets of people (North western Province), who acquire the subsidy of Rs.100,000 from the regional/ provincial government, for purchasing the machinery, and doing the transplanting as a business on a hire basis, and had been successful. So this can be imaged as a future trend of utilizing more machinery and will be determinant for invest in Agriculture. In some areas the farmers has abandoned the usage of mechanized transplanters, and also in some particular areas the chairman of the farmer organization has the responsibility of the machine, not willing to distribute among other farmers. Again some pockets of people tend to earn by hiring their machinery, and they continue it as a business where they have been successful. Though there are some practical restrictions in Sri Lanka, custom hiring also another future trended better practice, where the farmer gives the whole pick to the particular contractor. And the contractor will bring the machinery to the nursery and does the transplanting. Contemporary there are some customary mindsets that restrict the utilization of agriculture machinery. Farmers expect the technology of the machine to suit the manual practice. Apart from climatic restrictions like water scarcity, lack of knowledge of farmers, and the low adaptability rate of the community where there the training programs which provided are not taken into. Practically though the company tends to conduct training programs on Dapoc nursery establishment, the farmers still willing to continue broadcasting.

When looking at some point of view about the future trends, the company will be testing a trans- planter, specifically developed for the parachute nursery. This imported machine developed by the supplier could be used as a future development in the stream of agriculture machinery, to overcome the labor shortage and also to continue a quality transplanting.

When discussing the rationalism in the investment, most as the private companies, Hayleys themselves measuring it, in the terms of potentials. First the areas which are suitable for mechanized are going to be recognized. Then, identifying of the suitable machines which can be used for is carried out. Afterwards, those identified suitable machines are brought up to the country and test here (Because, all machines are not suitable for the country itself; so have to test minimum one season/ mostly two seasons). For instance one model of a combine harvester had been tested for three seasons. Then the modifications have been done and introduce to the field. Repeatedly, if further more modifications found, after introducing, modifications should be continued afterwards.

Quality parameters of the harvest can be refined by utilizing the machinery. Moisture content of the rice is a kind of a parameter that measures the quality. So, dryers has a great prospect in machinery for that perspective. There is an impending demand for mobile dryers in present. Fix dryers are capable of drying fixed 10 tons batch 12 hours where the drying gradient is 1% per hour. Mobile dryers, with a lesser time dries two-four tons per batch within an hour. Institute of Post -Harvest Technology (IPHT), a government body has developed a continuous dryer capable to dry at most 66kgs within in 12 minutes at 160 degrees. As a collaborative venture, Hayleys tends to join in developing this new invention. Though the inventors has applied for obtaining the patent for this invention, the higher temperature which operates by has some minus effects on the quality of the rice. It can increases the percentage of the broken rice and the taste of the rice can be altered. So the two-way discussions will be undertaken to readjust those effects and introduce to the field and market.

Some drawbacks have been sorted in investing on Agriculture machinery in Sri Lanka. Fundamentally, the company has once spent one million of amount to assemble a combine harvester. And a difficulty may emerge in handing over a machine for one million, and the way upon the farmers will lose the affordability.

There are some drawbacks in the channel of being mechanized by the farming communities too. The farmers who practice mechanization for the agriculture have to invest added cost to than the non- mechanized farmer. So, this will be a loss of the benefit to the particular farmer. To come over with the mentioned issue, an income intensive should be granted to the farmer who practices, or willing to practice mechanization for farming. `

Transforming from manual agriculture to mechanized agriculture can be a great substitute for labor shortage. Required labor hours for nursery establishment in the manual procedure estimated like as, half a day for 80 trays (half acres) and other than, for managing the nursery until 14 days, watering, drying (once in two days), foliar application (14 days period) and other management practices. Nonetheless a mechanized trans- planter only requires, one day, with two people (Operating and supporting) for two and half acres.

Other than paddy and other open field varieties of crops, Hayleys has glimpsed into dealing in machinery of tea, rubber, coconut like major exporting crops also. The company has developed a tea harvester, where the company promotes itself machine plucking of tea is quality than the hand plucking, because of the fact where the fermentation has not started yet, and regrowth of the shoot can be further occur. (Because of the fine cut)

Not only paddy, as open field varieties, the company has undergone a process of testing on a maize harvester and a groundnut thresher. (Pod). And also the company has developed and introduced a coconut de-husking machine, which is newly following demonstrations. Other than that, also the company has developed a rubber tapping knife. Furthermore, Farm waste dredgers / pulverized, which decomposes fast the thrown by s of agriculture also has been developed by the company. When look on other than harvesting of crops, the company has developed equipments for maintenance purposes too. Such as, pruning machines, earth augers for tea cultivation. Agriculture is not a sole component of crop, so the company has contributed for the dairy sector too. Portable milking machine, chop cutters like machinery and equipments have been introduced by the company for the ease of dairy farmers.

Specifying the protected agriculture sector implementing by the company, the range of products varies to shade nets, UV polythenes, insect proof nets, fruit and vegetable covers (Banana branches, insect attacks, and rodents' attack), poly tunnels, and net houses. This emerging protected agriculture products have been tested in the filed level as trials. At the moment company conducts a trial with a grape farmer in Jaffna. To examine the effect of color of the shade net, in regards to the increase in the yield, harness and the size of the grape fruit. (Green and black shade nets have been normally used and especially this research is carried out to determine the effect of the white color shade nets).

Extension is the channel which transmits these theoretical aspects into practical scenario. However, as in the present, the public extension sector is administrated by the regional government, and it has caused to shrink the capability of the department, though there are several plans and new projects have been implemented. At the moment, Hayleys also has stepped into extension service. On one aspect, they train and make aware the farmers and the owners of the machineries about the operational and maintenance, when the machine is bought. And on the other hand, they provide extension services to the government extension officers about those machinery.

On the view of collaboration with other entities, Hayleys and SLINTEC has some preliminary plans to sign for an agreement for manufacturing soluble urea. As SLINTEC is totally and thoroughly relying on the patent, the business plan initiation was not successful, and SLINTEC itself now has joined with an Indian company for the manufacturing of soluble urea. Internationally the company has linkages with two entities operational under United Nation: The Center for Sustainable Agriculture, which recognizes all the private sector machinery, manufacturers and processes and The ANTAC, which is the government officials to develop standards for the machinery. It is experienced that, though setting up standards has no issues, the implementation of those standards have more concerns such as the prevailing stage of the country. Otherwise, when the standards become very stringent, it will reach far beyond the average farmer. The flexibility of parameters, which concern in preparing those standards should be renowned.

Presently, government is more likely to be rely and depend on imports done by the private sectors, other than testing those machinery by the government. So, from one aspect it may be a burden for the private sectors too. This issue was aroused some years back when a seeder (Which to fix to the tractor) has been imported by the company after getting the government tender. When the company exhibited the samples to the government authorities, there was no dispute. By the time when company suggested for recommendations, to specify the varieties, those government authorities denied to do so, and suggested the company to examine it, in the field and the market. Lastly, when the seeder was introduced to the field, the department stated that the machine is not suitable for the field. There is a depiction of what the government does not want to be accountable in the flow, where the strength of the partnership ventures tends to be faded.

For expanding the acceptability of future demands and trends in agriculture, the company, looks forward and willing to continue, to work with the universities, where in the meantime they had functioned with University of Peradeniya, specially predominating the agricultural engineering aspect. Conducting researches in different thematic areas, mapping the fields of Sri Lanka and also, testing hydroponics. This future prospect will be a noble way of sharing technology. The company themselves owns an Agriculture Training School, where they have provided the training service to about 300 advanced level teachers in agriculture stream. Initially the company has received the syllabus and it has mentioned some machinery which are out dated. In this particular scenario, government can connect with the private sector to get the private sector involvement because, company itself willing to explore the new technology to the school syllabus.

When citing the practice of advanced technology by the company, Hayleys has applied the drone technology to the tea plantation sector and paddy sector. Basically, the drone technology has been used for chemical application. This technology had been used once for maize cultivation, when there was the epidemic situation caused by fall army worm. There are several advantages in using this technology in agriculture. When, drone systems is used for chemical application, other than manual application by a knap-sack sprayer, the user himself does not expose to chemicals. And as the emission is efficient, drone technology is faster compared to the manual sprayer. With the intention of promoting the significance of adopting to this advanced technology, the marketing communication division of the company has produced videos and documentary about advanced drone technology. Yet, there also some issues in regulating in the practical field level. In war era of the country, the government has some regulation restrictions on the quantity of lifting. The company has to grant the approval by the government, if the quantity of lifting exceeds one kilogram, and that regulation is still has not taken off.

When looking on eye in agriculture production, Hayleys produce the stainless steel knap-sack sprayer, since 1970s. In about 2013, when the government took back the custody payments for 0%, a competition was aroused between the imported companies and local companies. Though this issue was taken for the consideration of treasury, asking for a protection over this matter. The government sector (National Committee on Economic Development) did not lend a strong encouragement for the local manufactures, where their opinion was that private sector should stand by their own. When considering the other machinery such as tractors, the major parts of those machinery are the engine and the gearbox. The manufacturing of those components is hard as the volume and the requirement of Sri Lanka is very small. As there are less plants for manufacturing, importing is effective. So, the local value addition will be basically the labor. Though there are some South Asian countries like as Bangladesh who manufactures machinery locally based on the fact of cheap labor, the present trend of those countries also moving for imports by China.

Adjusting on the future demand, the company has established the “Agri machine operation”, since 2019. At the initiation level, the company has started testing harvesters, before introducing. Depending on the type of harvesting of paddy (Full feed harvesting) in Sri Lanka, the company wanted to introduce a Hay baler, which can bale, and planned to introduce to the dairy farmers in areas like Kurunegala and Polonnaruwa. Taiwan has manufactured a machine to produce rope from straw where Hayleys also looking forward to introduce that machine into Sri Lanka. It will be a good and cheaper alternation than coir to make coir. And also there are some other equipment that the company is looking forward to introduce to Sri Lanka like as preparing pallets using coconut husks. Agro biotech is the functioning agent of Hayleys who undertakes the tissue culture, located in Nanu –Oya. They function multiplication for the parental materials sent from the mother country, and also looking forward to produce materials in here itself. The multiplication of G_0 of potato seeds was not viable depending on several factors, majorly the high cost of production, lacking of fields and more rounds of multiplication trials. Hayleys own 70% of market share for seed potato in Sri Lanka. Calling upon the future demand, Hayleys has introduced a new variety, which is resistant to heat to Jaffna area, which has good pattern of growth.

When citing on the competition faced by Hayleys, as a business entity, they face for price competition with competitors as they try to import the same machinery which Hayleys introduced mostly for the first time, to a low price rate.

3.2.2. CIC Agri business (private) limited

Chemical Industries Colombo (CIC) Limited was incorporated in 1964 and at present it is better known as CIC Holdings PLC. CIC has initiated the business as an importing entity of chemicals to Sri Lanka (Crop solution, paints and chemical was the main business). Lending the path to Agriculture from Chemical industry, the government had thrust emerging private institutes to invest in Agriculture, other than trading. The general ill perception of the community about chemical usage was plus point on initiating the agriculture pathway.

CIC Agri Businesses (Private) Limited is a one of the main businesses of CIC Holdings PLC, which contains all the agriculture related businesses in CIC Group. It consists of several companies namely;

- CIC Seeds (Private) Limited

- CIC Agri Produce Export (Private) Limited
- CIC Agri Produce Marketing (Private) Limited
- CIC Dairies (Private) Limited

This manages over 10,000 acres of farmland and work with over 20,000 rural farmers in producing a wide range of Agri Produce including Healthy Rice, Fruits, Vegetables, Seeds and grains and Dairy products which caters to the country's food security, nutrition and import substitution initiatives. CIC uses internationally-accepted food safety standards and good agricultural practices that creates the product that contains the wholesome goodness and nutritional value required for nourishment. CIC also makes substantial investments in their research and development facilities which include rice breeding, soil labs, seed labs, food labs and tissue culture labs and work with reputed overseas principals for developing modern technologies comprising high yielding and pest resistant crop varieties into the country.

In addition, its own crop and livestock farms act as technology transfer centres to the farming community of Sri Lanka introducing new agricultural technologies.

Out grower system of CIC practiced on seed paddy, soy bean and bitter gourd giving great opportunity for local farmers to reap continuous income for their agricultural produce irrespective to market fluctuations.

As a private sector business organization CIC is conducting private rice research center in Pelwehera seed farm and conduct variety evaluation trials, hybridization programs to introduce good quality, high yielding varieties. Hence, CIC seeds (private) ltd provides great services to the nation. CIC 3-1 is their first breeder seed variety which was introduced as a recommended variety. CIC rice mainly targeting export market and it is great opportunity to earn foreign exchange to the country. CIC farm produce good quality Cavendish banana for local and export markets. Big onion true seed project supply quality big onion seeds for farmers and this helps to cut down the highest portion of big onion seed importing to country and this also helps to save foreign exchange. Plant nursery provides budded, grafted and tissue cultured plants of fruit crops, plantation crops, ornamental plants, forest plants and *etc.*

CIC provide training facilities for university and other agriculture base higher educational level students and also facilitate farm visit opportunities for school children, farmers and higher educational students.

In addition to that, CIC provide soil and seed testing service to the farmers using their fully equipped laboratory facilities.

In 1984/ 1985, when the government liberalized the seed sector, government encouraged private traders to establish in seed sector, where majority traders joined in importing the vegetable seed sector. The CIC Seed farm commenced its operations in early 1990's with the production and marketing of chili seed. Though the seed paddy was a messy operation with a high volume and low margin, the company acquired the Thalawa Seed Farm in 1992, the first farm to be privatized by the government, and initiated a seed paddy production program using the farm as a basis. CIC retains couple of seed categories. CIC undergoes the multiplication of basic materials of the government: public varieties (Ex-Batalegoda, Mahailluppallama and other research stations). And the distribution is processing through selling in their own farms and distributing among out- growers. Apart from that CIC recently has engaged in producing their own varieties. Based on the performance of the Thalawa farm, the government awarded the management rights of two other large state farms namely Hingurakgoda in 1998 and Pelwehera in 2000 to the CIC on a long term lease (Rs. 5 million, per year, per farm) with a view to enhancing the local seed production. The initial thrust of the company was to develop a sound seed paddy business. According to the information provided by the CIC within a short period of time, CIC Seeds became a major player in the national seed paddy supply system with a market share of about 30 percent. To avert the risk bearing by depending on seed paddy program with seasonal income, the company diversified its activities to produce other seed varieties and planting materials in the CIC farms as well as under contract growing. A trading operation too was initiated to import and supply hybrid vegetable seed and seed potatoes. The company today has become the foremost seed company in the country. The government has taken up steps to regulate the monopoly of seeds by particular entity, by providing the parental line free for everyone. And also there are some government regulations, and agreement on the seed sector, where those entities should sell the seeds lower price than the imported seeds, because a cost has not been allocated for the Research and Development.

The CIC set up a lab in Pelwehera to analyze soil and as a result researchers were in a position to recommend the fertilizer depending on the type of soil. The CIC Agri Businesses moved up the rice yield from 55 bushels per acre to 125 bushels at Hingurakgoda and planned to raise the yield up to 175 bushels per acre.

The CIC ventured into farming in 1998 with the leasing of a 1,500 acre government farm in Hingurakgoda. At Hingurakgoda there were two interesting activities a) the Agricultural Machinery Yard where the CIC Agri became accustomed to combine harvesters and other implements imported to suit local conditions. These harvesters are very useful to farmers as large areas could be harvested in double quick time, than using the manual labor. b) 50-acre Cavendish banana plantation where banana is planted under strict international conditions and the processing plant of banana exports. The packing house of banana was built to process banana for export market as per the agreement with one of the world's largest fruit exporter DOLE. This pack house has capacity of handling and storing 20 MT. The production of Cavendish banana ranges from 800000 to 900000 kg s per annum, while planting material production counts around 175,000 plants.

There are about 150 acre lands in the farm under micro irrigated banana crop. Cavendish, Kolikuttu, Ambul, Amban, Seeni & pulathisi are the main varieties cultivated in the farm. There is a collection of Banana varieties such as 'Kolikuttu', 'Seeni', 'Ambul', 'Ambun', 'Cavendish', 'Suwandel', 'Pulathisi', 'Alu' etc. and to supply the required materials use the Tissue Culture Laboratory.

The CIC leased the Pelwehera Government seed farm at Dambulla in 2000. At present both Hingurakgoda and Pelwehera farms are well developed using modern technology. The Pelwehera farm consists of Mango Germ plasm Collection, Agri Technology Park, Agribusiness Centre, Juiceez, Planting Material Display Centre, Desert Plant Greenhouse, Greenhouse Cultivation, Herbal garden, Commercial Vegetable garden, Fruit Garden, Banana Mother Plant Orchard, Mango Mother Plant Orchard and the Citrus Garden.

Around 1,300 acres of the Pelwehera Farm is under paddy cultivation and it is also focused at Agro Tourism while the Windsor Park holiday chalets take the center place of agro tourism. It includes Mango cultivation, Vegetable Garden, Machinery Yard, Seed Processing Unit, Banana Cultivation, Plant Nursery, Home Garden, Compost Production unit, Livestock Production and the Agri Holiday Resorts.

The CIC Agri not only raised their farms to modern levels as model farms where they obtained highest yields and ran them profitably and brought up their farms to the most modern level, but also offered every possible assistance to share the successful experiences with the farmers and any other person interested in farming. The company provides advice on poultry farming, cattle rearing, piggery, compost fertilizer manufacture, fresh water prawn and fish farming, etc.

3.2.2.1. Structural Distribution of Farms owned by CIC

CIC Holdings has been at the forefront of Sri Lanka's Agriculture Industry. Agriculture is by far the largest industrial sector in Sri Lanka, with approximately one third of the population employed in it. Agriculture holds a special place not only in Sri Lanka's economy, but in its culture and traditions as well. CIC Holdings has taken an approach to farming that looks not only at the bottom line, but uplifting of the rural farmers as well. CIC's most significant farms, in terms of size and output, are the Hingurakgoda Farm, the Pelwehera Farm, and the Malwanegama Thalawa Farm.

- Hingurakgoda Seed Farm -Total Extent – 1,300 acres
- Pelwehera Seed Farm - Total Extent – 670 acres
- Thalawa Seed Farm - Total Extent – 206 acres

Hingurakgoda Farm

Hingurakgoda in the Polonnaruwa district has traditionally been one of the most famous areas for paddy cultivation in Sri Lanka. CIC acquired the 1,340 acre farm in 1998 from the government on a long-term lease agreement.

Of the 1,340 acres, as much as 750 are being used for paddy cultivation. Hingurakgoda farm is best known for its cultivation of seed paddy, and is the largest seed paddy production farm in Sri Lanka.

The farm's main source of water is the Minneriya Reservoir. The highland area of this farm is used for the production of perennial crops as well as livestock, making it a multi-discipline farmland.

This farm acts as a fine example of the adoption of modern agricultural technology and increased mechanization and automation while protecting traditional farming knowledge and conventional agricultural methods.

As mentioned above, the Hingurakgoda farm is a multi-discipline farm, and is comprised of the following areas:

Paddy Cultivation

The 750 acres of paddy farms produces approximately 130,000 bushels of seed paddy to the local market every year. Ten popular varieties of rice are grown in the farm. Since acquisition by CIC, the farm's average yield of paddy per acre has increased from 60 bushels in 1998 to more than 130 bushels at present.

CIC employs an efficient network of out growers to produce high quality seed paddy that supplements farm production. Using the farm as a nucleus, these out growers are given technical knowledge and other forms of assistance. Seed paddy – produced within the farm and by out growers – is distributed throughout the Country using an island-wide dealer network.

Special research trials are conducted in collaboration with the Department of Agriculture to test new hybrid varieties of rice.

Bananas

The farm has a banana plantation that covers an area of just over 50 acres. High quality bananas are grown for the export markets using modern technology and the latest agricultural methods. The farm uses a high-tech sprinkler system for the supply of water and fertilizer.

Machinery Unit

The farm has a fully equipped machinery division that provides services to the farm and maintains agricultural machinery such as combine harvesters and combine threshers. This facility also functions as a testing location for new agricultural machinery.

Pelwehera Farm

CIC acquired the Pelwehera Farm in the year 2000 under the prevailing government's privatization program. The farm is located 2 km from Dambulla and covers 634 acres. Owing to the farm being in an advanced state of disuse and disrepair when acquired, a Rs. 100 million infusion was provided to improve the infrastructure and facilities within the farm. Today, this is considered the most diversified farm in the country.

Big Onion Seed Production – established to provide quality seeds to farmers throughout the country.

Tissue Culture Laboratory – To produce tissue culture planting material of fruits and ornamental plants

Rice Quality Testing Laboratory – Supports the Paddy Breeding Programme and Quality Rice Programme.

Banana Plantation – 150 acres of bananas grown using micro-irrigation techniques.

Paddy Breeding Section – Sri Lanka's first private sector paddy breeding program to introduce new varieties of paddy.

Banana Packing House – This facility is used to pack bananas for the export market with a capacity of 20 MT per day.

3.2.2.2. Research and development involvement by CIC

CIC Breeding Program

To improve quality of the paddy seeds CIC had stepped in to the good quality seed production. In 2006 CIC had invested on paddy breeding project. In the beginning they built green houses that had cost 12 laks. And purchased land from Pelwehera to plant the breeding materials. Pelwehera is the first and the biggest privet sector that is available in Sri Lanka. Other than that CIC allocated more staff members for the breeding program, Including researchers and assistants and helpers.

Following comprehensive research and a development program carried out in its farm, the company has developed over 10 rice types. In the beginning the breeding had been done using local varieties. The paddy industry cannot be rely on those local varieties due to few reasons such as low yield and eating quality is low. Many traditional varieties such as Kalu Heenati, Elvee and Suwandel with attributed medicinal values have been identified and developed with improved productivity and aimed at international markets. All these rice types are now marketed under the “Golden Crop” brand. In addition to growing in its three farms the company acquired the services of over 3,000 farmers in the Mahaweli System B, C & H and entrusted them with the task of multiplying the rice varieties identified and developed by the company. The CIC developed four rice varieties for the export market and already introduced new red rice ‘Basmathi’ and a new colored rice variety to the international and local markets. These two rice varieties were specially targeted at higher income group and there is a good demand for these types of rice varieties overseas also.

When citing on challenges faced by the company, one was the development of highlands in these farms. There were about 2250 acres of land with more than 60 percent in the highland. These highlands had to be developed by improving infrastructure facilities such as irrigation, farm roads, perimeter fencing and staff housing. Many programs were initiated in highlands to produce field crop seeds, fruits, vegetables and various types of livestock products. These farms were able to increase the livelihood of neighboring rural community.

In initial ages, the government had supported for the private sector rice research program. But it had been changed over with the years with newly appointed governments. In 2012 the rice research project was expanded. More land had been purchased for the research and more staff members had been hired for the research and field works. The capital had been invested on these facilities was 25 to 30 Mn rupees. And the recurrent expenditure was 10 Mn rupees. But then, when it comes to 2014 the budget for the research had been cut down almost by half. To 5 to 6 Mn rupees. From 2014 onwards the budget remains same each year until now.

Crop Research Station Pelwehera

Earlier days Sri Lanka had cultivated the improved crops that had been imported. After that government invested on research programs on crop development program. Up until 2014 private sector did not involve in crop researches but CIC, joined the industry in 2014 and developed around 500 varieties up to now.

They involved in developing hybrid Capsicum, Chilies, Okra and Brijal, mainly, with the help of DOA. For this project Minneriya and Pelwehera both used as research fields. They took local germ plasmas through DOA and developed them as their requirements. For this research project CIC has allocated a laboratory and experienced staff. Now they produce 70 kg seeds per month. For the purpose of development they hired graduates.

For 2020 CIC invested 24 Mn rupees for crop breeding and 18 Mn rupees for only for hybrid researches. Other than that by this section they produce breeder seeds and genetic purification, agronomic trails had been done.

CIC being a pioneer company and as an active giant in agriculture sector in Sri Lanka as a private entity, they own resources, in human and capital too. Agriculture being a blooming pathway to private sector, CIC has a great potential especially in seed production sector, than other private entities. Yet, as to their opinion the government influence should be a stimulator to invest more in Agriculture field, as Agriculture is earning profits, at a marginal rate.

Table 3.1: CIC budget allocation for rice and vegetable R&D

Year	Budget allocation (Rs)
2014/15	8,154,946
2015/16	5,615,940
2016/17	5,105,400
2018/19	6,763,860
2019/20	5,544,660

Source: CIC Agri Bussiness

The agriculture of Sri Lanka, should be transformed to modern agriculture in real time. Though there are so many sectors being developed under the developing agriculture, the rate is too minor. The information system of agriculture should be reformed, with anytime available data on agriculture production and marketing channels. Sri Lanka can initiate the demo farms under the modernization, yet, the process should be out of political influential (Selection of the farmers, consultations).

3.3. DETERMINANTS OF INVESTING IN AGRICULTURE BY PRIVATE SECTOR

The basic trading ambition of any private sector entity can be characterized as that of being able to sell low-cost products into high-value markets, and thereby maximize profit margins.

- **Relative Involvement of private sector as a stakeholder in the national flow of agriculture**

  Private sector nature in agricultural decision making at the same time the environment for that decision making heavily is dependent on the sound of the government interventions into collaborative sense of working, agricultural research, rural infrastructure, and market relationships. As to discussion evidences done with the major acting private sector entities mentioned above, "private companies wishes to be in the process of implementation rather than be an entity of discussions only. Government now undergoes the administration relying on the control mode, nevertheless this setup should be altered into development mode, and it will encourage private entities to invest more in agriculture and developing more joint partnerships with public sector."

  "The role of private sector in the implementation and the monitoring level should be marked specifically, as the consultation provided by the private sector in the foundation, should be conceded out to the implementation process also. If the local sector and the private sector is going to work as a team, the private sector will also have the opportunity to work in decision making process too."

  "A strengthen partnership between the government sector and the private sector is essential for the stability of the agriculture sector in Sri Lanka. Yet, the practical set-up is quite different from the theoretical perception. Still the public sector has some suspicion on the private sector in collaborative ventures, and when developing the linkage private sector also has a responsibility to work in compatibly. Because the co-operate sector has a different attitude than the private sector relying on the work ethics. This issue of perception may be a disadvantage in the long term of development. So, when the policy formation is going to implement, there are some clear cuts to be addressed. Though private sector is willing to provide their contribution to the process, the government still pays a reluctant to fulfill the demand or the necessity of the request of the private sector in regards. Private sector aims at the profit oriented culture, therefore the private sector needs the government to fulfill their needs too. They look for government support in conducting research and development in particular stream and in testing the machinery for suitability in the country."

- **Existing modalities for Public-Private- Producer -Partnerships for investment**

Public Private Producer Partnerships can be used as a great way of promoting the entities to stimulate investing more in agriculture, where the risk embedded with company itself is low in the venture.

In Sri Lanka, several partnership programs have been implemented throughout the years. Maize, exotic vegetables, fruits, dairy products have in lined with these partnership programs where those private entities gain the opportunity to invest more. Hayleys Agriculture, CIC Agribusiness, Plenty Foods Ltd, and Ceylon Agro Industries, CBL are some pioneer companies engaged in those partnership programs. Out grower programs also can be tallied under those partnership programs.

Under Out Grower (OG) farming system, implemented by Ceylon Agro Industries for maize cultivation, OG farmers and OG firms enter into a signed agreement where the OG firm agreed to buy-back the harvest at the right quality range at the agreed price-range and farmers to supply their entire harvest from OG farming operation only to the OG firm. Further, OG farmers were facilitated by a bank to obtain credit up to 30,000.00 LKR per acre which was channeled to the OG firm to provide on-time supply of basic inputs: hybrid seeds, crop protection chemicals and fertilizer along with agricultural extension services throughout the season and the insurance company for an insurance premium.

Currently also, the sister company of Hayleys ; the HJS is engaging with a buy-back project of Gherkin in Wakarei , where Hayleys is supplying inputs such as irrigation equipments for that particular buy- back system.

As mentioned by Hayleys, tenders are the dominant channels in supplying the equipmnets for the government. They obtain the quota and relying on that they may supply the requested to the Department of Agriculture, the projects implemented under the government as NADeP.

CIC also engages with partnership programs for maize cultivation and also for dairy industry. They supply inputs for the producers in the value chain, where they promote a buy- back system. (NADeP)

CIC has initiated collaborative program with DOLE Company for production of Cavendish Banana (Trials on, exchanging germ-plasm), which was taken off after five years.

- **Policies and the enabling environment for investment**

Creating a favorable policy environment is considered to be an effective way to promote private investment in agriculture. Considerable attention has been paid to analyze what constitutes an 'enabling environment' and what are the factors that would contribute to its creation. By and large, the provision of an enabling environment lies with the government.

As to the key persons, in Sri Lanka, the government support for research and development for the private sector is at the minimal level. The company itself has faced to some difficulties when the imported machines had tested from the FMRC. The process of certification and testing is too lengthy and time consuming. When another party joins in the buying process, it awaits the customer more and consequently the customer demand will be diminished. Once the FMRC has recommended the machinery is not suitable for using, they must provide some suggestions for modifications. Hayleys once modified a rejected machinery by FMRC and the customer company who purchased that, utilizes the machinery very well and they continued the purchasing process as well. So, it is better if the government and government authorities encourage the private entities by not only evaluating the draw backs, but also giving the instructions and suggestions for modifications too.

Policies and the enabling environment for investment should be strengthen by,

- Ensuring stability and security, including the safeguarding of rights to land and other property, contract enforcement and crime reduction.
- Improving regulations and taxation, both domestically and for international investments.
- Providing infrastructure and financial market institutions; and facilitating labor markets by fostering a skilled workforce, crafting flexible and fair labor regulation and helping workers cope with change.

  India and China, both of these countries, agri machinery is subsidized at the hand of the farmer. This is the case in most of Asian neighbours, such as Vietnam, Philippines etc. The subsidies range from 10% to 30%, and is done so to encourage farming as well as to improve the productivity and the profitability of the farmer.

  Government can well afford to facilitate reduce costs of inputs by removing the added costs on agri machineries and equipments. The first and foremost would be to remove all taxes that are levied on the machineries and implements. The next step would be to introduce agricultural financing, at least through the state banks, in a manner that farmers can access them faster and with less red-tape. Combined, this could bring down existing costs by around 18% to 20%, which is substantial for a farmer.

As the private sector key interviewees mentioned, there is a huge drawback in government on encouraging the usage and the manufacturing or importing of agriculture machinery when comparing with other Asian countries. When comparing with the countries like India, there influence of the government of encouraging manufactures is stronger. When referring to the data of Ministry of Science and Technology, it reveals that before 1962, all most all the tractors have been imported and by 1961/62, 880 tractors were produced. In 1973, all the imports were banned (Engines and pumps also). The imports were important until a capacity for producing them locally was established, and then the imports were severely restricted. Not only banning or restricting the imports, but also more expenditure on research and development on Agricultural Mechanization influenced local manufactures. Patent providing was another measure used in India, for inspiring the investment in private sector and public entities on agricultural mechanization.

Policies aligned with quarantine process in Sri Lanka is merely a constraint in investing, as to CIC in Cavendish banana processing, quarantine restrictions were badly affected, but with the interference of the public authorities, the company was allowed importing, 80 test tubes of in breeds and they were quarantined for a month and released.

➢ **Policies trends and incentives to investment**

The relevant policies for promoting investment are those that drive a wedge between value added as observed and the value added that would otherwise prevail in an undistorted opportunity costs situation with the use of border prices.

These policies include:

- Tariffs and export taxes, trade quotas, price subsidies or taxes on outputs and intermediate inputs, domestic price interventions, credit subsidies or rationing.

As the view to the key persons, the government implications of taxes on imported machinery has a great influence on the investment of private sector in agriculture. Basically tractors and harvesters are free from the VAT. But other products such as

UV polythene, they are entitled with the VAT. There is an identified trend of farmers in the willingness of being mechanized. So, the demand for that willingness should be amplified by the government. If there is a system to encourage farmers for being mechanized like by providing a subsidy as countries like Bangladesh (50% subsidy for rice trans-planters and rice harvesters), and Vietnam, the farmers will be more to likely to use machinery, and ultimately the production and productivity of agriculture will be increased, with the use of the technology.

- High protection to non-agriculture sector and/or selected industries.

- Exchange rate misalignment

Incentives and concessions are fuel factors supplied by the government for the private sector who invests in agriculture field. To foster agricultural industries, a particular number of attractive investment incentive schemes have been granted to investors, by the BOI which is structured to function as a central facilitation point for investors while granting very attractive incentives and various other facilities such as tax holidays or preferential tax rates, exemptions from customs duty and foreign exchange controls. Following chart illustrates an incentive scheme applicable for agriculture for different project activities.

Table 3.2: Project activities eligible for incentives and type of incentive

Project Activity	**Type of Incentives**
• Agriculture • Food Processing • Industrial & Machine Tool Manufacture (eg: Agricultural tools) • Other Designated Enterprises (eg: Rubber products) • Investments in excess of Rs. 500 mn in specified agricultural services	• Tax Rates – 1-3 years : 0 – 4-5 years : 10% – 6th year onwards – Agriculture & Food Processing : 15% – Others : 20% • Duty free imports of capital goods • Duty free imports of raw materials (for export quantities) • State land on 30-50 yrs lease

Source: BOI, Sri Lanka

- **Nature of the market avenue and market segmentation**

  In Sri Lanka, the market size is relatively small compared to fixed cost involved in many investment to undertake. Therefore, these entities undergo different strategies in marketing. These companies target on identifiable group of customers who have unique needs and preferences (niche market). Commonly the private sector entities in Sri Lanka in Agriculture market look forward with seed production, chemical industry and machinery. CIC Agribusiness mostly drives with seed production and agro chemical industry, where Hayleys Agriculture deals with agricultural mechanization specifically.

CHAPTER 4

CROP-SPECIFIC PARTIAL FACTOR PRODUCTIVITY, TOTAL FACTOR PRODUCTIVITY AND DECOMPOSITION OF AGRICULTURAL OUTPUT GROWTH

In the first section of this chapter, crop-wise partial factor productivities viz. land and labor productivity and the Total Factor productivity (TFP) growth have been estimated for rice, maize, chili, big onion, potato and soybean following Tornqvist- Theil index approach of the growth accounting methodology explained in chapter 1. These crops have been analysed within the import substitution framework that growth of these crop sectors is expected to meet the local demand. Growth of these crop sectors have been decomposed into their input growth and TFP growth components. Growths have been converted to growth index parameters by taking, in most instances, 1990 as the base year. Land productivity has been decomposed into growth of factor intensification on land and to TFP growth. Labour productivity determinants i.e. labour use on land and land productivity have also been calculated.

TFPG estimated by Tornqvist- Theil index approach of the Growth Accounting method includes not only the technological progress but also the growth of unmeasured inputs and growth of unmeasured input quality, as illustrated in the conceptual framework. Also TFPG captures the effects of factors such as factor utilization rates, imperfect competition in product markets and non-constant returns to scale.

TFP and partial growth parameters estimated from 1990 to 2017 for the above crops were analyzed against the technology, institutions, markets and the policy and regulatory frameworks, public and private sector investments and international partners' participation in these sectors wherever it is relevant prevailed during the said period in order to to understand the outcome of TFP growth. Taking neighboring countries experiences on the same development process, comparisons were made to highlight the relevant causal factors of their growth performances. Situation in Sri Lanka was compared with that of India, Bangladesh, Vietnam and Thailand.

In the second section of the chapter, technical efficiency and the factor productivity gap between farmers cultivating pineapple, banana, and papaya were analyzed. Factor productivity index calculated here has been approximated as a technical efficiency component of TFP since the analysis has been done on cross section for the year 2019. Technical efficiency varies among farmers due to farmers' level of technical knowledge (a number of agronomic practices in crop establishment), socioeconomic status (education, tenure, and nonfarm income) and accessibility to information and markets. The factors affecting farmers' efficiency of using resources and choosing the existing technology for increasing productivity has been estimated by developing a regression model. For pineapple, stochastic frontier function was also developed. Qualitative assessment on factors affecting productivity was performed for passion fruit crop.

4.1 IMPORT SUBSTITUTING DOMESTIC FOOD CROP SECTOR

4.1.1 Rice/Paddy

Paddy (rice), the staple food crop in Sri Lanka comprises the biggest share in the agricultural GDP (nearly 10% of agricultural GDP). Self-sufficiency in paddy production has been the primary goal in view of increasing food security in the country from its historical time. Wide array of policies were implemented by the successive governments to achieve this goal and has been of success irrespective of its cost effectiveness. Large scale irrigation investments, subsidised fertiliser, investment on research and development, investment on extension and education and paddy purchasing at a guaranteed price are among the main intervention programs implemented throughout in various degrees with huge budgetary allocations and donor assistance.

Increasing production over the last few decades brought the country near self-sufficiency (> 90%) in rice and more than 70 % of self-sufficiency in cereal. Owing to the increased cultivated area, especially the proportionately increasing cultivable area under irrigation with new improved high yielding varieties and fertiliser, a continuous growth of the paddy sector could have been achieved. The growth momentum achieved during 70's in paddy sector became to a standstill during 80's but the growth was regained during 90's on average 2.5% growth rate with fluctuations in production that Sri Lanka reached self-sufficiency except for considerable imports only during bad weathered years (Figure 4.1).

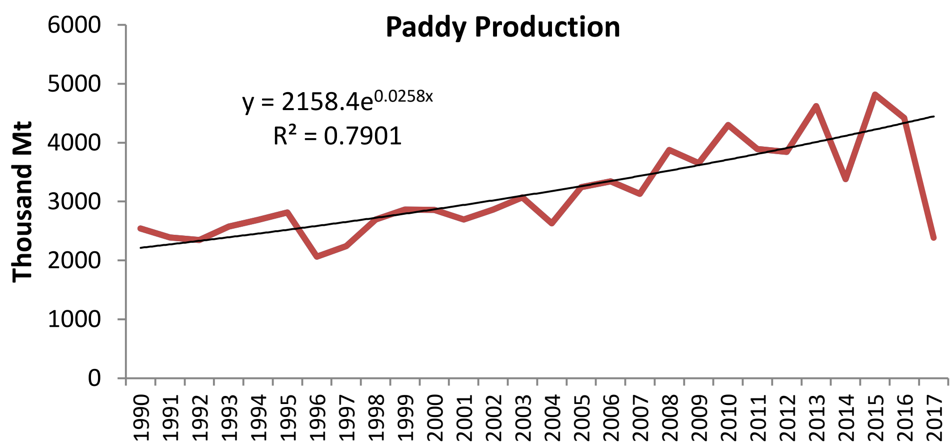


Figure 4.1: Paddy production from 1990 to 2017
Source: Department of Census and Statistics

The investment on irrigation continued that the average irrigated area increased from 230 thousand ha during 90's to 293 thousand ha by 2010-2018, particularly in the dry zone North representing major paddy producing areas. Cultivated extent under paddy increased after the end of civil war in the northern dry zone, mainly rain-fed areas (Figure 4.2 & 4.3). Therefore, maha cultivation increased farmers cultivating with rainfall.

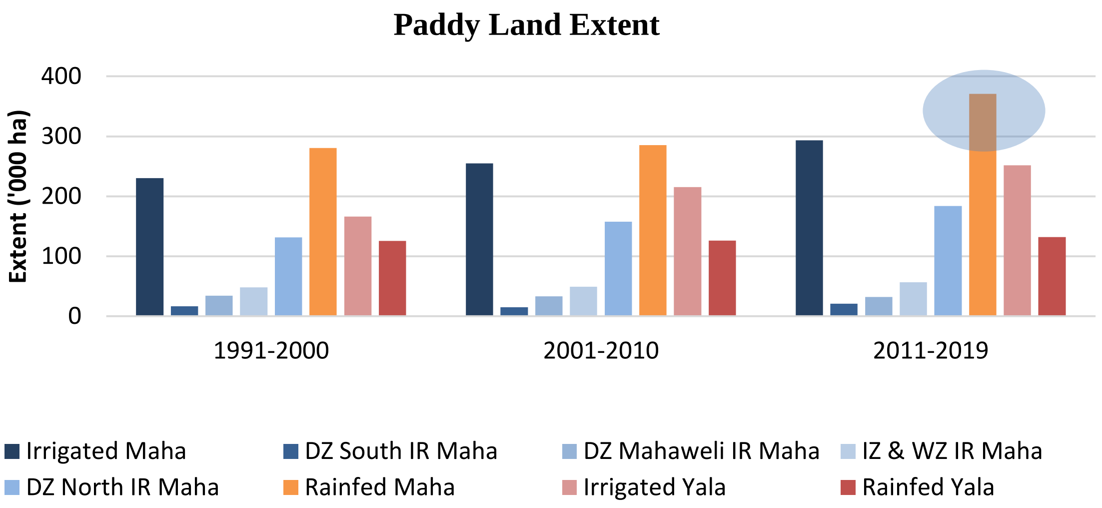


Figure 4.2: Extent cultivated by different agro-ecological zone and season
Source: Department of Census and Statistics

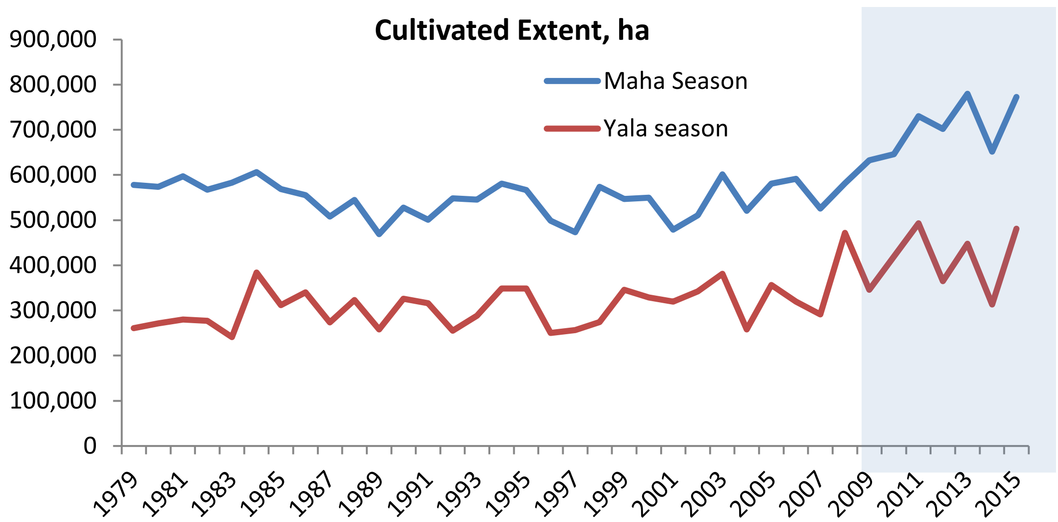


Figure 4.3: Total Cultivated extent of paddy from 1979 to 2017 by season
Source: Department of Census and Statistics

4.1.1.a Productivity

Land productivity

Average paddy yield increased from 2.5 mt/ha to 4.5 mt/ha in the last 35 years registering nearly 1.2 per cent growth during maha season and 0.9 percent growth during yala season (Figure 4.4).

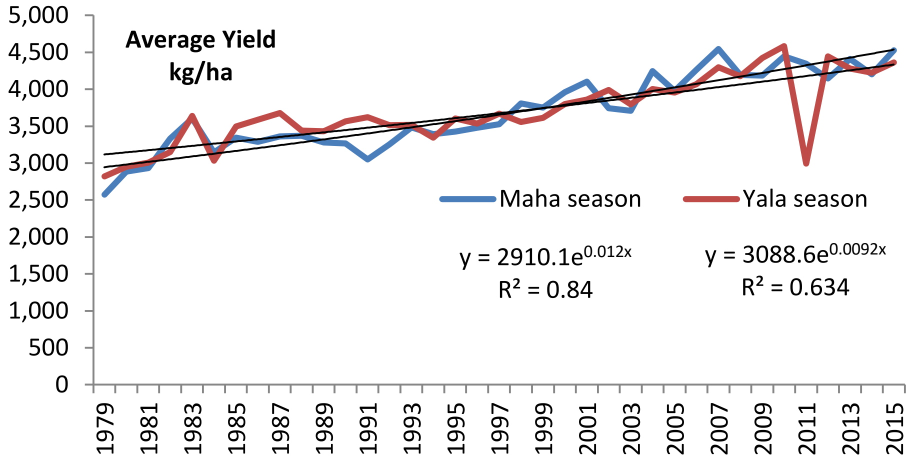


Figure 4.4: Average yield of paddy by season from 1979 to 2016
Source: Department of Census and Statistics

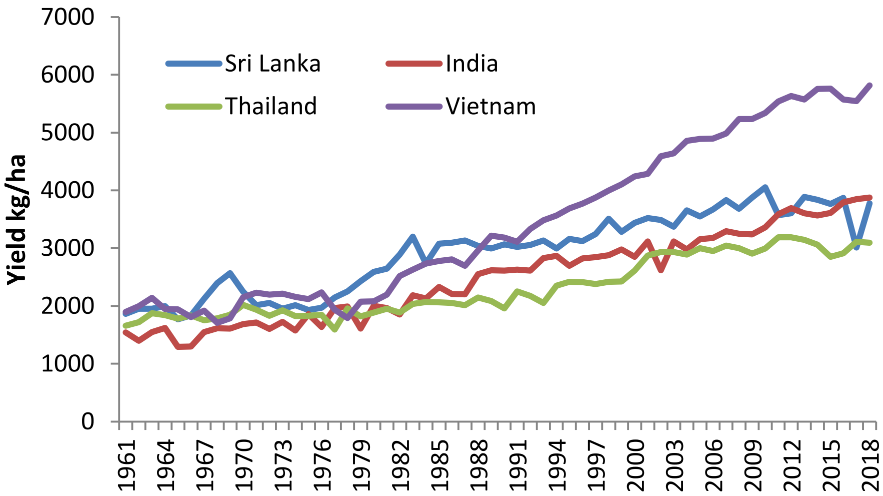


Figure 4.5: Average yield of paddy by neighboring country
Source: FAO

Sri Lanka has achieved a comparable productivity growth within the region and Sri Lankan yield was higher than the main paddy exporter in the world, Thailand. In the beginning of 90's Vietnam rice yield exceeded the Sri Lankan rice yield. Due to the high prominence Viet Nam placed on their Hybrid rice research program which began in 1983, Vietnam was able to bring in more land under Hybrid rice varieties that were released for commercial cultivation.

Labour productivity

Both mechanization and land productivity increases have brought higher labour productivity growth in the paddy sector. From the beginning of 90's, labour use per ha came down with mechanization which began by first with the mechanized land preparation and later with harvesting and processing being mechanized (Figure 4.6).

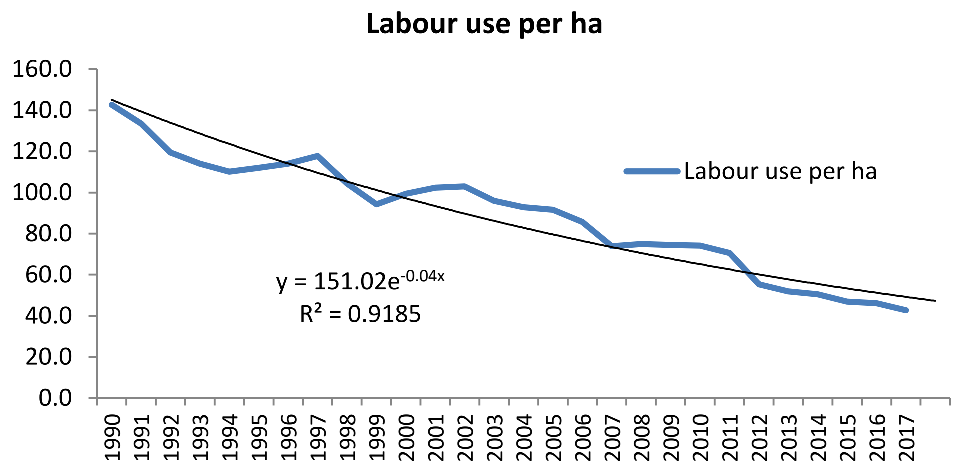


Figure 4.6: Labour use in paddy production from 1990 to 2017
Source: Estimated using cost of cultivation data, DOA

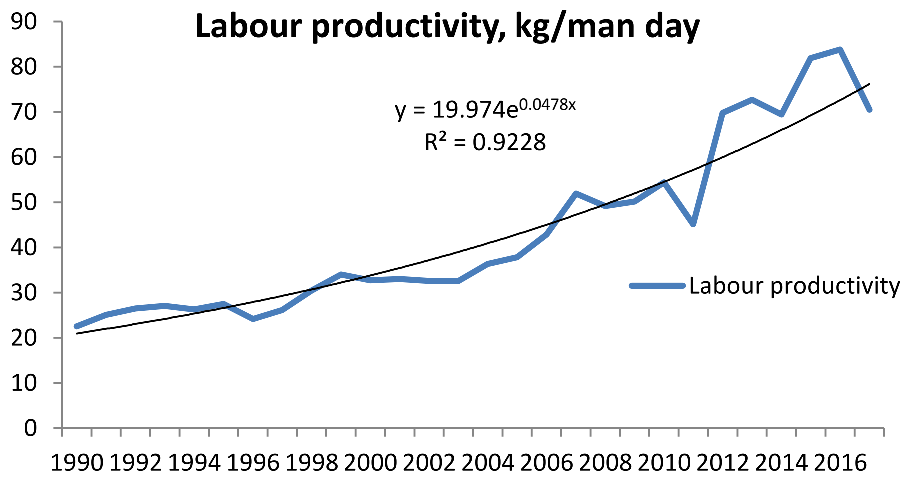


Figure 4.7: Labour productivity of paddy from 1990 to 2017
Source: Estimated using cost of cultivation data, DOA

Early 90's paddy farming operation required 140 man days per ha which is now only 42 man days per ha (Figure 4.6). In the irrigated dry zone labour use is still low that mechanized land preparation, mechanized harvesting and threshing, direct seeding and weedicide application are the common practices that labour requirement per ha is only 13-14 man days.

Labour productivity has been increasing at a compound growth rate of 4.7 percent over last 35 years (Figure 4.7) and in the last few years it shows about 6 percent growth.

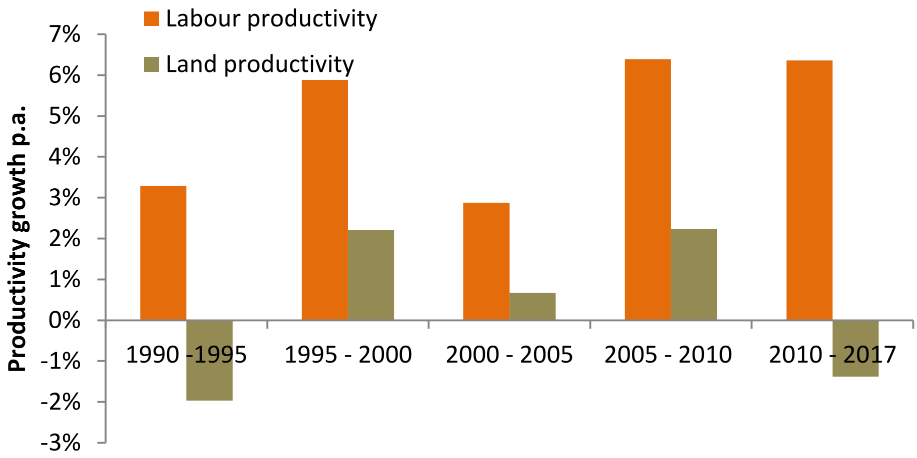
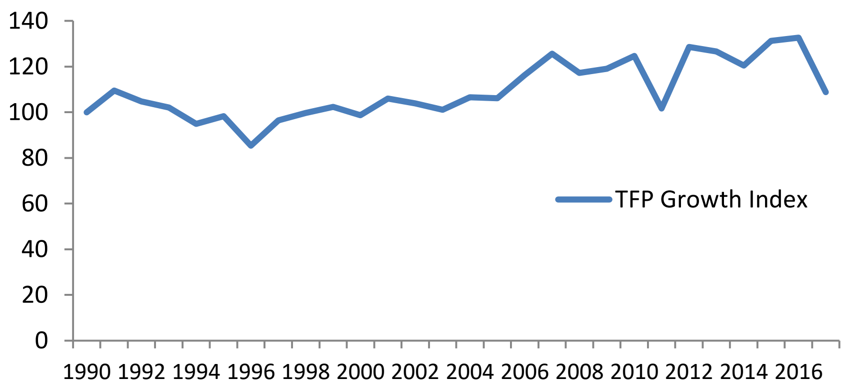


Figure 4.8: Land and labour productivity of paddy
Source: Estimated using cost of cultivation data, DOA and Department of Census and Statistics

Total factor productivity, sources of output growth and determinant of TFP growth

Output growth achieved by factors other than inputs or the total factor productivity is reviewed in this section comparing it with the input growth.



TFP is approximated to TFP growth index and It is calculated by taking year 1990 =100 and percentage TFP growth year to year.

Figure 4.9: TPF growth index of paddy

According to the TFP growth index, total factor productivity had been declining for the period from 1990 to 1996. However after 1996 TFP shows a stable increase except bad weathered years, 2011 flood, 2017.

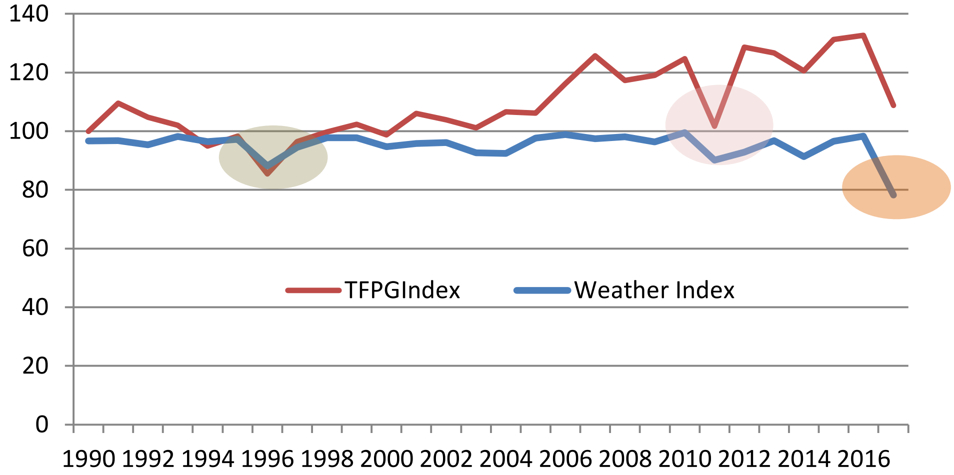


Figure 4.10: TFP growth index and weather index from 1990 to 2017
Note: Weather index is calculated dividing harvested extent by sown extent of paddy

Weather is a factor that affects the Total Factor Productivity. Extremely affected years due to bad weather were excluded in the TFP growth estimation done for different periods to capture other factors that are determinant of TFP growth other than weather.

Decomposition analysis of the paddy output growth is given in table 4.1. The analysis does not cover the period 1980's. Towards late 1990's new improved varieties that had been developed by that time had been almost adopted by the paddy farmers. The main varieties BG 94-1, BG 300, BG 350 were among them. By late 1990's more than 11% paddy extent had been cultivated with BG 352 which was released in 1992. A urea biased policy was implemented during 90's that Irrigation to Fertiliser ratio increased particularly after subsidy was re-established. In 1996, the subsidy on SA was abolished and since 1997, the subsidy was offered only for urea. It is observed from above analysis, during 90's the irrigated area has increased at a rate of 7-8 % while fertilizer use has increased at a rate of 21 % in the second half of the decade, especially urea use.

Total Factor Productivity growth had been negative during early 90's, depicting that other factors other than inputs have not been conducive for productivity improvement and the input use had been efficiently responding to increase output. This is evidenced from the finding of Wickramasinghe et al. (1995) that they had found not only the national rice grain yield is stagnating, but also the grain yields in research fields were gradually declining during this period. The grain yield of rice cultivars grown with high N fertilizer in long term N response studies had showed a declining trend during 90's. They had understood that the reduced nutrient uptake at important growth stages of the rice crop due to reduction in soil nutrient, particularly micro nutrients supply was a major limitation to increased rice yields.

Table 4.1: Decomposition analysis of paddy output growth

	1990-95	1997-00	2000-05	2005-10	2012-17
Land Extent	4.7%	6.0%	1.1%	3.2%	2.9%
Irrigated Area expansion	7.6%	8.1%	1.3%	1.4%	1.2%
Irrigated Land =1.7 * rainfed area	5.4%	6.6%	1.2%	2.7%	2.4%
Labour	-0.6%	0.0%	-1.1%	-1.0%	-1.7%
Fertiliser	**9.1%**	**21.6%**	-1.3%	**-3.8%**	-2.9%
Agro- chemicals (mainly weedicides)	5.9%	11.0%	2.1%	**15.0%**	1.9%
Tractor power	10.8%	14.1%	4.9%	7.8%	7.3%
Seed	4.7%	6.0%	1.1%	3.2%	2.9%
Irrigation Ratio	**2.9%**	**2.0%**	0.2%	-1.7%	-1.7%
Input growth	4.1%	6.8%	0.6%	2.9%	1.9%
Output growth	2.7%	7.9%	1.8%	5.4%	3.2%
TFPG	**-1.4%**	**1.1%**	**1.2%**	**2.5%**	**1.3%**
Share of Input growth on output growth		87%	32%	54%	59%
Share of TFP growth on output growth		13%	68%	46%	41%

Source: study estimates

Increasing fertiliser prices, extension education and introducing Zinc sulphate as a micronutrient source to apply per one season for all the paddy fields in 2001 would have made it efficient fertilizer use in paddy farming. In 1998 on wards DOA implemented the Rice Yaya (tract) Program, a ‘technology package’ consisting of eight mandatory practices that was introduced to all the farmers of an entire Yaya (tract). Adoption of BG 352 and BG 358 also happened during this period. TFP growth during the period from 200-2005 was 1.2% that contributed 68% of the growth of output.

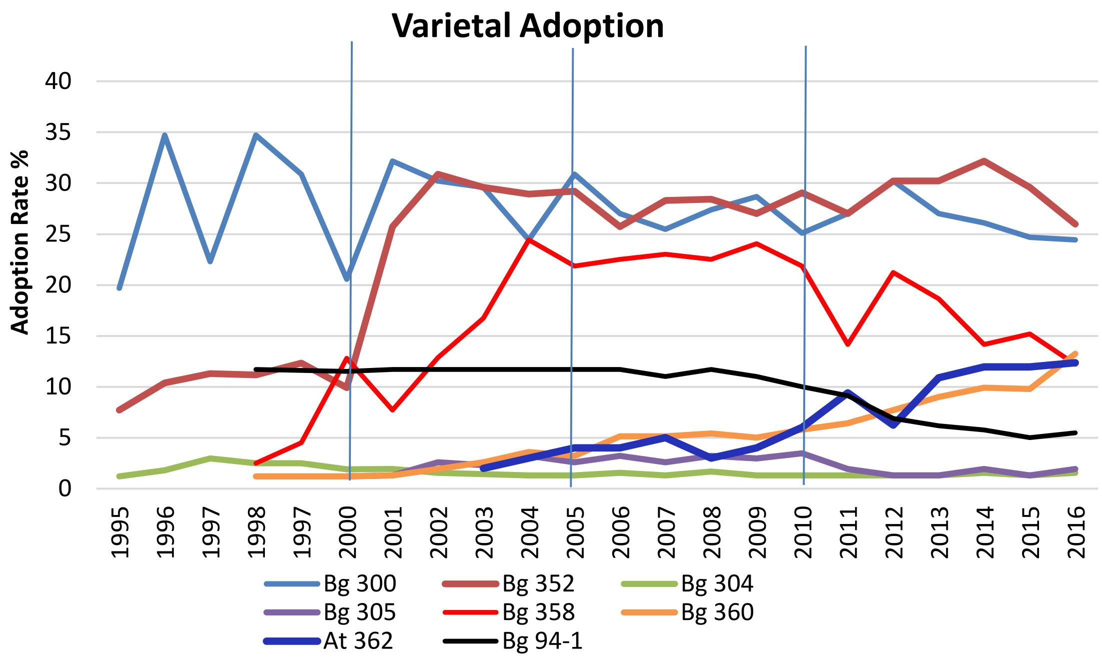


Figure 4.11: Varietal spread of main paddy varieties
Source: DOA

Even though the pest and diseases were problematic for rice cultivation in the early 1970's, with the increase in the usage of improved varieties with required genetic resistance to many biotic stresses and improvement of farmer pest management practices, the requirement of using more agrochemical for pest disease control is minimal. Herath Banda et al. (1998) revealed that weed infestation was the most disastrous constraint to bridge the yield gap between farmer's level and at research potential yield. The period from 2005 to 2010, the use of weedicide became one of the main input embodied technologies that brought yield increments. TFP growth contribution was 46 % during this period. Adoption new varieties At 362 and BG 360 was started during this period (Figure 4.11). Fertiliser use by farmers also brought to the level of DOA recommendation with the new policy implemented after 2005, thereby reduce the total fertliser use in paddy production.

Period after 2010, main varieties that had been in cultivation for more than 30 years have been replaced with two new varieties, At 362 and Bw 367 particularly in major dry zone paddy producing areas (Figure 4.12 &table 4.2). These varieties are very high yielding varieties with more adaptive characters. TFP growth after 2010 can be attributed to these varieties.

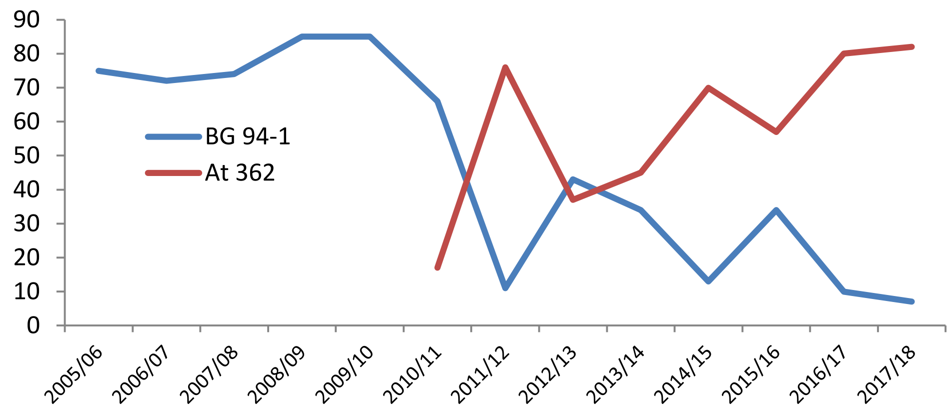


Figure 4.12: Spread of BG 94-1 and At 362 paddy varieties in Ampara East
Source: Cost of cultivation, DOA

Table 4.2: Spread of Variety Bw367

Year	Area	% Reporting
2015/2016 Maha	Kurunegala	18.00
	Polonnaruwa	16.00
2016/2017 Maha	Anhuradhapura	8.00
	Polonnaruwa	14.00
	Mahaweli “H “	10.00
2017/2018 Maha	Kurunegala	6.00
	Polonnaruwa	5.00
	Mahaweli “B “	17.00
	Trincomalee	19.00

Source: Cost of cultivation, DOA

Quality seed production is also contributing to TFP growth. Certified seed paddy production is mainly done by the private seed producers such as private companies, seed producers’ cooperatives, farmer organizations, and individual farmers using the registered seed paddy produced by SPMDC. Registered and certified seed paddy issues have increased as shown in the figure below (figure 4.13). Nevertheless the formal seed paddy production is about only 20% (which varies annually) of the national requirement, while a considerable informal seed paddy production is occurred in the country using the registered and certified seeds.

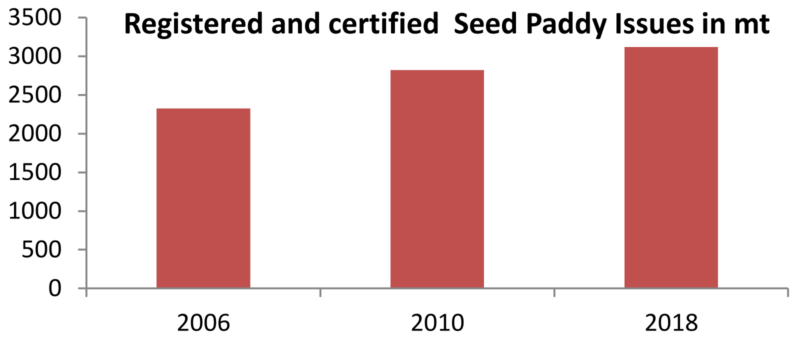


Figure 4.13: Registered and certified seed paddy issues in mt
Source: SPMDC, DOA.

Land productivity, input intensification and TFP growth

The following graphical presentations illustrate the level of input intensification on land and its effect on land productivity and the contribution of TFP on land productivity (figure 4.14). Factor intensification on land is continuously declining in the paddy sector after 1990. Of the main factors increasing land productivity, irrigation ratio is nearly constant during the period of the analysis (figure 4.15). Fertilizer and agrochemicals show a reverse relationship (figure 4.16). With regard to the machinery power and labor use, it shows again a reverse relationship and the cumulative effect is declining factor intensification (figure 4.17). Total factor productivity growth is contributing to the land productivity growth amidst declining factor intensification on land. This phenomenon is common in developed countries in their agriculture development.

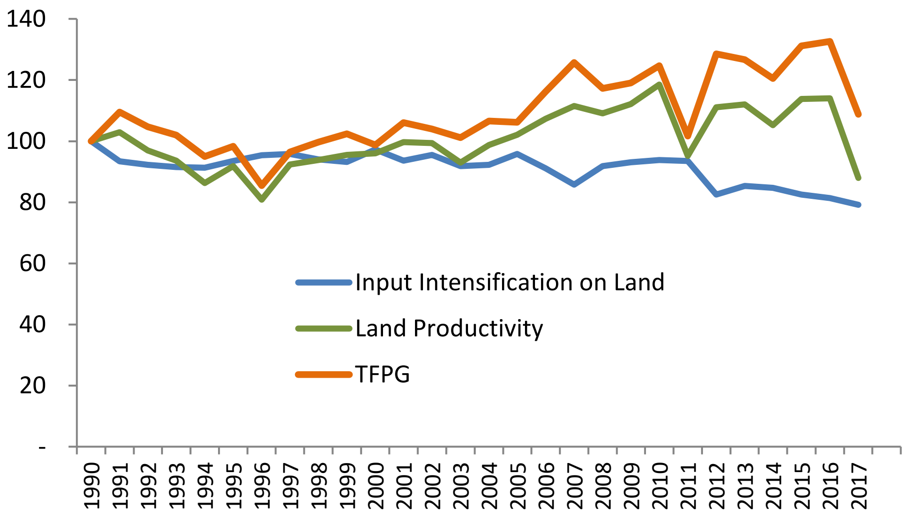


Figure 4.14: Land productivity, input intensification on land and TFP growth of Paddy
Source: Study estimates

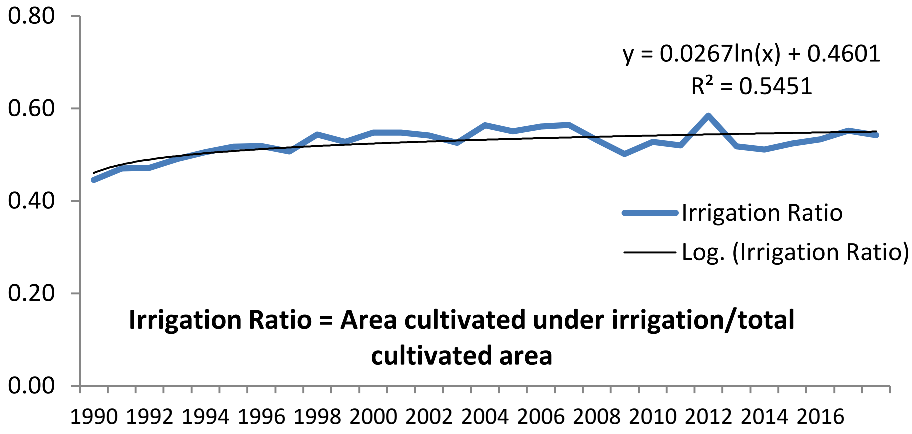


Figure 4.15: Irrigation ratio in paddy cultivation
Source: Department of Census and Statistics

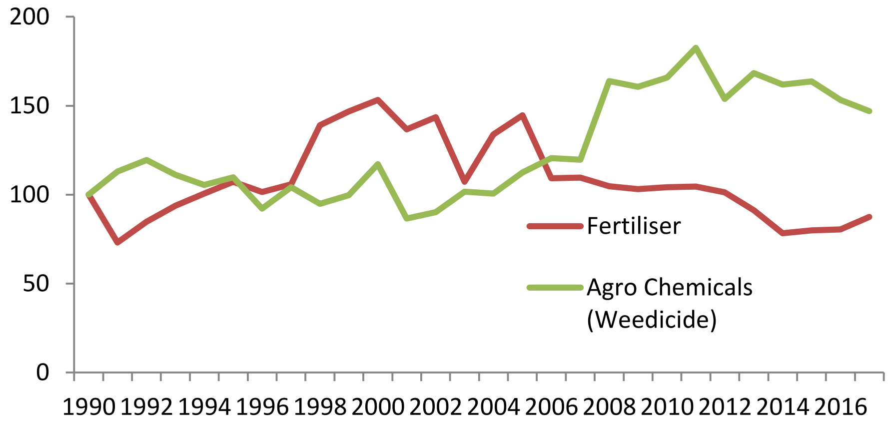


Figure 4.16: Per ha fertilizer and agrochemical use, base year 1990
Source: Study estimates using cost cultivation data

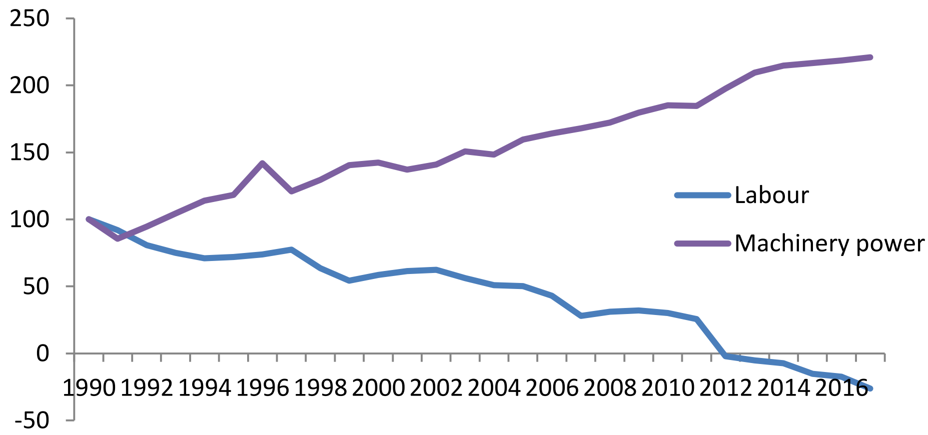


Figure 4.17: Per ha labour and machinery use, base year 1990
Source: Study estimates using cost cultivation data

4.1.1.b Determinants of TFP growth

National rice breeding program in Sri Lanka

The average yield of traditional rice varieties in about 1900 was about 0.65 t/ha (13 bushels/ac) and over the ensuing 100 years, rice scientists have been able to increase it over 7 fold. In fact, there are now rice varieties with potential yields exceeding 11t/ha and the national average yield is now approaching 5t/ha.

In about 1920 initial pure line selection method was taken place, after the phenotypic selection method in rice breeding history. That is selection of individual plants from population of traditional varieties for grain yield and other desirable attributes, and has been found that only 10% of yield increment could be obtained through pure line selection over traditional varieties in Sri Lanka (Pain, 1986). Sri Lanka has released first Old Improved Variety in 1957 keeping a landmark as an earlier country to start hybrid program (Pain, 1986). The first collaborative venture with International Rice Research Institute (IRRI) taken place at the same time in 1960. In 1969 Sri Lanka and IRRI renewed the program and included technology transfer activities. From 1960 to date the International Rice Gene bank holds in trust 2,027 types of rice varieties from Sri Lanka. Similarly aligned with the hybrid program; mass selection, bulk method are some of the key breeding methods followed throughout the breeding programs. The rice researchers soon realized that the quickest way of increasing yield was through application of chemical fertilizer. This was by then practiced elsewhere, particularly in Europe. But in Sri Lankan context, most indigenous varieties were susceptible to lodging and diseases, especially the blast disease, and the susceptibility to both these conditions were aggravated by application of nitrogen fertilizer and some resistant varieties, unfortunately, were not responsive to fertilizer, driven the necessities for breeding new varieties. Such varieties, namely, the H series emerged in the mid1950s with the breeding efforts that commenced in the late 1940s. The H varieties were characterized by resistance to leaf blast and good response to applied chemical fertilizer. However, with heavy fertilizer use even H varieties were susceptible to lodging leading to crop losses and poor milling quality of grain.

Developing lodging resistant varieties was become the major challenge for the rice breeders, but fortunately, a new plant type created in Taiwan around 1960, exemplified by Taichung (Native 1) paved the way. It had short sturdy lodging resistant stems and short, upright, narrow leaves which could efficiently capture sunlight. The IRRI based in the Philippines, experimenting with the new plant type developed the variety IR 8. However, both IR 8 and Taichung Native 1 failed to perform in Sri Lanka due to several reasons. Consequently, a major interdisciplinary rice improvement program was launched with the objective of breeding short statured lodging resistant and fertilizer responsive varieties which were also resistant to diseases. Bacterial leaf blight (BLB) had turned out to be a major disease both here and elsewhere in Asia. A series of new improved varieties (NIVs) were released with the requisite attributes and a yield potential. The new varieties had adequate resistance to BLB, and by 1974 the extent under them increased to over 55% as against the old improved varieties (OIVs, the H series) which were reduced to 24%. Over the years, more and more NIVs began to emerge, a major one being BG 94-1, a 3.5 month variety, which was able to replace even the existing 4 and 4.5 month varieties because of the higher yield potential and the ability to cultivate in both Maha and Yala seasons. The resulting conservation of water and field time was notable. The farmer acceptance of these NIVs continued to steadily increase replacing both the OIVs and the traditional varieties, and prompting breeders to steadily develop more and more dwarf statured varieties with increasingly higher yields.

Although the NIVs had resistance to leaf diseases, they were found to be susceptible to several pests such as brown plant hopper and gall midge. However, our breeders were again able to breed varieties resistant to these pests with the introduction of resistant genes from some Indian varieties. Interestingly, two of the new varieties that emerged, Bg 400-1 and Bg 276-5 also showed resistance to iron toxicity, enabling their introduction to high iron soils in the Wet Zone. In fact, they replaced the low yielding traditional varieties there from.

Until about the late 1980s the rice breeding thrust had essentially been for productivity to achieve self-sufficiency. The breeding scope thereafter broadened also to accommodate other attributes such as grain quality, nutritional value and consumer preference. All the NIVs bread hitherto were, however, white except Bg34-6 which was red but with limited yield potential. However, given the demand for red rice both from the northern and southern regions, a new high yielding variety of red rice, At 16 was developed for cultivation in the high potential areas. In the last two decades, NIVs exceeding 7-8t/ha such as Bg 358, Bg 352, Bg 300 and At 362 which are now the most popular varieties among farmers emerged.

Rice Research Development Institute in Sri Lanka which is the key responsible institute for rice breeding mostly practiced the conventional breeding method for the rice varietal improvement. The process used in this program at present is modified bulk method. Since from the past Sri Lanka has released thousands of improved varieties.).

Breeding programs on obtaining the hybrid vigor is still not a perfect technology. RRDI released the hybrid variety Bg 407-H in 2015 which has a 10 % yield increase compared to high yielding OPVs. However hybrid seed production has limitation due to low F1 yields in seed production. This is how when China first developed their hybrid seeds which they overcame later. FAO, in collaboration with IRRI, Japanese scientists, the China National Hybrid Rice Research and Development Centre (CNHRRDC) and other selected national research centres, initiated its global hybrid rice programme in 1986 to expedite the widespread use of hybrid rice technologies outside China. Sri Lanka's hybrid rice research programme started in the 1980s and by late 90's evaluation of promising CMS lines introduced from IRRI and from other countries and the transfer of cytoplasmic male sterility from IRRI-developed lines to Sri Lankan lines had started (Abeysiriwardena, Abeysekera and Dhanapala, 1997). Constraints such as lack of high performing germplasms, separate hybrid unit are some draw backs for hybrid technology practices in Sri Lanka. When rice breeding research in Sri Lanka is compared with the world, there is a huge gap between technological advancements in the breeding program.

Application of high concentrations of post-emergent broad-spectrum systemic herbicide, glyphosate was prevalently used to control rice weeds in Asian countries including Sri Lanka, which is now officially banned for paddy cultivation. Inducing herbicide resistance (HR) in cultivated rice is a novel approach to enhance selectivity and crop safety. Studies on induced HR in Sri Lankan rice varieties are limited and studies are required to include HR rice in a cropping program

Adoption of Varieties

Popularity of rice varieties is complex. Spatial as well as temporal variation of popularity of rice varieties could be seen. Bg 352, Bg 300, At 362, Bg 358, Bg 94-1, Bg 360 and Bg 358 are the most popular varieties among recommended varieties by DOA. Yield potential and other characteristics are given in table 4.3.

Table 4.3: Yield Potential of main paddy varieties

Variety	Year released	Pedigree	Recommended for	Maturity duration (days)	Higher yield Recorded/ Potential Yield (t/ha)
Bg 94-1	1975	IR 262/Ld 66	GC	105	8.5 /7
BG 300				90	6.5
Bg 350	1986	Bg 94-1///Bg 401-1/80-3717	GC	105	8.5
Bg 352	1992	Bg 380/Bg 367-4	GC	105	7
Bg 358	1996/07	Bg 12-1 / Bg 1492	GC	106	9.5
Bg 360	1999	88-5089/Bg 379-2	WZ	105	7
At 362	2002		GC	105	10
Bw 367	2012				

Source: DOA

Out of them At 362 and Bg 360 showed increasing trends of popularity while Bg 358 and Bg 94-1 showed decreasing trends. However Bg 352, Bg 300 and Bg 358 showed stable trends of popularity while Bg 300 and Bg 352 are the most popular rice varieties in Sri Lanka.

Return to Rice breeding in Sri Lanka

Rice breeding is an unprecedented success story in the annals of research in Sri Lanka on account of highly dedicated rice breeders and other rice scientists that has made the country self-sufficient in rice. Return on investment for the 40-year period, 1959 to 1999 on rice breeding and varietal selection reveals that a 1% increase in research investment increased national rice production by 0.37% (Niranjan, 2004). The benefit cost ratio and the internal rate of return were remarkable, being 2311 and 174% respectively.

According to the results of M.D.T. Dayananda Bg 300, Bg 352 and Bg 358 have higher adoption rate. Bg 360 has medium adaption rate and Bg 304 and Bg 305 has lower adoption. And results revealed that, Bg 358 gives highest IRR within 20 years and it is due to the higher attainable yield and the high adoption rate. Bg 300 is occupied 224% of IRR it resulted because of the high adaption rate. Attainable yield also high in Bg 300 but, it is lower than Bg 358. When comparing Bg 352 and Bg 360, Bg 352 have high adoption rate than the Bg 360. Even though is it is Bg 360 32 resulted 99% IRR while Bg 352 resulted 95%. Bg 300 is “keeri samba” and it fetch higher price than the Bg 352 (Nadu). Because of that, Bg 360 is having high return than Bg 352. Bg 304 has lower adoption rate. Hence, it results low returns. Bg 305 also having low adoption rate. But attainable yield is very high. Because of that Bg 305 resulted 113% IRR.

According to the study done by E.M.G.A.Ilangarathna, NPV, BCR and IRR for conventional breeding, RGA conventional, MAS and hybrid technologies are as follows (Table 4.4).

Table 4.4: Return to Investment by different breeding method

Technology	NPV Rs. billion	IRR	BCR
Conventional breeding	73.53	27%	127.64
Conventional with RGA	97.5	33%	150.61
MAS	18.59	19%	29.94
Hybrid	190.48	39%	249

Source: Ilangaratne, 2019

Highest NPV resulted to the hybrid technology that is Rs. 190.48 billion and the lowest NPV is for MAS, that is Rs.18.59 billion. Compared to conventional with RGA, general conventional method resulted into a lower NPV over time. It relies that hybrid technology bring characteristic incremental gains over other technologies. According to the sensitivity analysis, adoption rate, potential yield and elasticity of demand showed higher sensitivity to the NPV and IRR.

Current rice breeding objectives in Bathalagoda Rice Research Institute

The Institute continues to play a major role in the country's rice sector by releasing new high yielding rice varieties and introducing improved rice production and protection technologies to help farmers realize the yield potentials of the area. The research and development program at RRDI focus on increasing farm productivity from current 4.3 t/ha to 5.0 t/ha within the next 5 years while reducing cost of production and improving grain quality of rice.

In an effort to attain a quantum jump in rice yields, breeding program has been focused to develop varieties with a few tillers, sturdy culm and heavy panicles – a plant architecture designated as the new-plant type. Both traditional varieties and introduced lines from IRRI are used in the breeding program. The hybrid rice research program has been further strengthened.

Current initiatives of IRRI

There are some current initiatives in IRRI. Under three projects, IRRI is helping Sri Lanka develop varieties such as: Green Super Rice, which produces stable yields with less input; Hybrid Rice which produces more yields and is climate resilient; Climate-smart rice, which can withstand the effects of climate change. IRRI is tracking the diffusion of rice varieties across South Asia and aims to generate widely accessible databases on crop improvement. This will allow better understanding of the impact of food-crop genetics research on increasing availability of food for the poor and food-insecure in the region. The Closing Rice Yield Gaps with Reduced Environmental Footprint (CORIGAP) Project is one of several projects by IRRI, which aims to raise the productivity, profitability, and resilience of rice farming systems while ensuring environmental sustainability.

New technology directions to increase land productivity, labour productivity and sustainability

The machine transplanting method of crop establishment which was introduced under Yaya II program launched by DOA and Korea Project on International Agriculture (KOPIA) didn't drive a momentum as farmers didn't take up this technology widely. This transplanting machinery was introduced to reduce weedicide usage, to promote mechanical weeding and to increase the yield. According to a study done in Rajanganaya area, varieties such as BW367, AT362, BG359 and BG370 are found to be better varieties that can adopt machine transplanter in the dry zone. Transplanting is found to be giving more than 10% yield increase and weed free cultivation will increase the yield by 30%.

4.1.1.c Lessons from other countries

Viet Nam Hybrid rice research program

Viet Nam Hybrid rice research began in 1983 with the objective of evaluating CMS lines, identifying respective maintainer and restorer lines; improving F1 seed production; and evaluating hybrid rice varieties developed in China and by IRRI. In the late 1980s, the national hybrid rice programme was placed under the leadership of the Minister of Agriculture and Rural Development. In addition to two FAO TCP projects, the government has provided a budget of about US$300 000 annually. Hybrid rice varieties such as Shanyou 63, Shanyou gui 99, Jinyou 63, Boyou 64, Trang Nong 15 were released for commercial cultivation. The area planted to hybrid rice increased from about 11 000 ha in 1992 to about 102 000 ha in 1996. Progress was also made in F1 seed production. Seed production increased from about 302 kg/ha in 1992 to about 1 751 kg/ha in 1996 (Quach, 2002).

By 2010, the cultivation area of hybrid rice has reached 600,000 ha, gaining an average yield of 6.3 – 6.8 tones per ha, which offers a higher yield of 1.5 tones in comparison with conventional rice cultivated with the same conditions. This contributes to an achievement of annual increase in paddy rice production of 800,000 – 900,000 tons annually. Seed production covers an area of 1,500 – 1,700 ha with an average yield of 2 tones/ha providing a self-supporting of approx. 20% of total seed demand.

Vietnam is further improving the development of Hybrid combinations by solving the problems in relation to science technology for the mass production of quality rice as a rice exporting country. Expansion of private companies, joint venture and cooperation with other countries in the region, encouragement of foreign organisations and individuals in breeding investment & rice hybrid production are prioritized in Vietnam.

4.1.2 Maize

Maize is a C4 crop with a high photosynthetic rate that adaptive to various climatic conditions and uses water efficiently. Maize is grown as a rain-fed upland crop mainly during maha season in Sri Lanka. Its cultivation has now spread in the entire dry zone districts; Badulla, Ampara, Moneragala, Anuradhapura, Kurunegala becoming the most cultivated other field crop in Sri Lanka.

As the poultry industry gained its momentum with the local private sector and the multinational companies venturing into the poultry industry, the demand for maize substantially increased for the making of poultry feed. Imports continued to meet the requirement that import of maize were under liberal trade regime.

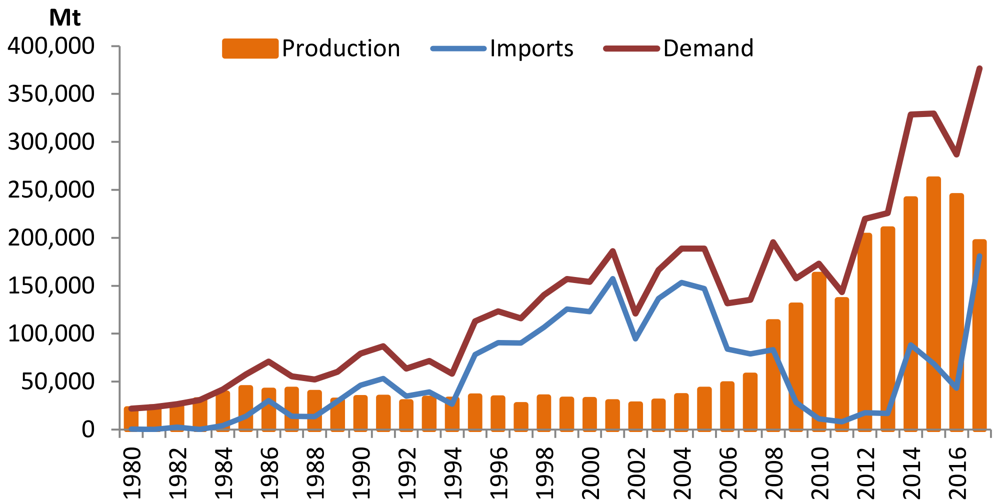


Figure 4.18: Production, Imports and Demand of Maize from 1980 to 2017
Source: Department of Census and Statistics

The first hybrid maize seeds were introduced by Ceylon Agro Industries in 1998 into the country and the company facilitated the farmers to benefit from the 1999 central bank introduced Forward Sale Contract (FSC) program. The main intervention in this sector for the development of maize as a commercial crop was carried out as the RDD of central bank continued the promotion of Forward Sale Contracts (FSCs) among farmers and buyers, for agricultural marketing in the country. Through this programs farmers were supported by the purchasing companies with a package including high quality seeds, fertilizer, farming advice and importantly, and a buy back guarantee for the crop. The RDD promoted this scheme by coordinating the activities undertaken by different stakeholders including PFIs, buyers, farmers, farmer associations and government and non - government organizations throughout the country. Buying companies also provided assistance through facilitating credit to farmers at low interest through banks and crop insurance schemes.

In 2005 a cess was imposed on maize to support the local production. Maize production increased. During 2009, import tax on maize was increased and later, importation was restricted since March 2009 to protect local producers.

Maize is now the second important cereal in terms of cultivation extent and production. Of local production 80-85% goes as a raw material for poultry and cattle feed industry.

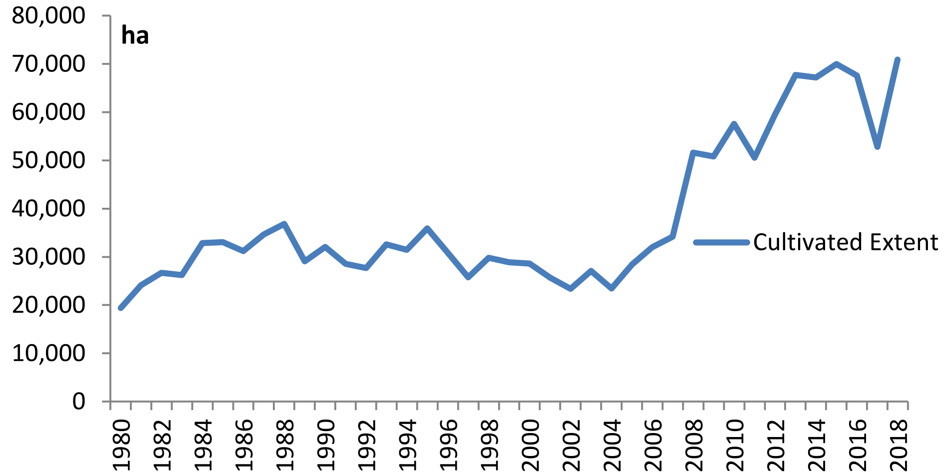


Figure 4.19: Total maize extent cultivated from 1980 to 2018
Source: Department of Census and Statistics

Table 4.5: Maize extent cultivated during maha and yala season by main district

Maha Season

	Ampara	Anuradhapura	Badulla	Kurunegala	Moneragala	Sri Lanka
1980-90	4342	5411	4951	1039	4373	27728
1990-00	5764	7216	4805	857	4354	28508
2000-10	3940	9782	4829	768	6080	29816
2010-18	4441	19571	4573	1225	19231	53509

Yala season

	Anuradhapura	Badulla	Sri Lanka
1980-90	160	245	1931
1990-00	144	231	1713
2000-10	493	1747	4995
2010-18	1340	4002	9127

Source: Department of Census and Statistics

4.1.2.a Productivity

Land productivity

Average maize yield increased from 1000 kg/ha to nearly 4000 kg/ha in the last 18 years registering nearly 8 per cent growth of national average yield (Figure 4.20). Sri Lankan maize yield is now comparable with the maize yield of countries in the region except Bangladesh. Country benefited from international technology transfers from its first introduction of hybrid maize variety by Ceylon Agro Industries in 1998. Bangladesh has achieved an unprecedented growth in maize yields in this region owing to the policies adopted by Bangladesh (Figure 4.21). A detail account of Bangladeshi's achievement in maize production is given later in this section.

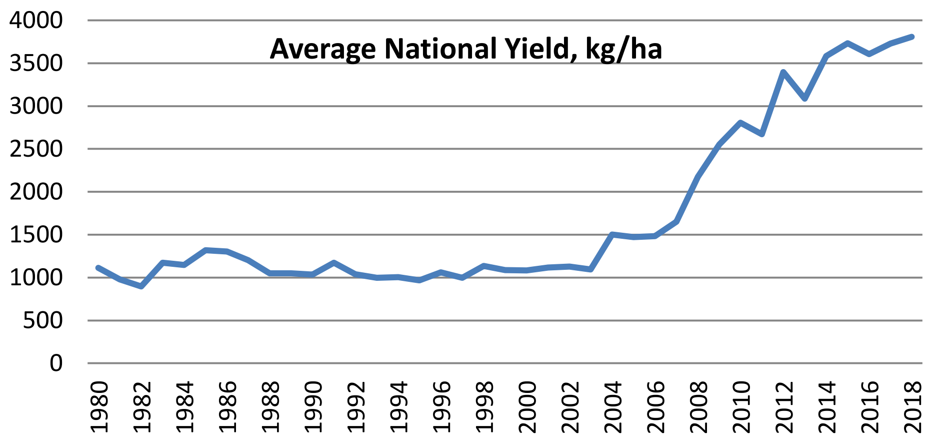


Figure 4.20: National average yield of Maize, 1980 to 2018
Source: Department of Census and Statistics

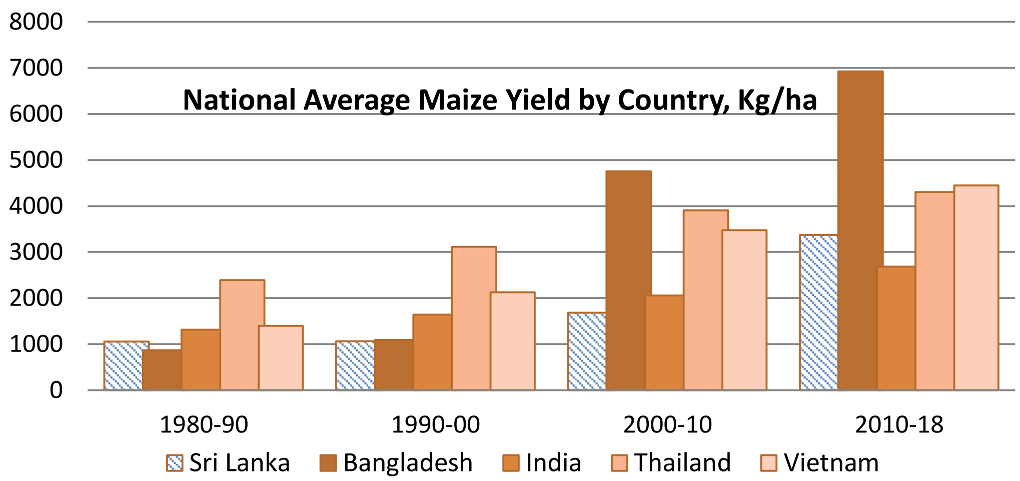


Figure 4.21: National Average Yield by country
Source: FAO

Labour productivity

Labour use in maize cultivation gradually declined as with land preparation and threshing being mechanized over the years. Labour use in different states in India for maize cultivation is more or less similar to Sri Lanka (table 4.6).

Table 4.6: Per ha Labour use in maize farming by country and states of India

	2004/05	2006/07	2014/15	2015/16
India				
Andhra Pradesh	81.3	77.0	67.2	59.4
Karnataka	69.3	69.5	63.6	64.6
Rajasthan	68.0	72.9	66.7	77.3
Bangladesh			123.5	
Sri Lanka	97.6	98.8	64.2	70.0

Source: Indian Ministry of Agriculture and Farmers welfare, Bangladeshi Ministry of Planning (2015), Study estimates for Sri Lanka

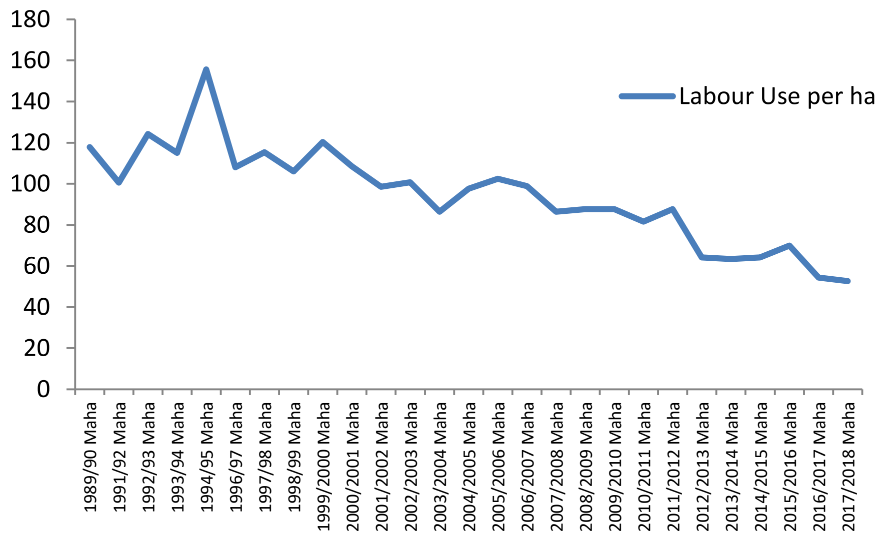


Figure 4.22: Labour use in maize production from 1990 to 2018
Source: Study estimates

Bangladesh labor use is still high that labour productivity in maize farming in Sri Lanka and Bangladesh has converged (Table 4.6 & Figure 4.23).

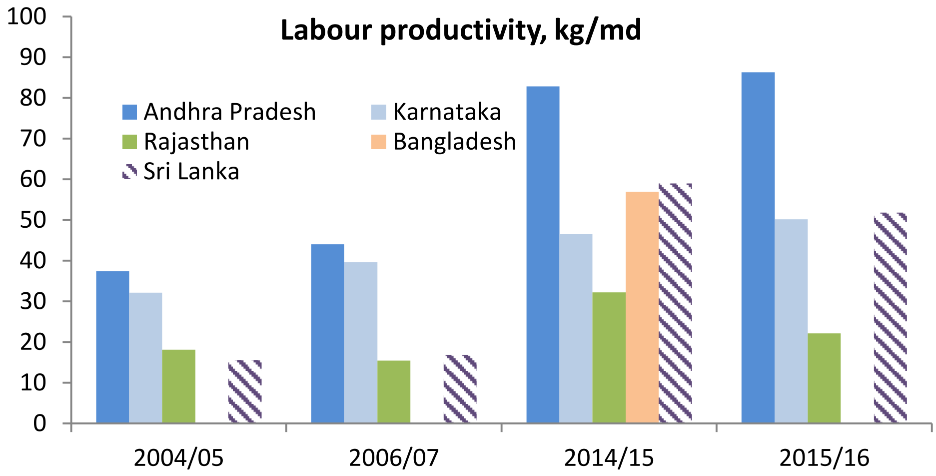


Figure 4.23: Labour productivity of maize by country and state of India

Source: Indian Ministry of Agriculture and Farmers welfare, Bangladeshi Ministry of Planning (2015), Study estimates for Sri Lanka

Total factor productivity

Commercializing of maize cultivation which began as the introduction of hybrid varieties in 1998 moving from subsistence farming to adopting improved management practices brought a complete change in maize production in terms of extent and productivity of maize farming in Sri Lanka.

Table 4.7: Input growth per annum by type of input in maize farming

Input growth p.a

	Land Extent	Fertiliser	Labour	Seed	Machinery for land preparation	Machinery power for threshing	Chemicals and other
1991-2000	-1%		-1%	-2%			
2000-2005	2%	25%	1%	3%			45%
2005-2010	12%	12%	8%	-8%	20%	17%	7%
2010-2018	3%	5%	-3%	4%	4%	4%	3%

Source: Study estimates

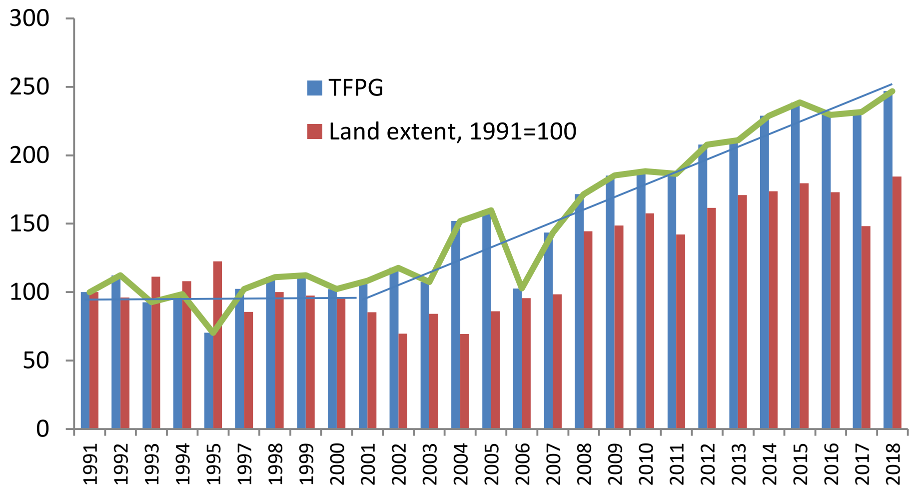


Figure 4.24: Land extent and TFP growth index, base year 1991
Source: Study estimates

Fertiliser and pesticide use became two of the important crop management practices at the early adoption of hybrid varieties. Input use increased at a rate of 7.2% during 2000- 2005 (Table 4.7). Highest TFP growth of nearly 14% was observed with the introduction of new varieties. However, TFP growth has been becoming more significant that its share in output growth has increased to 86 % during the period after 2010 as input growth declined (Figure4.24 & Table 4.8).

Table 4.8.a: Input, TFP and output growth of maize farming and its shares

	Output growth	Input growth	TFPG	Share of Input Growth on Output growth	Share of TFPG on Output growth
1991-2000	-1.0%	-1.0%	0.1%		
2000-2005	10.3%	7.2%	3.1%	70%	30%
2005-2010	23.2%	9.6%	**13.6%**	41%	59%
2010-2018	7.7%	1.1%	6.6%	14%	86%

Source: Study estimates

While Bangladesh has several locally developed hybrid varieties for commercial cultivation, hybrid varieties developed by the multinational company to the brand name Pacific are also cultivated that are also cultivated in Sri Lanka

- Bangladesh - PAC 339, PAC 999s, PAC 224, PAC 293, PAC 984, PAC 022, PAC 559
- Sri Lanka - PAC 339, PAC 999s, PAC 293, PAC 984

In Bangladesh, 100% of maize germplasm has been introduced through multilateral agreement with CIMMYT. Therefore, maize breeding is largely dependent on international cooperation and assistance.

4.1.2.b Determinant of TFP growth

Contract farming and out-grower schemes in Maize Production in Sri Lanka

The introduction of hybrid maize seeds to Sri Lanka in 1998 was an excessive turn on in the maize cultivation industry. With the poor performance of stabilization schemes, policy-makers began to pay more interest on market-based solutions for dealing with market uncertainty. Then, the contract farming (CF) was recognized as a mean to reduce risks related to price and quality and as a way to reduce coordination costs within the food supply chain. In addition, CF is considered as a risk transferring mechanism, which enables small scale farmers to transfer market risks to global agribusiness firms. Therefore, contract farming can possibly be considered as both risk reduction and risk transfer strategy, with reference to agriculture sector. Contract farming and out-grower schemes are an important component of many current public-private partnerships (PPPs) in developing countries

A forward sales contract (FSC) is an agreement between the seller and buyer to deliver a specified quantity of a commodity to the buyer at some time in the future for a specified price or in accordance with a specified pricing formula. A forward contract can be either extended to contract farming system by delivering inputs and extension service or confined to forward contract as it is.

As an alternative to the conventional government intervention in agricultural marketing, the Central Bank of Sri Lanka (CBSL), introduced FSCs under the '*Govi Sahanaya'* purchasing/pledge loan scheme in 1999. The Regional Development Department (RDD) is the apex agency to regulate these development credit schemes, under CBSL. The CBSL had allocated Rs. 2650 million for farmers and Rs. 6500 million for buyers per year, under the pledge loan scheme. The private companies such as *Plenty Foods Ltd*, *KST Company Ltd* and *Ceylon Agro Industries* were the pioneers who joined the program. After completion of ten year's direct involvement in 2009 by the CBSL, the system was left to its own operation, without further involvement of the CBSL. Since then, FSCs between farmers and buyers have altered to different forms and shapes and a few have developed to CF System.

Under Out Grower (OG) farming system, implemented by Ceylon Agro Industries, OG farmers and OG firms enter into a signed agreement where the OG firm agreed to buy-back the harvest at the right quality range at the agreed price-range and farmers to supply their entire harvest from OG farming operation only to the OG firm. Further, OG farmers were facilitated by a bank to obtain credit up to 30,000.00 LKR per acre which was channeled to the OG firm to provide on-time supply of basic inputs: hybrid seeds, crop protection chemicals and fertilizer along with agricultural extension services throughout the season and the insurance company for an insurance premium.

Mode of operation of contractual system

As to the literature, 89% of the cultivation in 2012 (by extent) was done in Maha season in upland, utilizing the rainfall. In these areas, contacted farmers were grouped into seventy to eighty member clusters and a leader farmer had been appointed for each cluster.

Improved technology of cultivation is being supplied to the farmers in the form of regular field visits conducted by a trained field officer. All the inputs (seeds, fertilizer and agro chemical) were distributed through leader farmers at the onset of the cultivation season.

Before the distribution of inputs, farmers had to sign the contractual agreement for the upcoming season, which included the detail of expected quality, quantity, price and date of the delivery. At the next step, farmers were required to pay a price advance (approximately 75% of the value of the inputs) to obtain the necessary inputs. Farmers were provided with on-call extension service, whenever necessary. During the harvesting, famers were provided with tarpaulin canvas to lessen the accumulation of moisture level during post-harvest handling. Farmers had to transport the product from their own fields to a temporary storage center, normally established at leader famer's premises. At the storage center, samples were tested for quality standards and payments were credited to the bank accounts of individual farmers within five working days. It is revealed that, full-time farmers who have higher proportion of agricultural income, higher agricultural land holdings as well as agricultural experience and family labor participation were more prominent in adopting contract farming system. Besides that, the interaction of package of services provided by the buyers, such as input and extension had positively and significantly affected the productivity (yield/ha) achieved by the contract farmers. Further, contract farmers have been able to fetch a higher price than the open market price, in most of the instances.

4.1.2.c Lessons from other countries

Convergence of Sri Lankan yield within Asia and hybrid development breeding program

In 1950s, he Department of Agriculture, Sri Lanka, attempted to develop maize hybrids but it did not gain grounds, because the private sector had not been developed at that time to take over hybrid seed production as seen in many maize- growing countries such as

United States of America. In addition, there was no demand for such high cost seed s from the subsistence farmers who preserved their own seed requirements after each crop. Demonstrations organized by the private sector and the Department of Agriculture in farmers' fields to introduce hybrids with improved cultivation practices paid rich dividends, creating a new interest among farmers on hybrid maize cultivation.

Attempts to improve the yield of open-pollinated corn were mostly disappointing. While it was possible to develop many different varieties, or to change the characteristic appearance of a variety by visual selection for special features, little progress was made in raising inherent yielding ability of a well- established variety. A field of open- pollinated corn is composed of both high- and low –yielding plants. The high- yielding plants result from favorable gene combinations; but the same favorable gene combinations are not always reproduced in the progenies of the high yielding plants since the plants are fertilized by pollen produced on both good and poor plants, all of which are highly heterozygous. This research program attempted to develop hybrids of intermediate maturity, with high yield and quality, to replace exotic hybrids of which seeds are very costly.

In 1998, a program was initiated to meet the requirement of developing hybrids locally by introducing inbred lines released by the International Maize and Wheat Improvement Center (CIMMYT) in Mexico, and Thailand, to develop hybrid maize varieties locally. Initial program was solely dependent upon exotic inbred lines in which over 160 different hybrids were developed between them, which were evaluated for yield and other desirable grain characters. Among the patent lines, there are six lines selected for Quality Protein Maize (QPM), which contain high percentage of lysine and tryptophan and four lines selected for drought resistance. In addition, there are two lines for multiple disease resistance, four lines for developing hybrids for using as local checks and twenty- three lines for general yield. Hybrids were developed to combine these characters into their progenies. Simultaneously a program was launched to develop inbred lines locally after deliberate selection of source materials, to give rise to high heterotic progenies. High heterosis, uniformity, tolerance to stress grain yield and quality were given attention in hybrid development. Of the 56 lines generated, first hybrids that were developed as early generation hybrids, were evaluated during Maha 2000/2001.

The maize is given as the first priority crop under other field crops in research and development programs at Field Crops Research and Development Institute of DoA. The several OPVs and hybrids were developed in the country in collaboration with CIMMYT during last 40 years. Farmers are demanding hybrid maize seeds and 95% of maize area is under hybrid maize. The 95% of the total hybrid seed requirement is met by imported high yielding hybrids. Hence national average productivity has increased up to 3.6 t/ha.

The main drawback is sustaining the productivity in maize lands due to land degradation and other abiotic and biotic stresses.

The current maize hybrid development breeding program is set to develop and introduce Maize hybrids having a yield potential of 8-9 t/ha under favorable ecosystems and desirable plant characters (erect leaves and strong stem) and ear characters (compete husk cover and grain filling up to tip). Further, development of Maize hybrids and parental lines for moisture stressed ecosystems is carried out under the program

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Philippines takes lead in approving / commercializing Bt maize and Glyphosate tolerant maize

4.1.3 Chilli

Chilli is one of the important cash crops grown in the country. It was traditionally a Chena crop that occupied large tracks (about 5 acre per farmer) in the dry zone Chena and was cultivated with maha rains. Cultivation during Yala takes place with supplementary irrigation. Part of the demand was met with imports from India. During the 1970-1977 closed economy period, chilli was promoted as import substituting crop and the imports were restricted. Extent cultivated sharply increased (Figure 4.25). However, legal restrictions on Chena cultivation and irrigation development in the dry zone dropped the extent under maha cultivation from its peak recorded in 1977. Chilli continued to be a protected crop even under the open market economic policies introduced in 1977 by limiting the government monopoly imports only to off seasons. During 1980's to the beginning of 1990's there was a clear shift of chillie cultivation to irrigated rice fields particularly under Mahaweli H. Expansion of cultivation in Mahaweli H increased crop yields and higher total production. By 80's farmers had adopted the variety MI 2 (variety released by the DOA in 1973) that gave a higher yield than MI 1. Chillie production recorded the highest in the country in 1986 & 1990 which was amounted to 106 thousand mt. A Floor Price Scheme was also implemented by the government for dry chillie purchases.

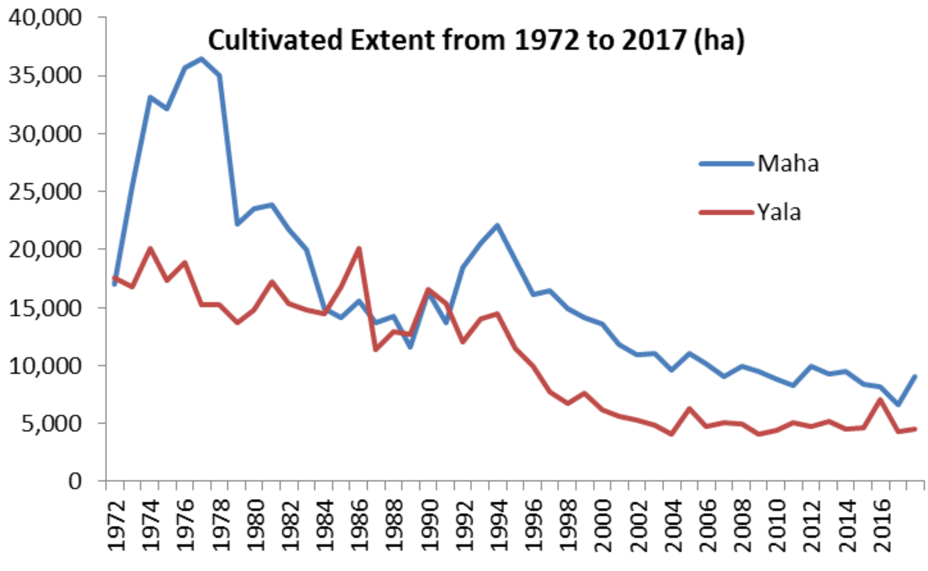


Figure 4.25: Cultivated extent of Chilli during Maha and Yala seasons, 1972-2017
Source: Department of Census and Statistics

Liberalization policies implemented on the import substitution crop sector after 1992 affected the dry chilli production in the country significantly. In 1992, imports were handed over to the private sector subject to quota and licenses. In 1994 imports of chilli were completely liberalized. Immediately after liberalizing, bulk quantities of dry chilli were imported by the private sector that badly affected the farm gate price. In 1996 the government removed the existing 35% duty on imported chilli which resulted imported chilli from India flooded the market at a very low price. Farmers couldn't compete with the price of imported dried chilli arriving from India. Subsequently the dry chilli production drastically declined and the chilli cultivation mainly took place for green chilli production.

Currently maha cultivation takes place in dry uplands 'Goda hena" mainly in Anuradhapura (44%), Moneragala (18%). In Kalpitiya Peninsula chilli is cultivated in both maha and yala seasons with supplementary irrigation. Close proximity to Marketing infrastructure at in Norochcholai Dedicated Economic is an advantage for chilli farmers in Kalpitiya.

Total green chilli production in 2018 amounted to 60,600 mt from both seasons (Figure 4.26). Only less than half of the green chilli goes for annual dry chilli production which is about 7,500 Mt. Therefore imports have increased sharply to meet the annual chilli demand (Figure 4.27). In 2016, country imported 51,040 tons of chilli amounting to 92,534 thousand US Dollars (92 million US Dollars) from India. Sri Lanka is a main export destination for Indian dry chilli exports (15- 18% of dry chilli exports of India to Sri Lanka) and relatively lower FOB price is maintained.

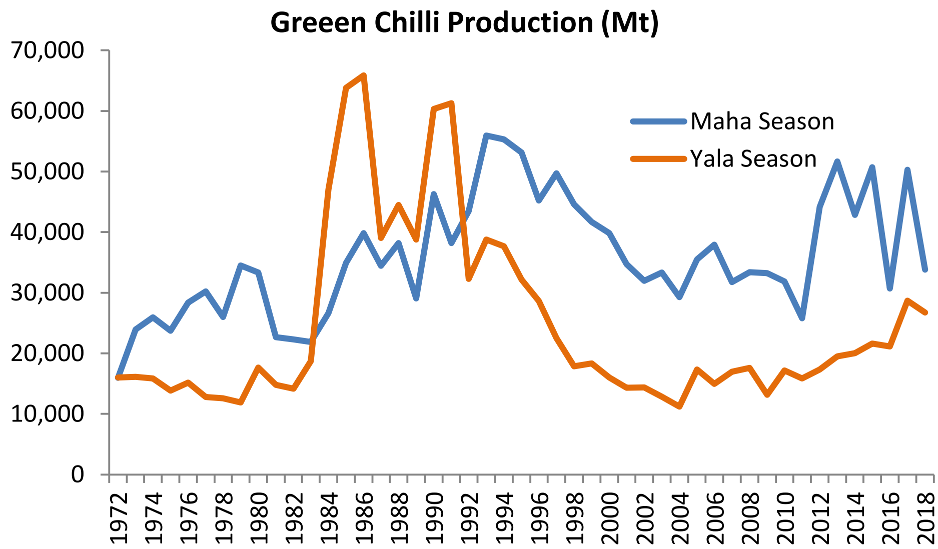


Figure 4.26: Green Chilli Production during Maha and Yala seasons, 1972 -2018
Source: Department of Census and Statistics

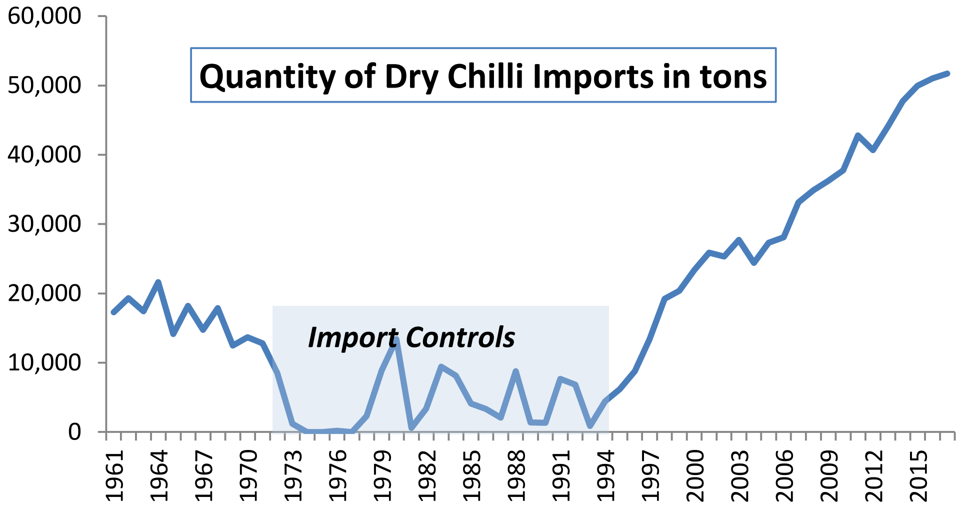


Figure 4.27: Quantity of dry chilli imports, 1961 - 2017
Source: FAO

The most recent government intervention program to develop the chilli sector is under the National food production programme 2016 – 2018. The objective of this programme is to reduce the import of dry chilli and the country to become self-sufficient in green chili. In 2016, a number of 622 agro-wells, 1008 water pumps, 495 micro irrigation kits(1/4, ½ acre), 34 power sprayers, 15 Chilli Grinding machines, 51 rain shelters, 12,500 nursery trays, 10 chilli village, 85 tarpaulin covers were provided and media programmes were held. A sum of Rs.116.9 million was expended for this program through the Ministry of Agriculture.

4.1.3.a Productivity

Land productivity

Sri Lanka national average yield of chilli is comparatively low when the national average chilli (green chilli) yield with the countries in the region is compared. India is the world leader in chilli production followed by China, Thailand and Pakistan.

Table 4.8.b: Average productivity of chilli in countries in the region, 2010-2018

	Green Chilli (mt/ha)	Dried Chilli (mt/ha)
India	8.44	1.94
Thailand	13.5	2.89
Vietnam	NA	1.45
Bangladesh	NA	1.32
Sri Lanka	4.5	

Source: FAO

The first yield shift is observed with the introduction of chili as a cash crop from Chena into Mahaweli areas with supplementary irrigation (figure 4.28). The variety MI 2 was promoted during this period. The potential yield of DOA released varieties is given in table below. Again after 2009, yield trend is observed with the introduction of series of new high yielding varieties by DOA.

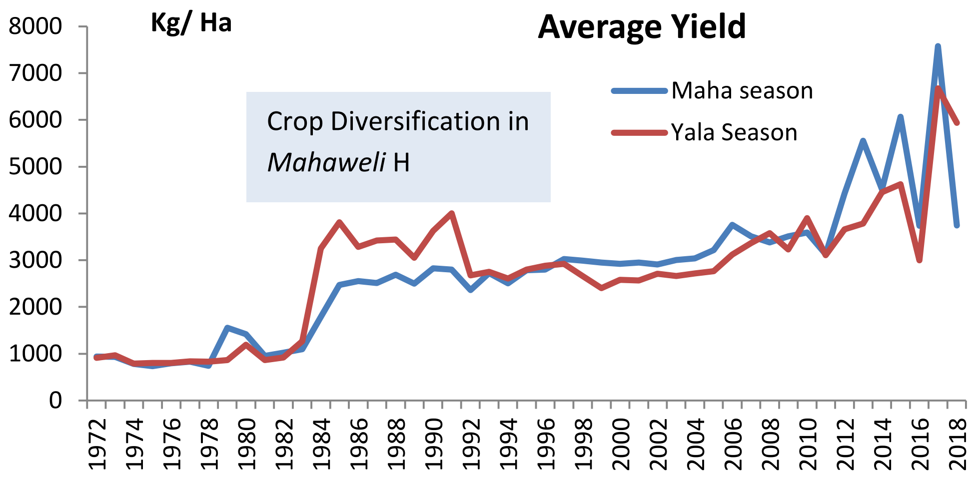


Figure 4.28: Green chilli average yield 1972 - 2018
Source: Department of Census and Statistics

Labour productivity

Since the maha cultivation takes place in dry uplands 'Goda hena" mainly in Anuradhapura and Moneragala, both labour and machinery power are not abundantly used for land preparation and crop management (Figure 4.29). Therefore per ha labour use in maha season is relatively less than yala season (Figure 4.30). During yala cultivation pump irrigation is practiced that require machinery power.

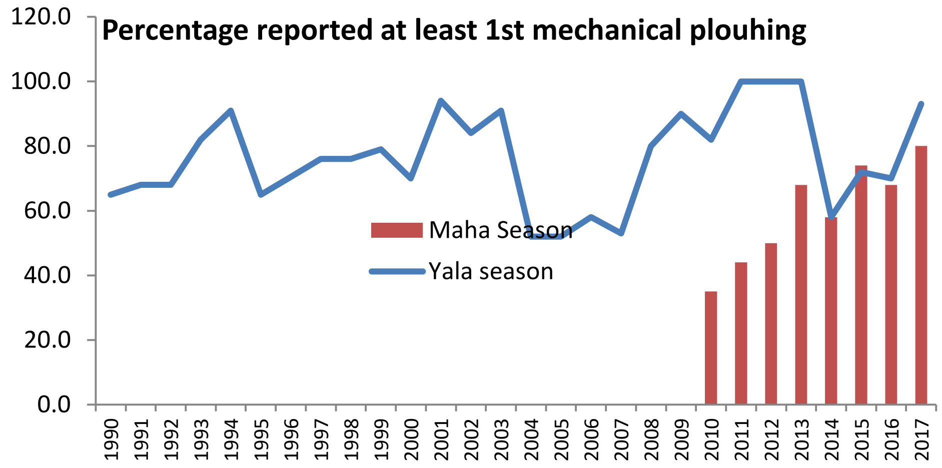


Figure 4.29: Percentage of chilli farmers reported mechanical ploughing
Source: Study estimates

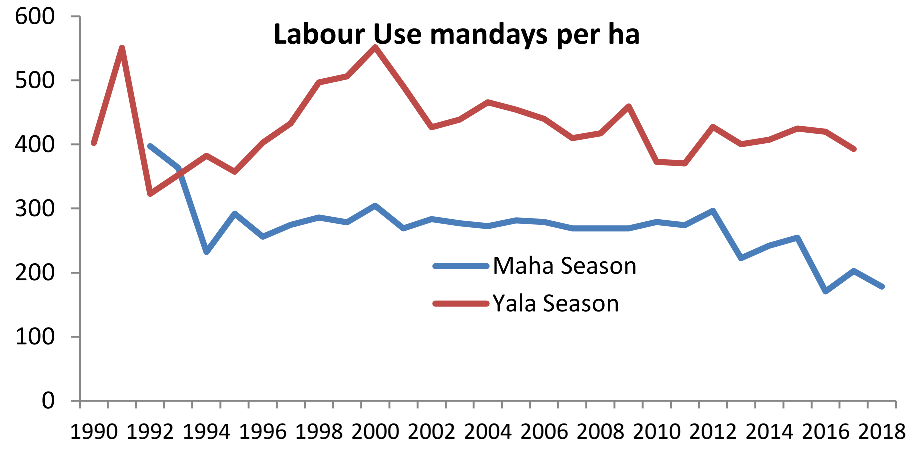


Figure 4.30: Per ha labour use in chillie cultivation during maha and yala seasons
Source: Study estimates

Table 4.9: Per ha labour use for chilli cultivation, 2012

Country/State	Mandays/ha
Maharashtra, India	md/ha
Small Farms	425
medium Farms	434
Large Farms	451
Sri Lanka	
Maha season	296
Yala Season	427

Source: Jagtap et al, 2012, study estimates for Sri Lanka

Per ha labour use for chilli cultivation in some states in India is similar to Sri Lanka (Table 4.9). However, Indian labour productivity is higher than that of Sri Lanka as chilli land productivity in India is higher than Sri Lanka.

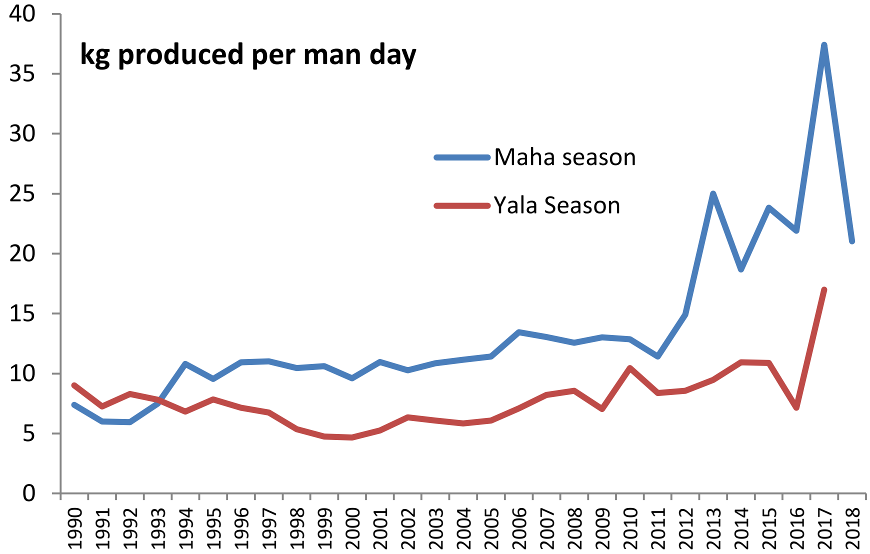


Figure 4.31: Labour productivity of green chilli by season
Source: Study estimates

Total factor productivity

TFPG index constructed for maha chilli cultivated is given in the figure below (Figure 4.32) for the 1990-2017 period. Growth of TFP is observed throughout the period with a sharp increase after 2010/11.

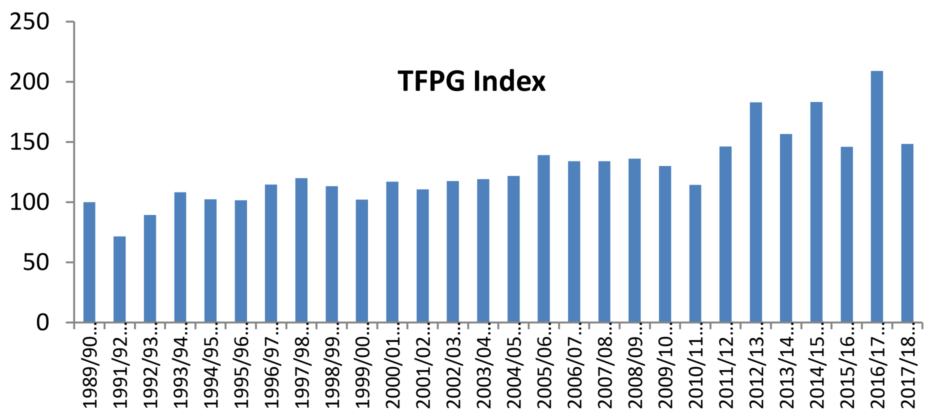


Figure 4.32: TFP growth Index for chilli farming, base year 1990.
Source: Study estimates

Highest TFP growth is observed during the period from 2010 to 2015 (Table 4.10), when new improved high yielding varieties started to release from the FCRDI of DOA. The years 2016 & 2017 were badly hit due to drought.

Table 4.10: Decomposition of output growth of chillie*

	Land expansion growth	Land productivity growth	Land intensification growth	TFPG
1990-1995	4.9%	0.3%	-3.8%	4.1%
1995-2000	-6.2%	1.1%	0.8%	0.3%
2000-2005	-4.7%	1.7%	-1.5%	3.2%
2005-2010	-3.4%	0.9%	-0.1%	1.0%
2010-2015	0.2%	11.3%	-1.3%	12.6%
2015-2018	0.2%	-7.4%	1.1%	-8.5%

**Output growth = Land expansion growth +Land productivity growth*
Land productivity growth = Land Intensification growth +TFP growth
Source: Study estimates

The outputs of varietal development program, combined quality seed production program of DOA and private sector (CIC) and the expansion of cultivation in Kalpitiya belt with supplementary irrigation are main factors can be explained for the TFP growth over the period based on few factors.

4.1.3.b Determinant of TFP growth

Varietal development program of Chilli

Locally developed MI 1 and MI 11 were the main varieties grown in 80's. Most MI 1 grown areas were replaced with MI 11 variety by latter part of 80's (Figure 4.33). In order to face the dry chilli stiff competition from India under liberalized regime, and to increase the efficiency and productivity of chilli production, local breeding programs were undertaken. From mid 90's there were chilli hybrid seed imports in very small quantities in the market when the seed imports were liberalized in 1990.

Although there were seed imports, MI 2 and KA 2 were widely adopted varieties by dryland farmers. MI 2 and KA 2 varieties have similar yields, but KA 2 is more adapted to biotic and abiotic stresses (Figure 3.34). No specific hybrid import had the adaptability to the local conditions to create a substantial demand. Under the varietal development programs of the DOA few open pollinated varieties were released to increase the farm yields. KA-2 was released in 1991 that has the same potential yield as MI 2 under low management practices and occasional water stress. It shows well managed cultivation with assured water can reach the potential yield as in the Mahaweli H area during crop diversification.

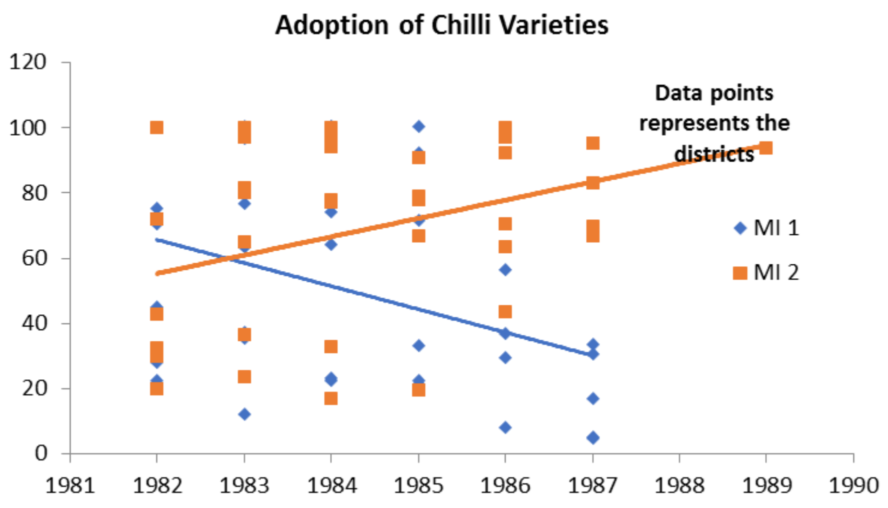


Figure 4.33: Adoption of MI 1 and MI11 chilli varieties in 1980's
Source: DOA

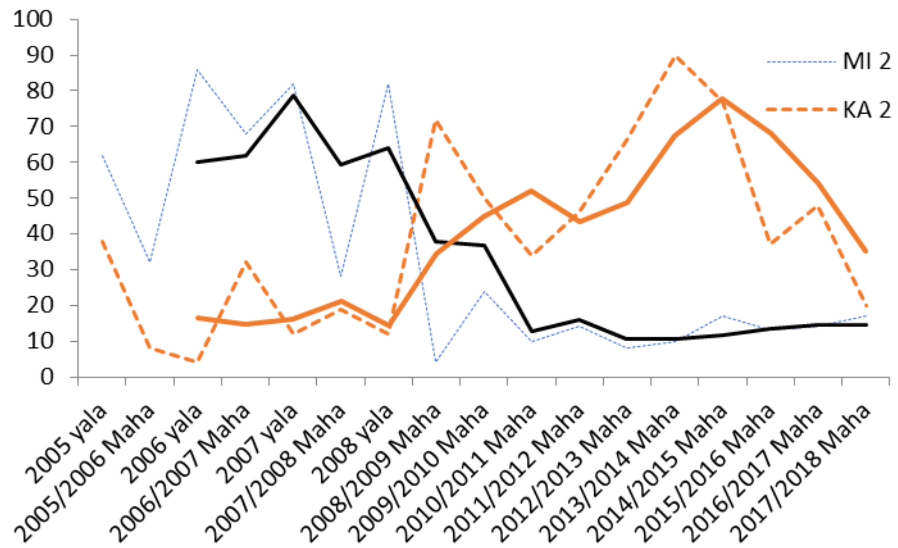


Figure 4.34: Adoption of MI 11 and KA 2 chilli varieties after 2005
Source: DOA

Table 4.11: Farmers Adoption of main chilli varieties by location

		MI 2	KA 2	MI 1	Dil Hit	Heen miris	Galkiriyagama	MICH	Other*
2005 yala	Kalawewa	**62**	38						
2005/2006 Maha	Anuradhapura	**32**	8	8					52
2006 yala	Mahaweli " H "	**86**	4	10					
2006/2007 Maha	Anuradhapura	**68**	32						
2007 yala	Mahaweli " H "	**82**	12	6					
2007/2008 Maha	Anuradhapura	**28**	19	16					37
2008 yala	Mahaweli " H "	**82**	12						
2008/2009 Maha	Anuradhapura	4	**72**	4					20
2009/2010 Maha	Anuradhapura	24	**50**						26
2010/2011 Maha	Anuradhapura	10	**34**		4				52
2011/2012 Maha	Anuradhapura	14	**46**						40
2012/2013 Maha	Anuradhapura	8	**66**						26
2013/2014 Maha	Anuradhapura	10	**90**						
2014/2015 Maha	Anuradhapura	17	**77**						6
2015/2016 Maha	Anuradhapura	13	37			30	10		10
2016/2017 Maha	Anuradhapura	14	48				22		16
2017/2018 Maha	Anuradhapura	17	20	7		37	7	7	5

- Other varieties represents traditional and imported hybrids

Source: DOA

The varieties MI Green, Galkiriyagama Selection, MI waraniya 1, MICH 3, MIPC 1 were developed mainly for green chilli production after 2009 (Table 4.11) with a potential yield of 10-15 t/ha. First local chilli hybrid, MICH HY 1 developed by the Department of Agriculture was released in year 2015 with the green chilli yield potential of 32t/ha.

Yet, MI 2 and KA-2 are the widely adopted varieties by farmers. The new varieties are on the adoption. According to a HARTI survey in 2012, only 2% farmers in sample location in Anuradhapura knew about the variety Galkiriyagama Selection and none of the farmer had known about MI green variety. These two varieties were released in 2009. According to the DOA, high incidences of pest and diseases, particularly leaf curl complex (LCC), moisture stress, use of inferior quality seeds, poor crop management and high input costs have hindered realizing potential yield of chilli. The ban on agrochemical monocrotophos in 1995 is also considered to have negatively affected in controlling particularly leaf curl complex (LCC). Monocrotophos is still being used in India. Reduced tank water retention capacity due to siltation of tank beds of many small tanks in the dry zone has caused less water for maintenance of cultivation.

National average green chilli yields have been able to increase to 7.6 mt/ha during maha and 6.6 mt/ha during yala.

Table 4.12.a: Chilli Varieties Released

1962	MI – 1	Myliddy X Tuticorin) 1000 - 2000 kg ha-1 of dry chillies
1973	MI - 2	Selection from MI – 1 With supplementary irrigation, the average yield in yala is about 2500 - 3000 kg ha-1 and in maha about 1500 - 2000 kg ha-1 dry chillies
1991	KA - 2	MI - 2 X PC – 1 The average dry chilli yield of KA - 2 under supplementary irrigation is about 2500 - 3000 kg ha-1 in the Yala season and about 1500 - 2000 kg ha-1 in the Maha season.
1996	Arunalu (BL - 39)	MI - 2 X Santaka 1996 Yala season under irrigation is about 2500 - 3500 kg ha-1 and in the Maha season under Rainfed conditions is about 1500 - 2000 kg ha-1.
2002	MI-HOT	(BL39 x IR) x KA-2 2002 With supplementary irrigation, the average yield in Yala is about 2500-3500 kg ha-1 and in Maha about 2000 kg/ ha.
2009	MI Green	(MI 2 x IR) (MI 2 x 142A) 2009 Pods are having dark green shiny surface with high level of pungency. Under irrigated condition potential yield of this variety is 12-15t/ha as green chilli.
2009	Galkiriyagama selection	Selection from locally grown landrace in Anuradhapura district during 1990s
2011	MICH-03 and Waraniya-01	
2015	MI Chilli Hybrid 1	MICH HY 1 (1st Local chilli Hybrid) (Galkiriyagama inbred line x MI Waraniya 1 inbred line) 32 t/ha, Moderate Resistant to Chilli Leaf Curl Complex
2017	MICH HY 2	

Source: DOA

In 2015 the 1st local chilli hybrid, MICH HY 1 was developed by the Department of Agriculture in their chilli hybridization program that started in 2009 (Table 4.12.a). This hybrid variety is highly suitable for green chilli with the potential yield of 32 t/ha of green chilli. MICH HY 1 performs well in all the major chilli growing areas within the country during both Yala and Maha seasons. This variety is Moderate Resistant to Chilli Leaf Curl Complex, the major problem in chilli cultivation within the country. Local hybrid varieties exhibit superior characters than most hybrid imports. Therefore this technology breakthrough can shift chilli production frontier with supported intervention. Particularly, seed production program needs to be streamlined for quality seed production.

Seed Production

Currently 25 % of the seed requirement is the target of the formal seed supply program as most varieties are OPVs. This is a combined effort of DOA and private sector, particularly CIC. When demand for hybrid varieties go up, 100% hybrid seed requirement must be produced and seed production program needs to be streamlined for quality seed production. Already there are private sector investments in chilli hybrid seed production and state banks have disbursed loans for chilli seed production in poly tunnels. In order to absorb these seed farmers into formal seed supply system, regulatory guidelines are required to maintain the quality of chilli seed production through the seed act.

Seed and planting material Development Centre of DOA produces 7000 - 9000 Kg of local chilli seeds annually. These seed are produced by farmers selected from seed and planting material Development Centre. Those have been established as chilli seed villages. Among those villages, Kahalla chilli village make more contribution to the chilli seed production.

Current Interventions by the Ministry of Agriculture as development programs

Input intensification and TFP growth promoting interventions are carried out as development programs that are targeted to different food crop sector achievements through the ministry. Introducing new technology, financial support, providing machinery and other equipment and infrastructure development are common components of these interventions. Credit is an important input for adoption of technology and optimum use of inputs. A great majority of food crop growing commercial farmers depended on credit to finance their production activities. According to a study done by HARTI, 90 percent of farmers who cultivated chilli had obtained credit.

In 2016, Ministry of Agriculture implemented a program to provide a number of 622 agro-wells, 1008 water pumps, 495 micro irrigation kits(1/4, ½ acre), 34 power sprayers, 15 Chilli Grinding machines, 51 rain shelters, 12,500 nursery trays, 10 chilli village, 85 tarpaulin covers and a sum of Rs.116.90 million was expended under the Ministry of Agriculture for the purpose. With a view to steering new farmers towards chilli cultivation, there is a program to pay Rs 10,000 per hectare under 50% government contribution for ploughing the lands of farmers, provide them with with chilli seed at 50% concessionary rate, conduct demonstrations to control chilli leaf curl complex and make aware officers and farmers. In addition 583,000 polythene bags for 50% farmer contribution were supplied to home gardens with a view to disseminating chilli cultivation.

4.1.4 Potato

Potato has been a hardly competitive crop being produced in the hills and it required a large capital for importing inputs for its cultivation. Due to the pressure from the potato growers in the up country, potato continued to be cultivated as the leading crop in up country region. It has a high land productivity compared to other crops grown in the region and it is the livelihood of farmers in the main producing areas in Badulla district. Therefore the government continues to impose a duty during the main producing months in order to safeguard the vulnerable fanners.

Potato production increased drastically in the country from 1980 with the restriction on issuing licence and the 100% import duty on potato. Extent cultivated under potato in both seasons increased from about 4,530 ha in 1980 to about 7,880 ha in 1990 (Figure 4.35). The import duty was gradually reduced to about 35%, while the import restriction policy remained intact. In 1995 production increased due to large stocks of good quality imported seed potato, favourable weather conditions and the extension of cultivation into non-traditional areas.

As the ban on free imports was lifted in 1996, potato farming was negatively affected due to availability of large stocks of imports in the markets. A sudden drop in the cultivated extent was observed, particularly in Nuwara Eliya district and the national production drastically declined from 100,755 mt to about 27,170 mt in 1999. Again in 2000, the protection was increased for potato farming and the extent under potato increased and thereby local production increased to about 79,500 mt in 2005.

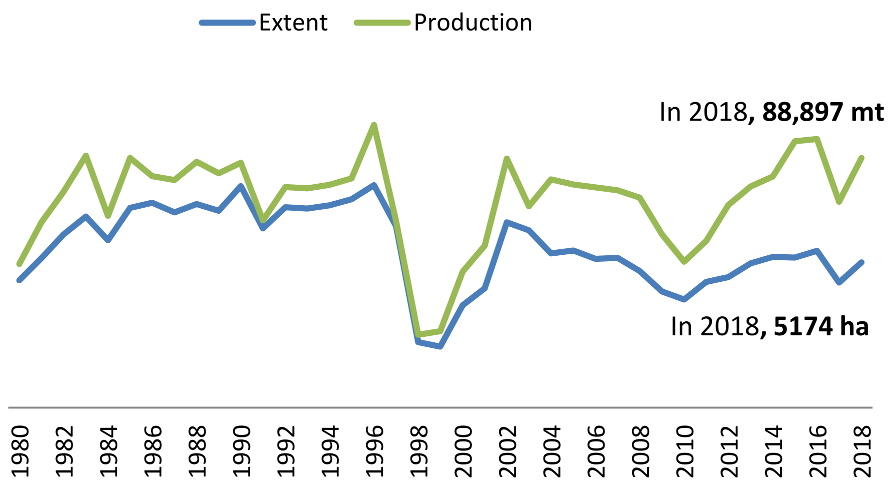


Figure 4.35: Extent and production of potato, 1980 - 2018
Source: Department of Census and Statistics

Potato cultivation takes place in two major seasons; maha and yala in Nuwara Eliya and Badulla districts and in Jaffna district during maha. Potato farming is one of the principle livelihoods of farming communities in Badulla district. In the district, on average 3,840 ha are cultivated with potato in rice fields during yala season (Kumburu Kannaya) as well as in uplands during maha season (Kandu Kannaaya). In Nuwara Eliya district, maha cultivation mainly takes place from January to March and yala cultivation from June to September. Accordingly, the main production from Nuwara Eliya district reaches the market from April to June (maha harvest) and from October to December (yala harvest). In Badulla district, two main peak producing seasons are found between February to April (maha harvest) and from October to November (yala harvest). Potato extent cultivated in Badulla, Nuwaraeliya and other districts during maha and yala seasons is given below (Figure 4.36).

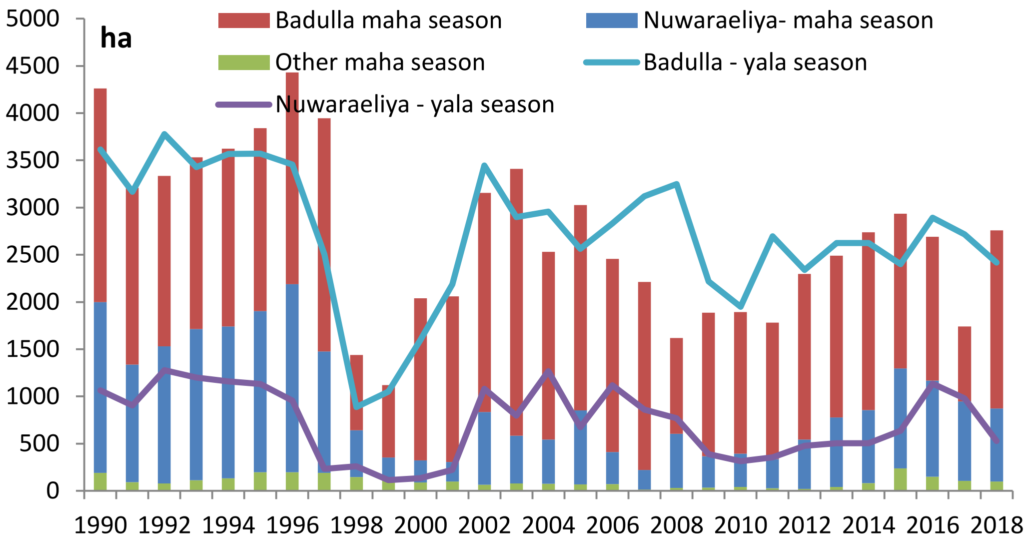


Figure 4.36: Potato extent in major cultivating districts during maha and yala seasons
Source: Department of Census and Statistics

Potato is one of the crops that require inputs intensively for its cultivation. More than 95 percent of commercial potato farmers depended on credit to finance their production activities. For the main input, seed potato, farmers mainly depended on private sector seed imports for its cultivation. Inferior quality and the disease susceptibility of the seeds available in the market and the high cost of imported seeds were significantly making the farming not economical and viable. Seed potato represents more than 50% of the capital cost of potato farming owing to the scarcity of healthy seed potatoes at a reasonable price. Farmers are largely dependent on credit from financial institutions. Government rapid multiplication program using tissue culture technology which began in 1997 for producing pre basic seeds made a considerable impact on the seed potato supply and potato production in the recent years.

4.1.4.a Productivity

Land productivity

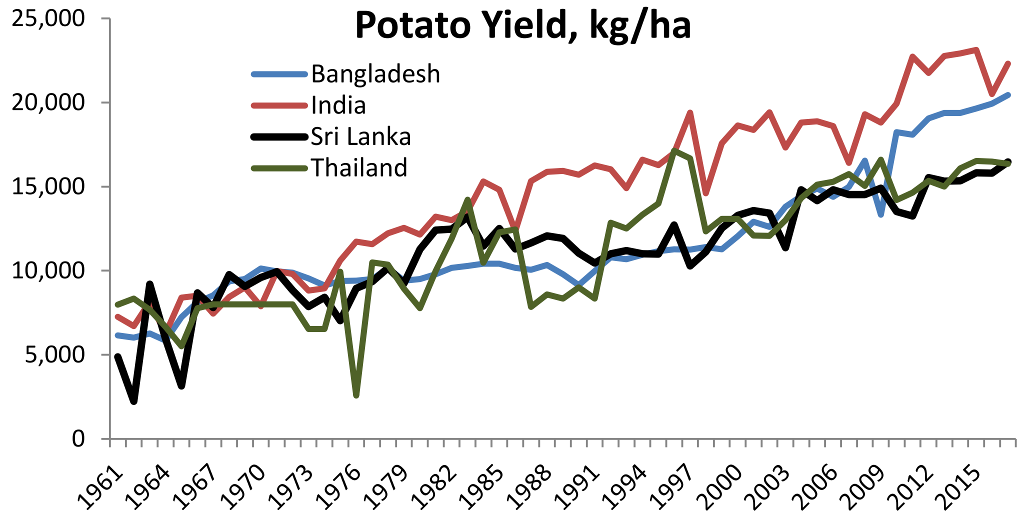


Figure 4.37: Average potato yield in Sri Lanka and neighbouring countries
Source: FAO

In the early adoption of the exotic varieties, increasing use of inputs resulted in potato yield increase from 5 mt/ha to 14 mt /ha. Then the yield was stagnating from mid-80's to the end of 90's until the local micro-propagated local seed production began. Sri Lankan yields are having yield gap of 5mt/ha within the region.

Labour productivity

The determinants of labour productivity, i.e. per ha labour use and the land productivity of potato farming in Sri Lanka are not comparable with Indian potato farming. Sri Lankan potato farmers use more than twice the labour use in India and the land productivity of potato farming is low in Sri Lanka (Table 4.12.b, Figure 4.37, Figure 4.38 & Figure 4.39).

Table 4.12.b: Per ha labour use in potato farming in Sri Lanka and India by state

	Labour Use (mandays/ha)	
	2004/05	**2015/16**
India		
Bihar	157.6	89.9
Himachal Pradesh	101.5	68.7
Uttar Pradesh	129.8	82.6
West Bengal	178.2	154.7
Sri Lanka	302.2	274.7

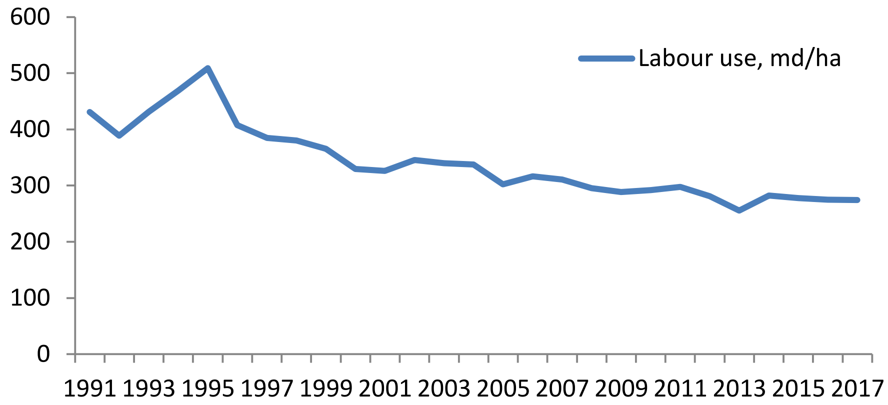


Figure 4.38: Labour use in potato farming
Source: Study estimates

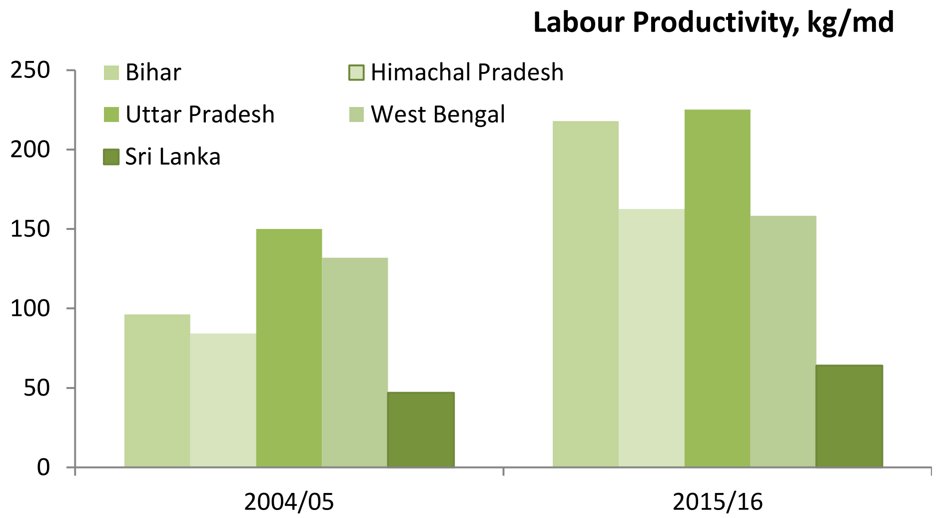


Figure 4.39: Labour productivity of potato farming Sri Lanka and Indian States
Source: Indian Ministry of Agriculture and Farmers welfare, study estimates for Sri Lanka

Mechanization in potato framing is on the adoption mainly in land preparation (Figure 4.40). In order to increase the labour productivity of potato farming, mechanization is considered as viable strategy. Mechanization towards preparation of beds to the ridge and furrow system with 2 wheel tractor propelled implements are being designed by Seethaeliya scientists.

Plans are also underway to introduce drip irrigation system better technology than sprinkler irrigation for water management. A cable system to transport produce from farm field to the collector point is also being planned.

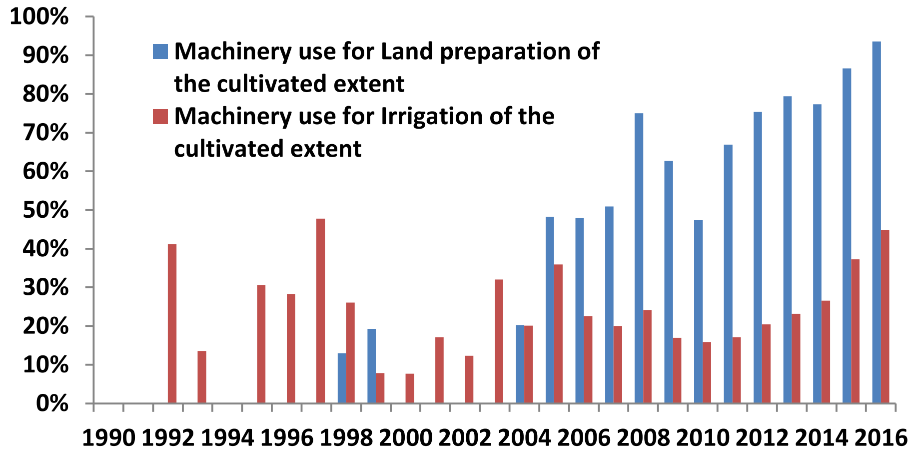


Figure 4.40: Machinery use for land preparation and irrigation in potato farming
Source: Study estimates

Total factor productivity

After the removal of licensing on imports in 1996 potato became relatively less attractive and this policy shock continued until, the protection was increased for potato farming again in 2000. TFP drops sharply during this period (1996 to 1998) (Figure 4.41). TFP shows an increase after 2000 with the protection policy and with the local seed production program increasing the local seed supply over potato seed imports. A review of local seed production program is given below. From 2005 to 2017 TFP was growing at 1.3% per annum (Table 4.12).

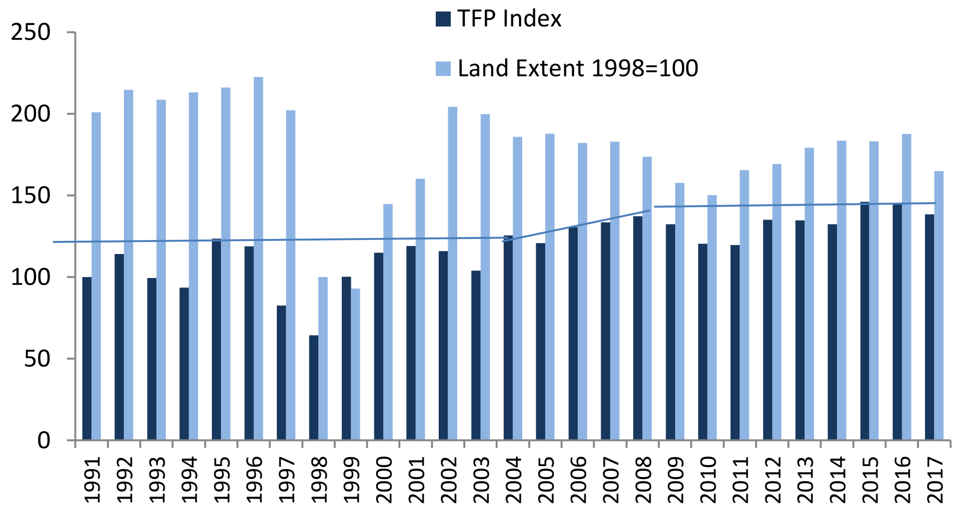


Figure 4.41: Potato land extent, 1998 as the base year and TFP growth index, 1991 as the base year
Source: Study estimates

Table 4.12.c: Output growth, input growth by type of input and TFP growth

	2005 -2017 Growth p.a.
Input growth p.a.	
Land Extent	-0.10
Fertiliser	-2.89
Labour	-1.29
Seed	-0.08
Machinery power – land preparation	8.37
Machinery power -Irrigation	3.06
Chemicals and other - Pesticides	**5.65**
Total Input growth	-0.005
output growth	1.338
TFPG	1.342

Source: Study estimates

While farmers reducing fertilizer for cultivation at a rate of 2.89 p.a., agrochemicals use to control pest and disease are increasing at a rate of 5.65 % p.a. (Table 4.12.c)

Input Intensification and TFP

Land productivity is mainly attributed to the TFP growth that is evidenced since 2003 which is growing at 1.3 % p.a.

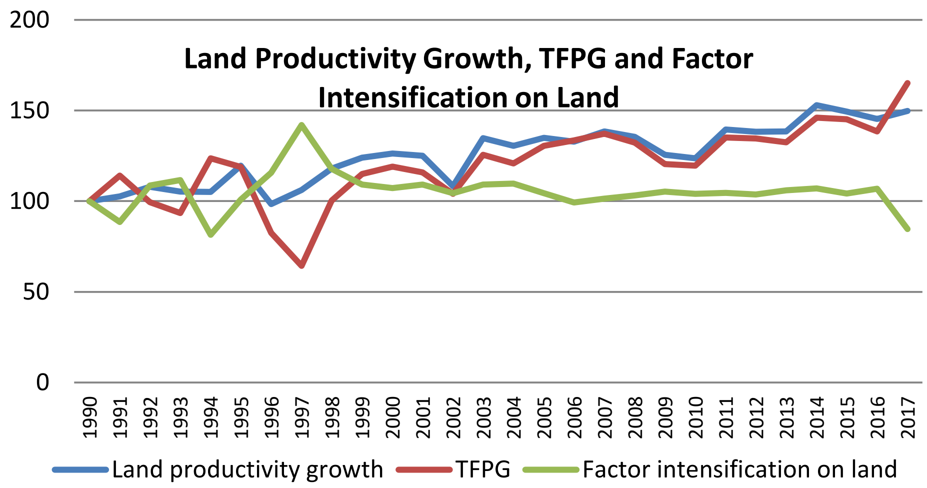


Figure 4.42.a: Land productivity growth, TFP growth and factor intensification on land
Source: Study estimates

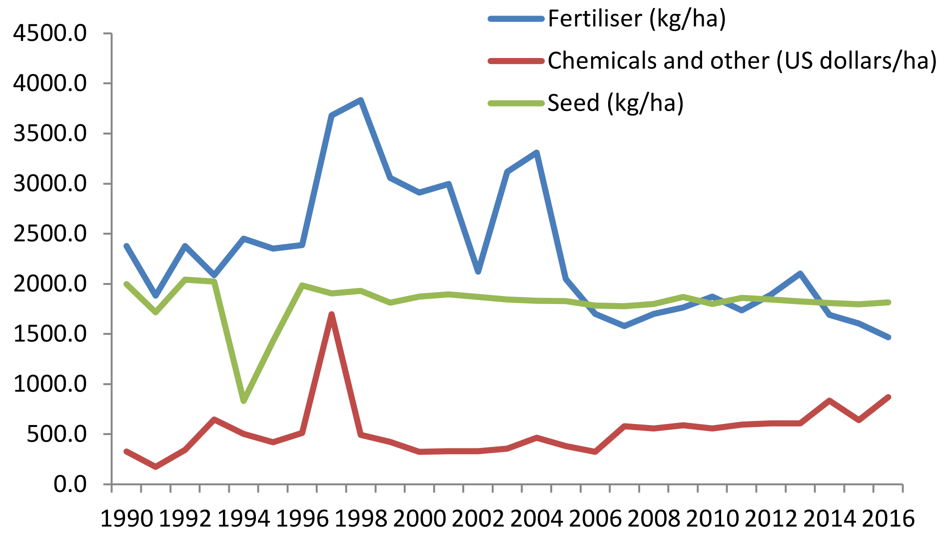


Figure 4.42.b: Per ha input use by type of input

4.1.4.b Determinants of TFP

Need of a consistence policy on potato sector

Government policy towards this sector varied significantly over the years due to number of reasons including government fiscal policy and pressure from different groups. Though government liberalized the potato industry from late 70's government imposed a high duty or restricted on issuing license for edible potato imports in certain years. Conversely, in some years, government relaxed the duty and a more liberalized market was maintained to increase the welfare of the consumers. Accordingly local production drastically changed hampering a stable policy on potato. Therefore tariff and non-tariff measurements are the main policy instruments of the government which determines the potato production in the country. Production decisions, management of the crop and importantly seed production program are affected by the trade policy on edible potato.

Variety development program and quality seed potato production in Sri Lanka

Main varieties grown in Sri Lanka are primarily imported varieties. In the initial variety development programs, few varieties were developed from lines received from International Potato Centre such as Sita, Krushi. However farmer's adoption of these varieties was very low. Although the department has recommended few varieties Granola, Hillstar, Desiree, Sante, raja, Kondor, Isna, farmer's adoption is mostly the variety Granola. Hillstar is a high yielding local variety suitable to local climate that can be a competitive variety with many imported varieties. However, Granola and Desiree were the two main imported seed varieties cultivated by more than 60% of the potato farmers in 2005. By now Granola has become the mostly cultivated variety and it is the variety being used for seed production by the department in its mini- tuber production program. Few recent introductions such Red La Soda and Sassy are recommended by DOA and are being cultivated in Jaffna area.

According to the current variety development program, new exotic varieties which are imported by private sector are tested for their adaptability.

Until the liberalization of seed potato industry, the formal seed supply to the potato farmers was fulfilled through imported seed potatoes multiplied in the DOA seed farms. Seed potato imports were liberalized in 1989 and the dominant role played by the government seed farms became less important. Seed imported by the private sector entered into the market in large quantities and farmers started to mainly dependent on seed potato imported from Europe for cultivation. Currently seed potatoes are imported under zero import duty. Majority of the seed requirement was met through informal seed system comprising exchange among neighbors, friends, relatives, and villages and non-availability of quality planting material in adequate quantities and at affordable prices was the major bottleneck in potato cultivation.

The widespread adoption of tissue culture – or micro-propagation - as a means of multiplying disease-free plants that can then be used to produce healthy seed tubers for farmers was a major innovation for the potato industry in developed countries in the 1970s. Although this technology delivers healthy seed tubers, micro-propagation of plantlets was costly, requiring sophisticated technology and well-trained staff which was a constraint for many developing countries. Nevertheless, several countries adopted less expensive ways of propagating seeds with tissue culture technology and by now they have been able to produce good quality seeds at a low price.

In 1997, *Seethaeliya* agriculture research station of DOA started the government rapid multiplication program using tissue culture technology and it started to make an impact on the seed potato supply. In vitro plants that are produced in research labs are being cultivated in hydroponic and aeroponic systems under protected tunnels for the production of minitubers. Pre basic seeds/minitubers (GO) produced are used in multiplication programme in five seed potato farms in N'Eliya Districts. Excess seed materials of the above are issued to seed growers in the area specially in Badulla district. Currently research divisions (*Seethaeliya & Bandarawela*), government seed farms *(Seetheliya, Mipilimana, Piduruthalagala, Udaradalla, Kandapola, Bopaththalawa*) and private sector contract growers together supply seed potato requirement under this program. Under this program, 4th to 5th generation seeds are marketed by the DOA farms as certified seeds for commercial cultivation. Although current mini-tuber production can meet the demand of the local cultivation, involuntary imports are done during rainy season.

Table 4.13: Seed potato production and imports, 1985 - 2018

Year	Production (Mt) in Government Farms	Go seed issues to Contract growers	Imports (Mt)	Remarks
1985	1830		2450	Government imports
1986	2606		1966	
1987	2481		1970	
1988	2692		1350	
1989	2091		3500	Seed potato imports were liberalized in 1989
1990	329		150	
1991	420		1300	
1992	899		1526	
1993	215		565	
1994	330		**8025**	Zero import duty on seed potatoes imports were announced
1995	--		**14187**	
1996	--		5200	
1997	--		1122	
1998	--		1707	
1999	NA		1764	
2000	NA		2795	
2001	NA		6725	
2002	NA		7029	
2003	NA		5031	
2004	NA		3724	
2005	NA		5718	
2006	228		2245	G1 & G2 and C1,C2 &C3 seeds are issued for commercial cultivation by government Farms
2007			1782	
2008		140,500 (No)	1208	
2009	218		1010	
2010	201		1015	
2011	289		1097	
2012	388		1926	
2013	515		2218	
2014	324		1817	
2015	714		2485	
2016	345		2840	
2017	699	1, 113,055	1611	
2018	784	974,870		

Source: DOA, Department of Customs, ITC trademap

With the commencement of new potato production program, G1 seed potato is produced and supplied to farmers for self-seed production. Seed potato production by government farms, G0 seed issues to contract growers and seed imports from 1985 to 2018 are given in table 4.13.

Strengthening of formal potato seed production system by integrating micro-propagation is a sound technological option (Wickramasinghe, 2012). The success of the adoption of this technology is largely attributed to the efforts of the research stations, DOA and the provincial extension services and also the interventions such as IFAD for diffusion of this technology to farmers through Farmer Field Schools (FFS).

4.1.4.c Lessons learned from the region

Variety development program and seed Potato production program in India

In India, Potato breeding program was initiated, in 1935 in Potato Breeding Station, Shimla. Regular breeding program was started in 1949, with the establishment of Central Potato Research Institute (CPRI), at Patna. Headquarters of CPRI was later on shifted to Shimla, in 1956, in order to facilitate hybridization, and maintenance of seed health. The major breakthrough of potato development program, came in 1963 with the development of “Seed Plot Technique”, which made it possible to raise, evaluate, select and multiply breeding material under disease free materials in plains. This led to the development of a system, wherein crossing was attempted in the hills and raising of seedling, evaluation and maintenance of segregating population was done in the plains. All varieties released by the CPRI carry the prefix KUFRI as a memento, to the place of hybridization. Later in 1971, All India Coordinated Research Project on Potato (AICRP-Potato) was initiated with its headquarters at CPRI. The mandate of AICRP (Potato) is to coordinate and monitor multi location trials with improved potato hybrids; agronomic practices related to crop production vis-à-vis identification of remunerative potato-based cropping systems; plant protection measures and post- harvest technologies, all aimed at increasing production, productivity and utilization of potato in the country.

The breeding methods of potato in India can array as;

- Introduction
- Clonal Selection
- Hybridization and Selection
- Backcross method
- Heterosis
- Biotechnology

Till date, 50 potato varieties have been produced and released by CPRI for cultivation under diverse agro-climatic conditions of the country. Out of these 50 varieties, 24 varieties are under cultivation today.

CPRI has developed ‘Seed Plot Technique’ in 1970s to carry out disease-free seed production in the sub-tropical Indian plains under low aphid period. This technique, aided by biotechnological approaches for virus elimination, has sustained the National Potato Seed Production programme. An alternate technology for crop production through botanical seed called ‘True Potato Seed’ (TPS) has been developed by the CPRI, which is suitable for regions where quality seed tubers cannot be produced. The TPS technology offers low cost on seed, case in storage and transportation, and lower incidence of diseases and insect-pests. Three TPS hybrids namely, TPS C-3, HPS I/13 and 92 PT-27 have been recommended for commercial cultivation. Tissue culture technology has been widely used for production of disease free quality planting material.

Two interspecific potato somatic hybrids *viz*., *Solanum tuberosum* dihaploid C-13 (+) *S. etuberosum*, and C-13 (+) *S. pinnatisectum* resistant to Potato Virus Y and late blight have been developed. Four new hybrid varieties of potatoes, developed by the central potato research institute, have been recommended for release as commercial varieties. It is intended that, the new varieties -- ms/92-2015, hybrid jw-160, hybrid ht/92-621 and hybrid sm/87-185 -- would boost potato production in the entire country and offer wide choice to various regions to adopt the suitable variety for export and processing.

CPRI Shimla, has developed transgenic using crylab and asmotion gene for resistance against potato tuber moth and late blight disease. CPRI, in collaboration with JNU, New Delhi developed 8 Indian varieties using AMAL gene for increase total protein content. Transgenic potatoes have been developed for late blight resistance, reduction of cold induced sweetening, high protein content, Potato Tuber Moth, virus resistance (Potato Virus Y, Potato Apical Leaf Curl Virus) and altered plant architecture. Two indigenous genes and gene constructs have been cloned. Scientists at the National Institute for Plant Genome Research (NIPGR) in New Delhi are planning to seek regulatory approval for commercial cultivation of a high protein potato that they have developed through genetic modification. Nick named 'protato' the protein packed genetically modified (GM) potato contains 60 per cent more protein than a wild-type potato and has increased levels of several amino acids.

Variety development program and seed potato production program in Bangladesh

Potato production in Bangladesh also expanded in remarkable fashion: from 343,000 t in 1961 to 7.9 million t in 2010. Area harvested jumped from 56,000 to 435,000 ha during the same period. Various factors outlined above in the case of India also apply to

Bangladesh. In addition, one key element catalyzing the potato´s expansion in Bangladesh was the successful introduction of shorter duration, high–yielding rice varieties.

Tuber crops research came as breakthrough in Bangladesh in 1960 by releasing “Eigenheimer” of potato variety through introduction. With a view to diversify the research activities on potato, the Potato Research Centre was established in 1977 and later on, it named as Tuber Crops Research Centre (TCRC) in 1988. Introduction and selection of exotic potato varieties has been the major means of variety selection since its inception. In this process, established varieties are imported from different countries and evaluated for 4 to 5 generation under Bangladesh condition. On the other hand, some research programme is done under the programme of germplasm evaluation and selection where, most of the cases, germplasm are imported from other countries Hybridization has been started since 1999 at TCRC. Within the limitations, the TCRC, BARI has already released 5 varieties. Under this process, 6 to 8 generation of evaluation is required for release of a variety following hybridization.

For recent TCRC, BARI has released total about 58 varieties. Out of 58 varieties released by TCRC, BARI, 46 from exotic varieties and 5 from germplasm received from International Potato Center (CIP) and 5 varieties released from hybridized materials developed by TCRC.

The new era has been started in TCRC by giving 5 potato varieties: BARI Alu-35, BARI Alu-36, BARI Alu-37, BARI Alu-40, and BARI Alu-41 from their own hybridization programme. These varieties are much more acclimatized with the own environment and performed more than 40 t/ha tubers yield that is very important to increase national average yield and even though it’s taste to eat like as that of local variety. Bangladesh Agriculture Research Institute (BARI) has also developed late blight resistant RB potato using its own cultivars in 2006 in collaboration with Wisconsin University and Indonesian University which are currently under greenhouse and field trial. While, BARI Alu-46 is being a late blight disease resistance variety, farmers need not to use fungicide during the growing period of potato. It is assumed that annually Tk. 430million foreign currencies will be saved. It will reduce use of fungicide and eventually lessen environmental pollution.

Scientists from BARI's Tuber Crops Research Center (TCRC) developed the transgenic lines by crossing the leading Bangladeshi varieties (Diamant, Cardinal, Multa, Granula, Local) with transgenic variety Katahdin at Wisconsin University and Indonesian and tested them in greenhouse and multi-location field trial.

Status of collection and conservation:

TCRC, BARI has collected about 400 exotic potato varieties, 300 TPS progenies and 2500 potato germplasm. The exotic varieties and germplasm are generally collected from the Netherlands, France, Germany, India, UK, USA, Philippines, Taiwan, Indonesia, Canada and CIP, Peru. So far, TCRC are maintaining more than thousand germplasm and about 40 varieties. All the exotic varieties and hybrid clones are being multiplied at BSPC, BARI, Debigonj and conserve there as well. At present TCRC, BARI is maintaining most of the released varieties. Most of them are being maintained under field as well as laboratory conditions as *in vitro* plantlets or micro tubers and some are also maintained as true seeds in the laboratory.

Tissue culture/In vitro seed potato supply

Horticulture Improvement Center under Bangladesh Agriculture Development Corporation (BADC) has taken step against the existing crisis of breeder potato-seed. They are expecting that it could be solved easily through successful expansion of tissue culture technology at the grassroots. BADC thinks there has been a bright prospect of enhancing the production of breeder seed through best uses of the innovated technology and the farmers have a vital role to make the prospect into realistic. Accordingly, BADC has undertaken a programme for producing 25,000 metric tons of seed-potato through applying tissue culture technology by 2012 in the country. To make the effort a complete success, two more tissue culture laboratories would be set up soon as mentioned by BADC officials.

While private sector such as The Bengal Seeds Company Limited has undertaken a program for producing 948 metric tons of different category seed potato through applying tissue culture technology during the current season and the plants are growing well. Apart from NGO like Bengal Seed Company, BRAC is also producing tissue culture plating materials of potato in Bangladesh.

Mini-tuber seed potato supply

There is a great potential of mini-tuber seed supply and multiplication in Bangladesh, whether from tissue culture or hydroponically produced pre-basic materials and or imported mini-tuber multiplication by contact growers or at farmer level through guided seed plot technique supported by Dept. of Agriculture Extension, Bangladesh. This approach could be also visible by private companies who have already established production of pre-basic seed potato and contact grower channel. Tuber Crop Research Center, Bangladesh Agriculture Development Corporation and Seed Certification Agency (SCA) of Bangladesh could play pioneer role to establish mini-tuber seed supply chain. Certified seeds of ‘A’ class and downgraded seed of ‘C’ class might be cheaply available during growing season if mini-tuber multiplication system become establish in

Bangladesh at farmer level supported by DAE. Thus, a simplified schematic diagram is shown below for mini-tuber supply chain of formal sector.

Meristem Culture Technique

The viruses and other diseases of potato can be eliminated by using meristem culture technique; around 20 biotech labs in the universities, research institutes, government and private organization in Bangladesh using meristem culture technique to produce virus free seed potato. The meristem culture-derived plantlets from the biotech labs are cultured sequentially to produce the breeder seed, foundation seed and certified seeds.

Future Programs

"Feed the Future Biotechnology Potato Partnership" is newly launched project where intended to develop the sector of potato production using the high technology. As a result of this project, Bangladesh is willing to introduce '3R-gene potato', a genetically modified organism (GMO) or biotech potato variety, which would save 25-28 per cent production cost as the BT variety is late-blight disease resistant, a fungal disease. To this end, a Memorandum of Understanding (MoU) was signed between Bangladesh Agricultural Research Council (BARC) and Michigan State University on November 3, this year to. Bangladesh Agriculture Research Institute (BARI) is the implementing agency of the research partnership project.

4.1.5 Soybean

Soybean, Glycine max (L.) Merr., a food legumes rich in protein has a good potential to promote as a commercial crop in Sri Lanka. It is grown to process as a vegetable protein in various forms and as an animal feed supplementary. It can be processed in to a wide range of food products for human consumption, such as textured vegetable protein (TVP), soy curd (tofu), soy ice cream, soy source, soy milk and soy oil. Soybean is used in as a raw material in production of poultry feed. Soybean can be cultivated both in the Dry and Intermediate zones of Sri Lanka and in general soybean requires relatively less amount of water for cultivation than many other upland crops such as maize, chili and onion. Therefore, soybean can be cultivated with minimum supplementary irrigation. Currently, cultivation is limited to Anuradhapura district and System H of the Mahaweli Irrigation scheme.

Cultivation of soybean is a relatively new to Sri Lanka, although it is reported soybean has been growing in some localities in upcountry from ancient times. From late 50's FAO and WHO promoted Soybean as a non-animal based food supplementary to meet the nutritional needs at low cost in Asia. In 1967, soybean varietal trial and agronomic trials were started on a limited scale in the dry zone areas of the country at the Agricultural Research Station at Mahailluppallama. One of the important mandates of FAO started Freedom from Hunger Campaign (FHC) was the introduction of cultivation of soybean in Sri Lanka.

In 1975, UNDP–FAO International Soybean Project (INTSOY) provided funding to the Soybean Development Program in Sri Lanka which was started to expedite the possibilities of utilizing soybean for food as well as for feed purpose. Until 1981's, the program was executed by the FAO in collaboration with INTSOY headquartered at the University of Illinois, USA. The objective of the INTSOY program was to improve human nutrition around the world through the expanded use of soybeans both as human and animal feed. This program was expected to address a wide range of issues related to the cultivation of soybean and its uses. This included the introduction of small – medium scale processing units for extraction of soybean oil as a viable alternative by solvent extraction method, promotion and developing new markets for soy foods and integration of soybeans into traditional diets and food recipes of Sri Lankans. In 1979, a fully equipped pilot scale processing plant for carrying out product development research and human resource development was established at Central Agricultural Research Institute at Gannoruwa with the assistance from UNDP, UNICEF and CARE (Shurtleff and Ayoyagi, 2004).

Soybean cultivation in early years mainly was on up lands during maha season and limited cultivation in yala season with supplementary irrigation. During the INTSOY project period, the cultivated extent of soybean increased and 5185 ha had been cultivated in 1984. The govemment introduced a Floor Price Scheme in 1979 to protect the local famers under which the Paddy Marketing Board (PMB) got involved in purchasing soya bean from the local farmers. According to studies, this scheme was not effective as a salvage price. For example, for a long period between 1982/83 maha and 1995 yala the floor price remained constant, while the production cost was increasing, leading to a decline in the net profit. The declining profit discouraged the local farmers to invest on soya bean. Due to the absence of a proper marketing system and importation of soy based products including defatted soy flour, soy oil and soy sauce at relatively lower prices, cultivation dropped gradually and it decreased to about 694 ha in 2000 (Figure 4.43).

The demand for soybean in the open market is very limited and therefore, majority of farmers cultivate this crop by signing a forward sales agreement with the soybean product manufacturing industries. After the year 2000, due to the expansion of the soy based product manufacturing industries, the cultivated extent gradually increased. Yala season cultivation under supplementary irrigated conditions in paddy fields expanded and cultivated extent increased to about 8316 ha in 2017.

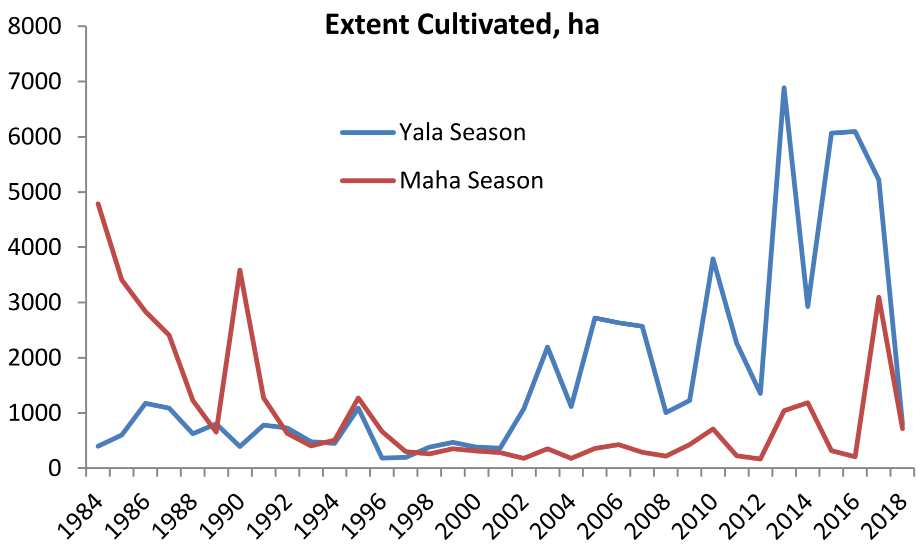


Figure 4.43: Cultivated extent of Soybean during maha and yala season
Source: Department of Census and Statistics

Total supply to the soy food and feed production has increased from early 2000 with the private sector coming to the processing industry (Figure 4.44). Of the total requirement, imports constitute 30 % in 2016 & 2017. The local production goes mainly for production of soy based food products while entire imports go to animal feed production.

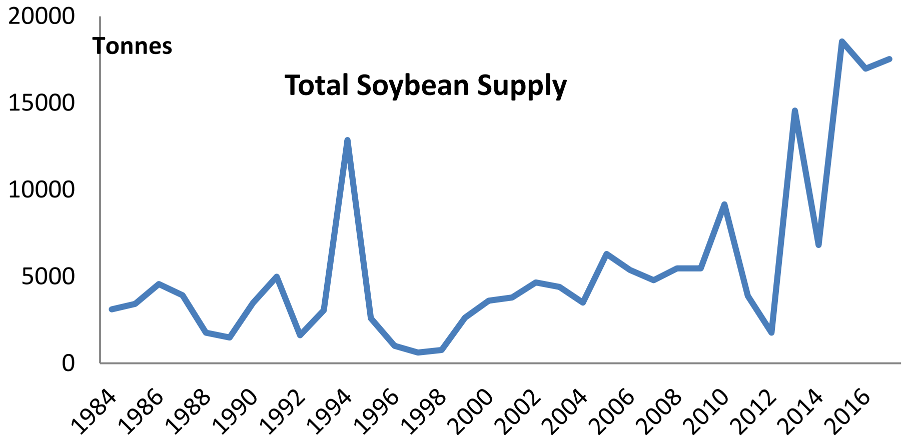


Figure 4.44.a: Total Soybean supply by means of production and imports
Source: Department of Census and Statistics, Department of Custom

In 2017, the total production of soybean was 14,363 mt and country imported 3,176 mt of soybean from USA.

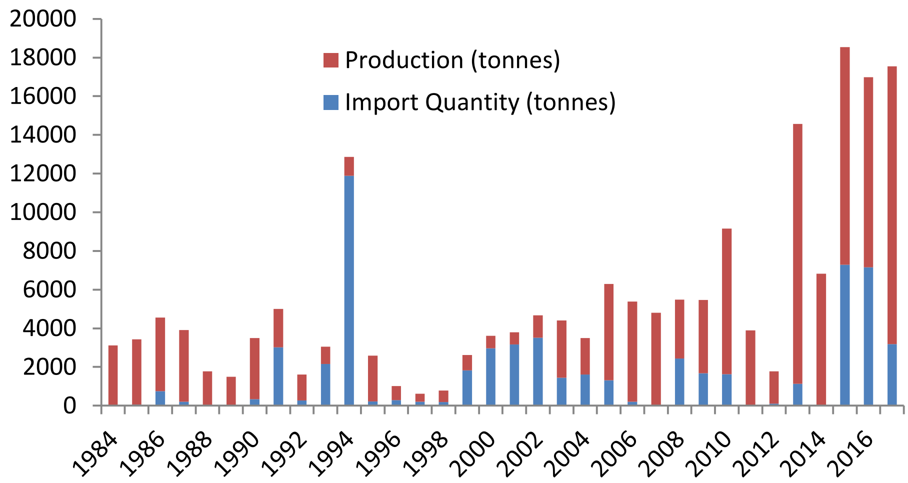


Figure 4.44.b: Production and Import quantity of Soybean
Source: Department of Census and Statistics, Department of Custom

Using Low Cost Extrusion cooker Thriposha production program began with the assistance of the CARE Canada in 1976. The flour in Thriposha made from locally grown soybean in whole and mixed to a ratio of Maize 70 to Soy 30. Soybean usage was 1566 tonnes per year, purchased from local sellers and Paddy Marketing Board at the start of the program. From 2010, Sri Lanka Thriposha Ltd., a fully government owned Company belonging to the Ministry of Health undertakes Thriposha production program. In 2012, around 3310 mt was used for Thriposha production.

Companies who process soybean to produce Soy based food and animal feeds plays an important role in increasing production and productivity of soybean having their buyback programs and supporting farmers with quality inputs. These companies have their contract farmers who supply good quality seeds for which DOA provides training for farmers. Oil extraction plant was installed recently to extract oil and to produce oilcake as by product for animal feed. In 2018, 219,917 tons of oilcake was imported to the animal feed industry mainly from India and USA.

As a cheap source of protein and as an animal feed, there is a good potential to promote soybean as a commercial crop in Sri Lanka. Soybean can be easily cultivated under rainfed condition in uplands during the maha and in yala seasons, under supplementary irrigation in the paddy fields compared with the other legumes. Relatively low labour requirement for management and the possibility for mechanization due to synchronized maturity can increase labour productivity from soybean farming.

4.1.5.a Productivity

Land productivity

Average soybean yield fluctuates around 1.5 per ha. This is comparable to the average soybean yield of India, Thailand and Vietnam (Table 4.14). Nevertheless India cultivates 2000 times the extent of Sri Lanka and India is the 5th largest producer of soybean in the world. When the Indian soybean farming is considered, soybean was a new crop in India and its commercial cultivation was started only during 1968-70, the same years, soybean was introduced to Sri Lanka. It is commercially cultivated for production of oil (75-80%) and de-oiled cake (DOC) or soymeal as a byproduct. Less than 25% soybean is used for the production of soy based food products. The extent under Soybean in India is 11 million ha.

Table 4.14: Average yield of soybean of Sri Lanka and India

	Average Yield(Kg/ha)	
	Sri Lanka	India
1970 to 1980	1097.5	847.8
1980 to 1990	909.9	749.8
1990 to 2000	933.3	988.3
2000 to 2010	1525.1	1035.9
2010 to date	1479.6	1093.6

Source: Department of Census and Statistics

Soybean yield shows a clear shift after 2002 (Figure 4.45) when private sector assured marketing of farmers produce. During this period average soybean yield was increased by more than 9% per annum. Both maha and yala yields have more or less converged with the reduced maha cultivation and increased yala cultivation.

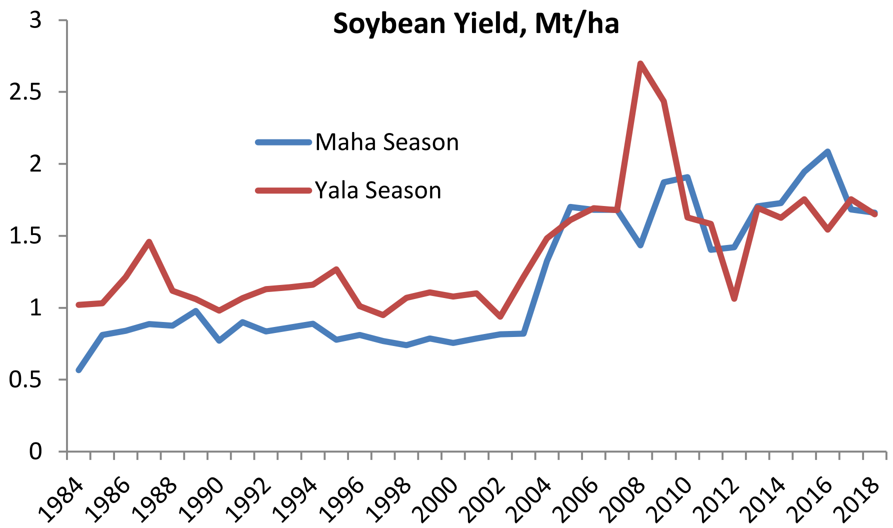


Figure 4.45: Soybean yield during maha and yala season
Source: Department of Census and Statistics

Labour productivity

The labour productivity index calculated from 1992 Yala season onwards shows that during the last 25 years, index has increased by 100% partly attributed to the mechanization and the land productivity increases in the crop sector (Figure 4.46 & Figure 4.47). Soybean requires less labour for management compared to many other field crops and mechanization can be done easily due to synchronized maturity. The average labour use per ha in 1992 was 150 man days and it dropped to 100 man days by dropping the labour use by 50 %. Mechanization in tillage and threshing grew fast that ploughing and threshing were 100% mechanized by 2000. Land productivity shift in early 2000 contributes to the other 50% increase in labour productivity (Figure 4.47).

However compared to labour productivity of soybean cultivation in India, labour productivity of Sri Lanka is low (Figure 4.48). Still Sri Lankan farmers use more labour for management of the crop. On average Indian farmer uses 25 to 60 man days per ha for soybean cultivation while Sri Lankan farmers use more than 100 man days per ha (Table 4.15). This labour requirement is mainly for preparation of beds & ridges, seeding, weeding, water management and harvesting are higher. After 2010, weedicide application for manual weeding is reported.

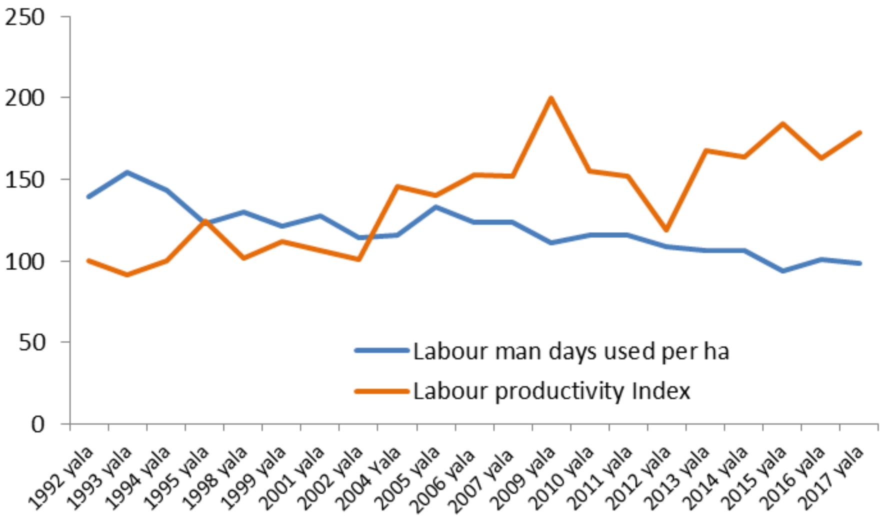


Figure 4.46: Per ha labour use and the labour productivity of soybean
Source: Indian Ministry of Agriculture and Farmers welfare, study estimates for Sri Lanka

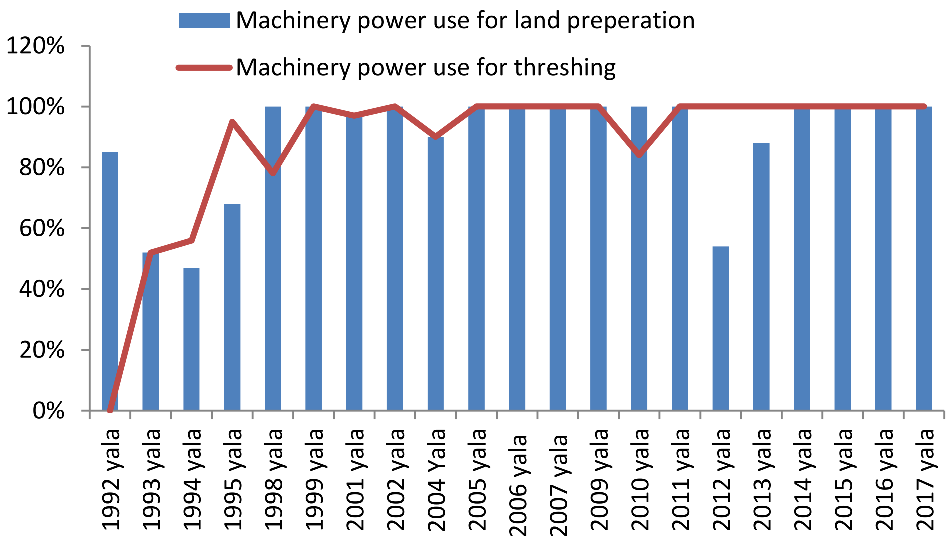


Figure 4.47: Machinery power use for land preparation and threshing in Soybean farming
Source: DOA

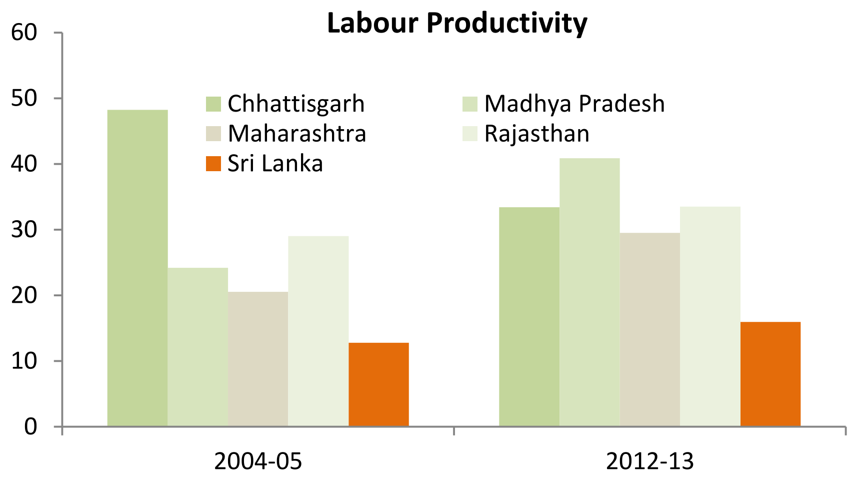


Figure 4.48: Labour Productivity of soybean Kg/man day

Table 4.15: Per ha labour use in soybean farming in Sri Lanka and India

	Labour mandays use per ha		
	2004-05	*2012-13*	*2015-16*
India			
Chhattisgarh	21.8	23.5	44.6
Madhya Pradesh	43.7	34.4	31.3
Maharashtra	60.9	57.7	54.8
Rajasthan	45.6	38.9	42.3
	2004 Yala	*2013 Yala*	*2016 Yala*
Sri Lanka	116.0	108.0	101.3

Source: Indian Ministry of Agriculture and Farmers welfare, study estimates for Sri Lanka

Total factor productivity

TFP index constructed for soybean for the 1992-2017 period is given in the figure below (Figure 4.49). When 2012 the extreme weather year (2012 drought) is not accounted, three different periods can be found based on average TFP values as prior to 2004, 2004-2010 and 2010 onwards.

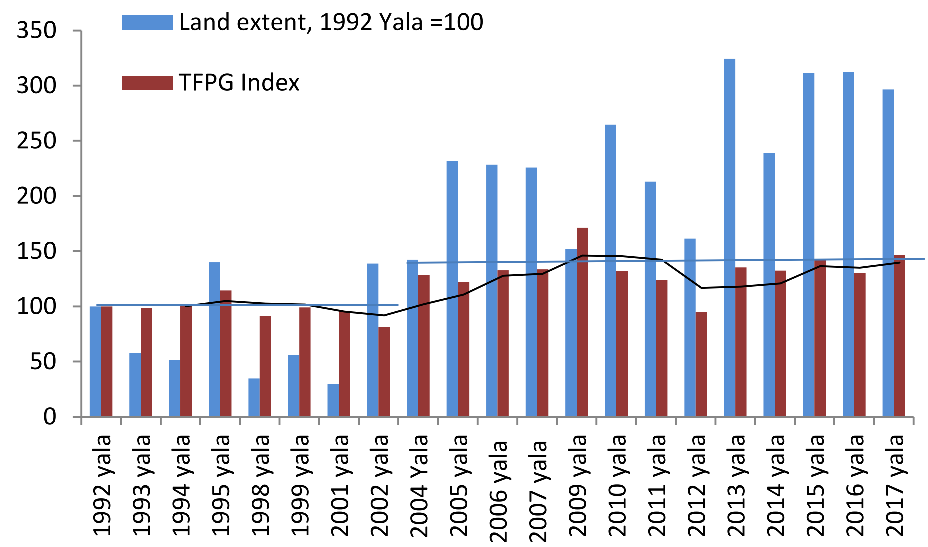


Figure 4.49: Land extent and TFP growth index, 1992 yala = 100
Source: study estimates

Input Intensification and TFP

Below discusses the land productivity gains achieved through factor intensification on land and TFP. Over the period of this analysis there is no significant increase in total factor intensification on land (Figure 4.50 & figure 4.51)). However the disaggregated analysis shows agrochemical use has increased with the private sector investments in this sector from early 2000. Pre weedicide application, plant protection chemicals application and nitrogen fixing bacteria inoculation are some of the management practices encouraged by private sector. These inputs have component of capital embodied technology and disembodied technology that increases the TFP. Use of good quality seeds for planting is also contributory factor for increased TFP with the private sector coming into venturing in soybean production.

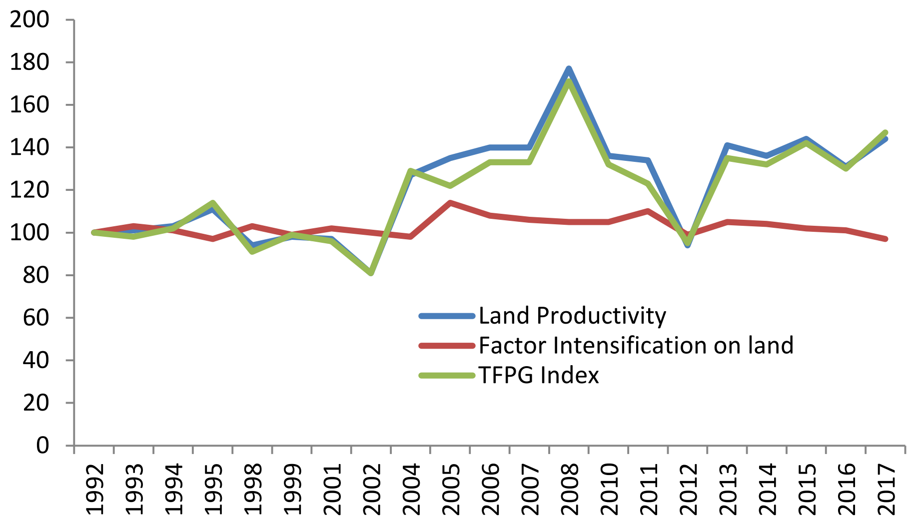


Figure 4.50: Land productivity, factor intensification on land and TFP growth index, base year 1992

Source: Study estimates

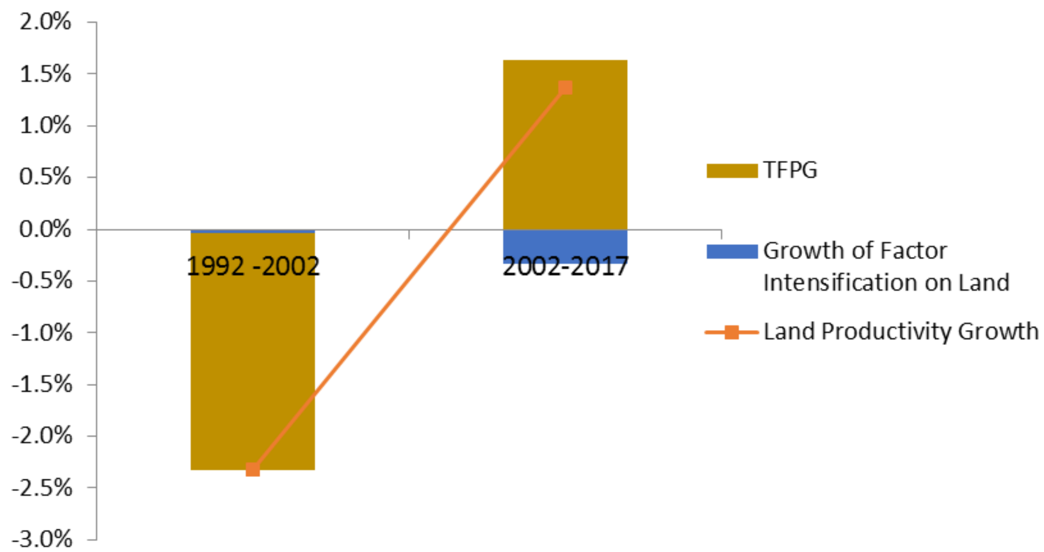


Figure 4.51: Growth of Land productivity, factor intensification on land and TFP

Source: Study estimates

Due to the scattered cultivation and comparatively small extents are cultivated, the impact of biotic constraints to soybean production is relatively small in Sri Lanka. Diseases in soybean are rarely observed. Although no severe outbreaks of pests or diseases have been recorded in soybean, some pests are becoming destructive that pesticide use has risen since early 2000 as the cultivated extents started to increase.

Pesticide application is on the increase. Pest infestations due to climate change and the cultivation of PB 1 for almost 40 years is a problem. At the stage of pod maturating “bean fly damage” is observed. Bad management practices such as farmers applying glyphosate to dry up the leaves at harvesting are reported.

4.1.5.b TFP determinant factors

TFP change in these two periods can be explained based on few factors.

1. Entering the private sector in soy processing industry and their investment in contract farming
2. Cultivation expansion in Mahaweli H where water stress is less (Figure 4.52 & figure 4.53).
3. An assured market for soybean to the soybean farmers
4. Extension support of DOA for quality seed production

Due to the fact that there is no demand for soybean in the open market, most of the growers are willing to cultivate this crop only when a contract grower system is available. In most of these contract agreements, the marketing company supply seeds and other inputs while the grower agrees to sell the produce at a fixed price.

Non-availability of quality seeds is another hindrance for the profitable cultivation of soybean due to loss of germinability within the short period of time. The main reason for loss of viability within short period of time is high oil content of soybean seed. Therefore, seeds cannot be stored for a long period. The most adaptable variety, Pb 01 loses its viability within 3-4 months after harvesting. The unsteady market also affected on low availability of quality seeds.

Private sector ventured into soy processing industry made investments to develop good quality seeds.

Plenty food private limited

It is a pioneer company in cereal food production in Sri Lanka started its operation in 1996. Locally grown soybean are purchased for the production of cereal samaposha They gradually build a system of contract growing with farmers in major irrigated schemes, Huruluwewa, Dewahuwa, Nachchcaduwa. They supply seeds and other inputs to farmers and purchases soybean to an agreed price. In 2005, they started a program with IFS to give farmers an inoculum for nitrogen fixation. They also provide fungicides for seed treatment. The company has its own extension program and is closely working with FCRDI in Maha Illuppallama. They also have seed farmers who produce seeds for their own farmers as DOA seed production is not in required quantities. Current extent under company contract grower system is 4000 Ac. The average farmer yield is 859 kg per Ac (2122 kg/ha). Best farmers yield rise to 3705 kg/ha. Seed production subsidies – 2013

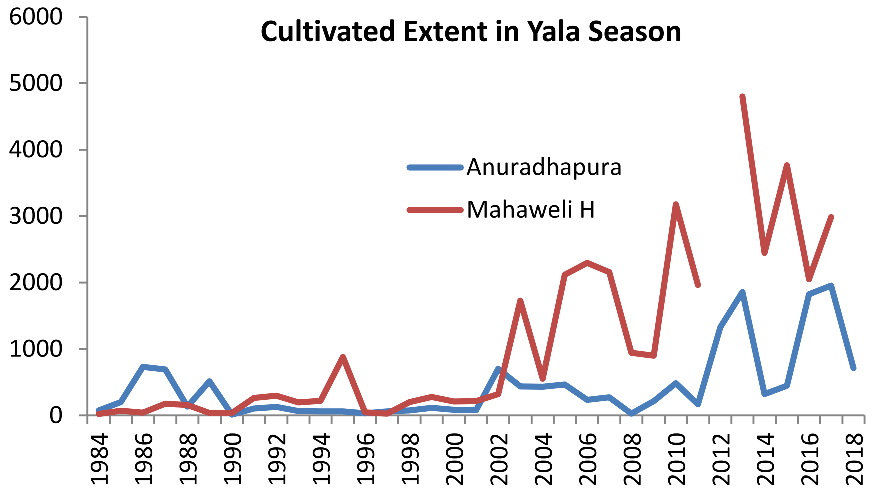


Figure 4.52: Soybean cultivated extent during yala season
Source: Department of Census and Statistics

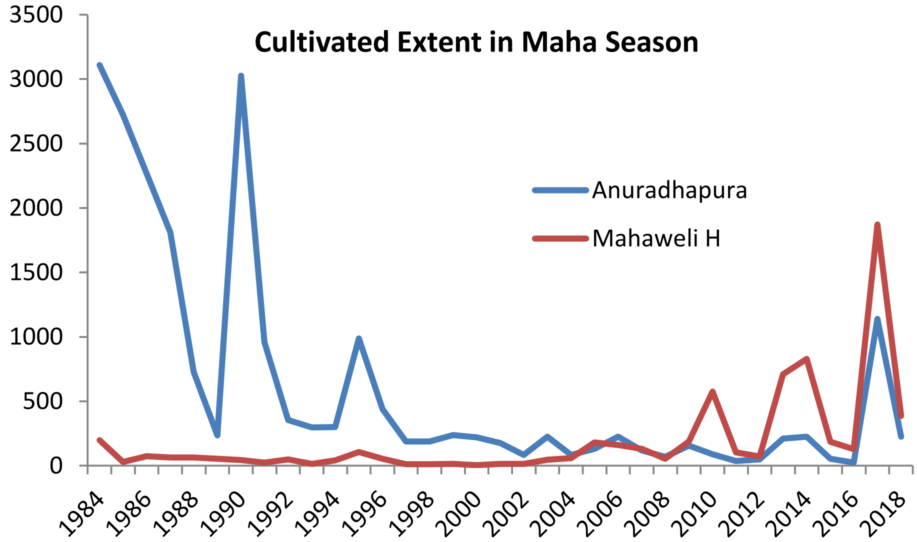


Figure 4.53: Soybean cultivated extent during maha season
Source: Department of Census and Statistics

Variety Development Program

- The Department of Agriculture has three recommended soybean varieties for general cultivation by the farmers. But the variety Pb 01 which was introduced during early stages of the Soybean development program is still popular among local farmers. Variety PM 13 and PM 25 were locally developed and PM 13 is almost similar to the Pb 01 in many characteristics but the demand is low compared to the Pb 01. Among the recommended varieties Pb 01 matures with 80-85 days with a yield of 1,700-2,000 kg/ha. PM

- Soyabean seeds are not permitted to import as a planting material under plant quarantine act
- Since this is an introduced crop, there is no genetic variability exists within the country

Objective of the current soybean breeding program is to develop varieties having yields above 5 t/ ha under irrigated and 3 t/ ha under rain fed conditions together with the other desirable traits such as determinate growth habit, large seeds and tolerance/ resistance to pest & diseases.

• Three F6, three F4, one F3 and two F1 populations were established in the field as bulk populations for generation advancement. Three new crosses were made with the objective of developing high yielding varieties. Further evaluations will be carried out.

Hundred and seven lines received from Michigan State University were evaluated with the local recommended varieties to select lines with high yielding and agronomic characters which will be suited for mechanical harvesting. Further evaluation will be carried out.

• Eight promising lines selected from germplasm evaluation of the lines received from Michigan State University were evaluated in PYT. Trial will be repeated due to poor plant count.

• The lines with better characters compared to Pb 01 of M7 generation obtained by irradiating seeds of the variety Pb 01 with 50 kr, 100 kr, 150 kr, 200 kr and 250 kr strengths were selected to evaluate in PYT.

4.1.5.c Lessons from other countries

Soybean breeders continuously adapt tools and technologies that encompass classical breeding, mutation breeding and marker-assisted selection, biotechnology and transgenic approaches, gene silencing, and genome editing. In addition to breeding technologies, improved agronomics, precision agriculture and digital agriculture have advanced soybean production and profitability

In most other parts of the world, GM varieties of soybeans are replacing non-GM varieties and providing cost advantages, at least in the immediate term. India has not yet allowed the cultivation of GM varieties of soybeans. If India does not keep pace with the rest of the world in adopting new technologies, it will lose the domestic as well as the export market to other major soybean producing countries such as Brazil, Argentina and the United States. It seems that the niche India enjoys in the export of non-GM soya products to the European Union is small compared with the loss of the domestic and international markets to soya products from GM varieties being grown in other countries.

Indian soybeans lose their competitive edge because of poor productivity. The recent productivity level of soybeans in India is about one-half of the average yield in China and one-third of that in the United States, Argentina and Brazil. Moreover, soybean yield in India is stagnant around 1 000 kg/ha, but input requirements are rising because of the increasing susceptibility to insects and pests and the nutritional imbalances in soil, resulting in a small squeeze on farm income.

4.1.6 Big Onion

Big onion (Allium cpa Var. Cepa of family Alliaceae) cultivation was started as a cash crop in the 1980s' in order to supplement the income of the paddy farmers during the dry season. Initial cultivation got under way in rice fields in the mid country intermediate zone which was then spread towards the areas in the low country dry zone. Big onion is a highly seasonal crop and its cultivation is limited to the yala season in paddy fields (Figure 4.54). Therefore, the main **big onion production** takes place during the months of **August to October.** Accordingly, domestic big onion supply from yala season arrive the market from August to October which meets only 25 - 30% of the big onion demand. Nearly 70 % of requirement is still imported to the country mainly from India and Pakistan.

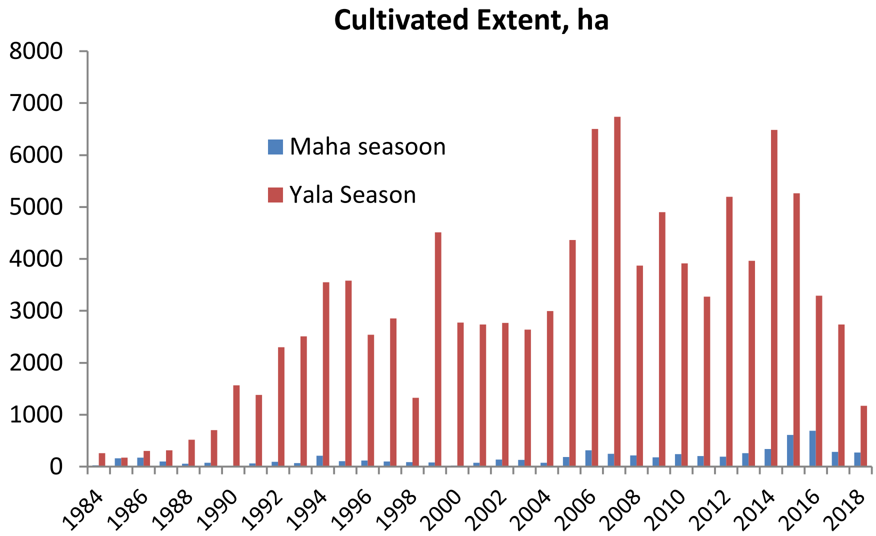


Figure 4.54: Cultivated extent of Big Onion during maha and yala seasons
Source: Department of Census and Statistics

Big onion cultivation has mainly spread over the areas in Anuradhapura and Matale districts (Figure 4.55) and the cultivation is mainly confined to localities in Sigiriya, Dambulla, Galewela, Devahuwa, Naula, Mahaweli H area and surrounding areas due to the specific climatic suitability for big onion cultivation.

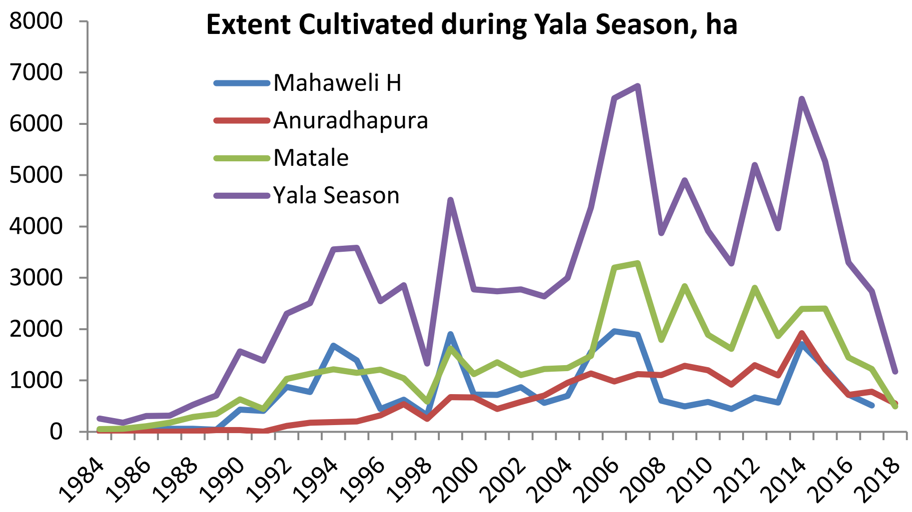


Figure 4.55: Cultivated extent of Big Onion during yala season by district
Source: Department of Census and Statistics

Big onion cultivation is primarily determined by the import policy of the government and the trade barriers in exporting countries, particularly India in addition to the prevailing weather. Extent cultivated increases in the years when the producer prices of the preceding season were favourable owing to the implementation of import restricting policy by the government. In contrary extent cultivated drops when imports are liberalized.

Until mid-1996, government adopted a trade restrictive policy for the imports of big onion which involved import licensing requirement and high import tariff. In mid-1996, the Government liberalised the imports by removing the licensee requirement and duty waivers were provided. Also 1996 recorded a year of drought. Cultivation extent dropped and the stiff competition from cheaper imports continued. Big onion cultivation further dropped. In 1998 India banned big onion exports resulting very high price in the local market. That prompted many farmers in the Matale District and Mahaweli 'H' area to cultivate big onions in 1999. However, from following season farmers started to face the competition from imports.

In 2006 government made tariff adjustments to protect certain domestic agriculture produces. Customs duty on big onion imports increased from Rs. 10 per kg to Rs. 20 per kg and a cess of Rs. 10 per kg was introduced on imported big onions to ensure a fair price to local big onion producers. Cultivated extent increased by nearly 1,500 ha in 2006 and more than a 50% increase in cultivated extent was observed in Mahaweli H area.

Due to the import duty waivers granted in 2008, farmers dropped cultivation.

Due to the increase in the extent of cultivation in the Northern Province and the increase in the Special Commodity Levy on imports targeting the harvesting time, production of big onions increased since 2011.

In 2015, 5875 ha was cultivated both maha (612 ha) and yala (5263 ha) season and 89,770 mt was produced. Cultivation dropped after 2015 due to bad weather and subsequent drop in big onion seed production. In 2019 India banned big onion exports that led to huge shortage in big onion supply in the market.

Table 4.16: Production, imports and supply of Big Onion

	Production	Imports	Total supply	% Imports
2001	31,966	114,586	146,552	78%
2002	31,560	133,679	165,239	81%
2003	32,301	134,174	166,475	81%
2004	37,508	120,080	157,588	76%
2005	55,552	122,454	178,006	69%
2006	73,616	130,441	204,057	64%
2007	92,166	164,551	256,717	64%
2008	57,371	173,611	230,982	75%
2009	81,707	159,510	241,217	66%
2010	58,930	170,072	229,002	74%
2011	61,037	177,538	238,575	74%
2012	83,561	152,929	236,490	65%
2013	69,635	149,490	219,125	68%
2014	101,166	162,373	263,539	62%
2015	89,767	225,421	315,188	72%
2016	65,222	113,652	178,874	64%

Source: Department of Census and Statistics, FAO

4.1.6.a Productivity

Land productivity

National average yield of big onion was 9 mt/ha before 1998 and it has increased to about 12 mt during the recent past. However, the highest national average yield of 13.8 mt/ha was recorded in the year 1999.

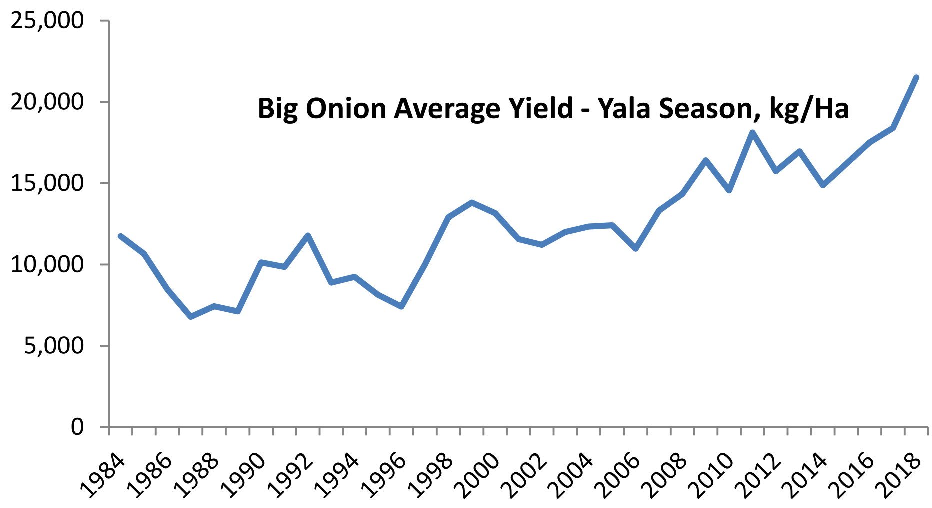


Figure 4.56: Average yield of Big Onion during Yala season
Source: Department of Census and Statistics

Table 4.17: Average yield of Big Onion in neighboring countries

	Average Yield (kg/Ha)				
	Sri Lanka	**India**	**Bangladesh**	**Thailand**	**Vietnam**
1980-90	8,177	10,289	4,022	10,590	3,105
1990-00	9,164	10,539	4,098	13,183	2,996
2000-10	10,547	13,270	5,711	26,019	3,141
2010-18	14,405	16,025	9,075	26,347	3,684

Source: FAO

Big onion yield of Sri Lanka is comparable to big onion yield of India. However, Thailand yield exceeds 25 mt per ha (Table 4.17).

Labour productivity

Onion crop is highly labour intensive and labour accounts to the main cost component in big onion production. The preparation of nursery, transplanting, weeding, and harvesting are accounted for main share of labour. Big onion cultivation is more or less a family enterprise in Sri Lanka that utilises the family labour for the operations. Per ha labour use has come down from 500 man days to 300 man days from 1999 to 2017.

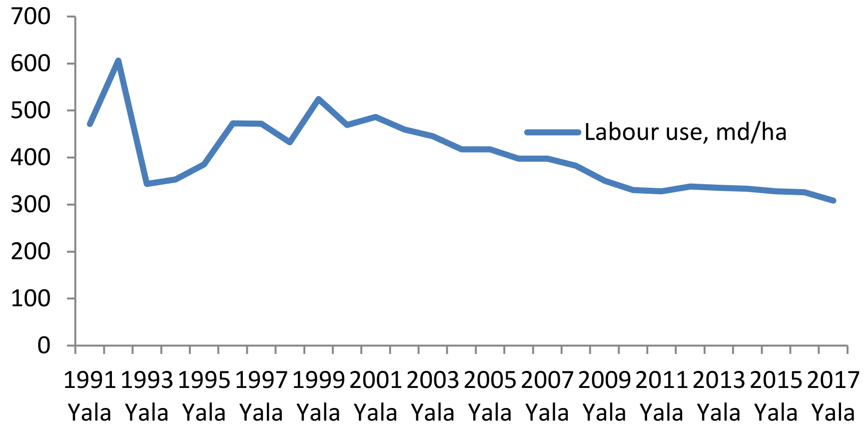


Figure 4.57: Per ha labour use in Big Onion farming
Source: Study estimates

Table 4.18: Per ha labour use in Big Onion farming in Sri Lanka and Indian States

Labour use per ha (man days)

	2004/05	2006/07	2014/15	2015/16
Maharashtra	233.2	187.1	194.7	179.6
Karnataka	141.2		81.4	99.2
Gujarat		149.5	211.6	213.4
	2005 Yala	**2007 Yala**	**2014 Yala**	**2016 Yala**
Sri Lanka	417.4	397.7	333.4	326.0

Source: Indian Ministry of Agriculture and Farmers welfare, study estimates for Sri Lanka

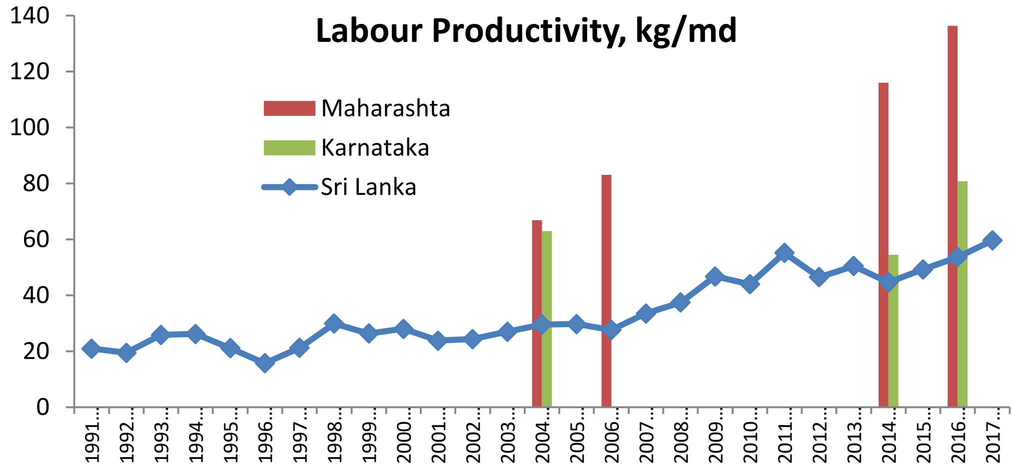


Figure 4.58: Labour productivity of Big Onion in Sri Lanka and Indian States
Source: Indian Ministry of Agriculture and Farmers welfare, study estimates for Sri Lanka

However labour use in big onion cultivation in main states of India is as twice as low compared to labour use in Sri Lanka (Table 4.18). Labour productivity of big onion in India is much higher in states like Maharashta compared to Sri Lanka due to both efficient labour use and average yield (Figure 4.58).

In China, U.S.A. and many European countries, onion cultivation is fully mechanized. India has initiated programs to develop machineries and implements to mechanize onion farming activities to bring down the current level of labour use to compete with world partners. ICAR-Directorate of Onion & Garlic Research provides the leadership.

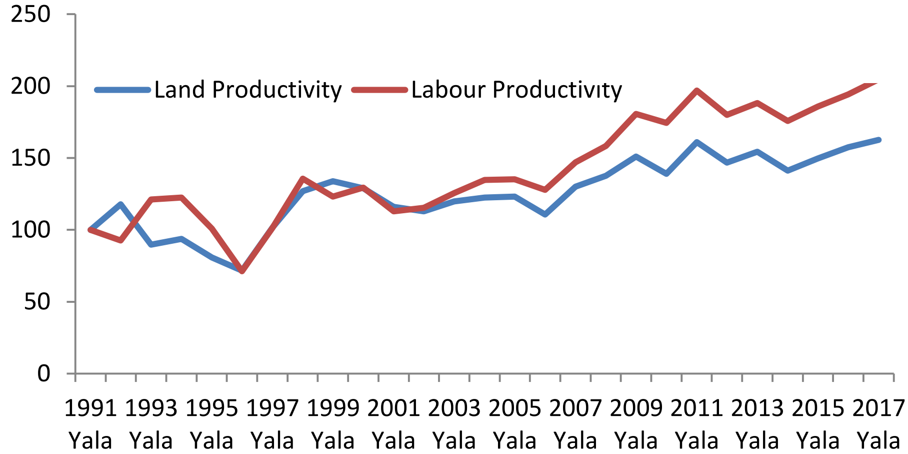


Figure 4.59: Land and labour productivity of Big Onion
Source: Study estimates

Of the two factors responsible for labour productivity, drop in per ha labour use after 1999/2000 also contributed to increase labour productivity (Figure 4.59).

Total factor productivity

TFP index estimated for the yala season by the study is graphically shown below (Figure 4.60). Since 2005, significant TFP growth is observed. This is shown by increased per annum land productivity growth from the period of 1991 to 2005 and 2005 to 2017 with declining per capita growth of input intensification on land (Figure 4.61). The disaggregated factor input intensification on land is considered, the use of fertilizer, seed, labour and machinery use has decreased while the use of chemicals has slightly increased (Table 4.19).

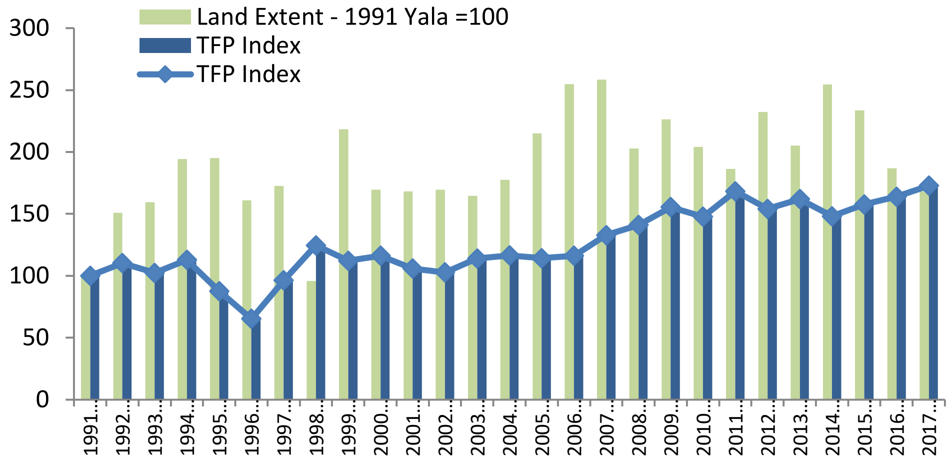


Figure 4.60: Land extent and TFP growth index based on base year 1991 yala
Source: Study estimates

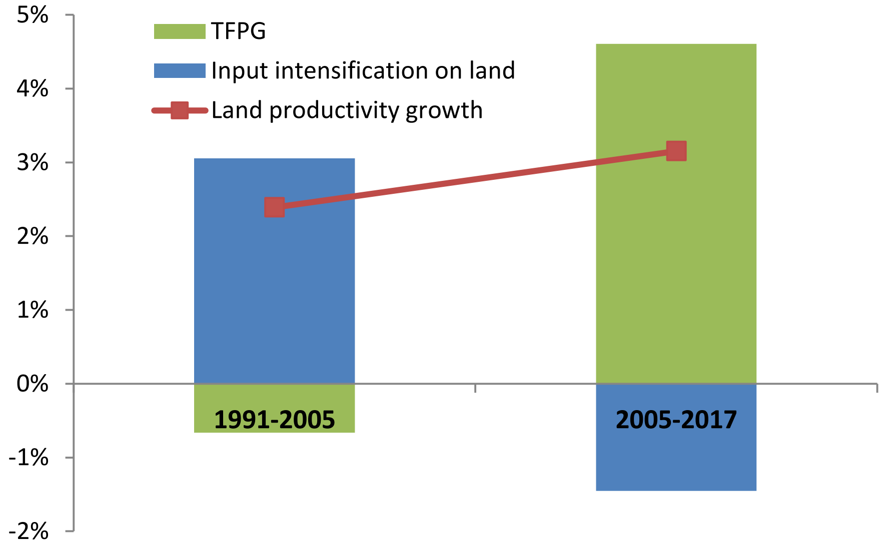


Figure 4.61: Input Intensification, TFP and Land productivity
Source: Study estimates

Table 4.19: Factor intensification on land by factor

	Fertiliser	*Labour*	*Seed*	*Machinery for land preparation*	*Machinery irrigation*	*Chemicals and other*
1991-2005	8.5%	0.0%	0.2%	2.7%	0.6%	4.9%
2005-2017	-2.0%	-2.2%	-2.1%	0.3%	-0.1%	5.5%

Source: Study estimates

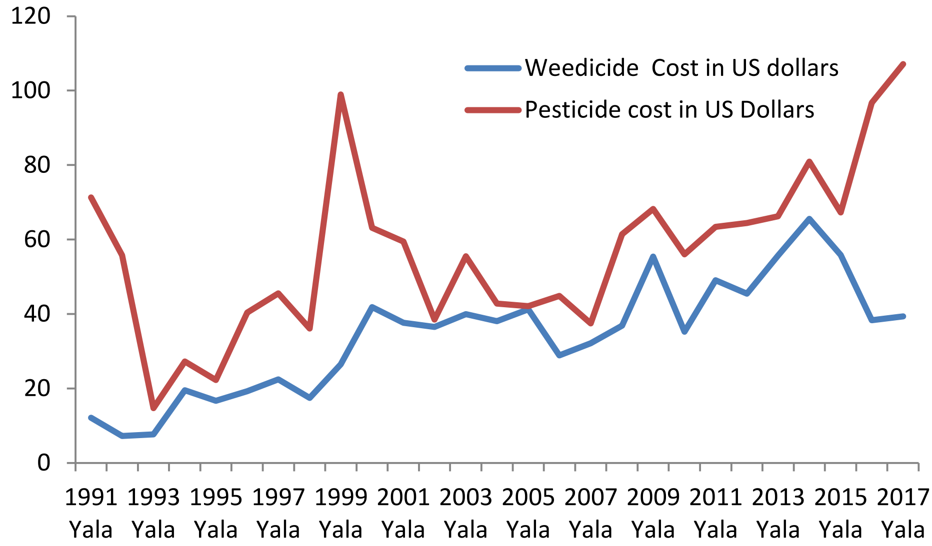


Figure 4.62: Weedicide and pesticide use per ha in US dollar terms
Source: Study estimates

To cultivate one ha of land it is required 7.5 - 8.5 kg of true seeds. If proper nursery techniques are used with high quality seeds it can be reduced up to 6-7 kg/ha.

4.1.6.b TFP determinant factors

Varietal technology and quality seed production

Seeds play a vital role as the important input that determines the yield level of big onion.

DOA imported over 95 percent of onion seed before 1990. Since ASCs are scattered throughout the country, farmers had access to DOA seed. After 1990, however, with the change in the administrative structure and withdrawal of KVSs, private seed dealers emerged. Since then, the government permitted private sector to import onion seed (DOA, 1990).

The National Seed Policy of commercializing the seed and planting material sector was announced in 1996. The Seed Act focuses on enhancing the production and marketing of high quality seeds. Government initiated the duty free import of seed and planting material. The private sector was expected to play an important role in the seed industry. Since then, the seed imports that were made illegally by the private sector constituted 80% of the seed requirement. As importation of true seed costs a large amount of foreign exchange in addition to the problems

Except for a few selections of Indian varieties, big onion cultivation is mainly dependant on seed varieties imported from India by private traders. Varieties, Rampur Red, Nasic Red, Pusa Red and Agri found light red are recommended for Sri Lankan conditions considering the factors such as high yield, seed setting ability, storage adaptability, pungency, colour, etc.

- Pusa red - Variety was developed at IARI, New Delhi, India. It is well adapted to dry zone of Sri Lanka. 90- 100 days to mature the crop. Average yield is about 20-25 mt/ha. High pungency, Light rose in colour
- Rampure -Originated from India. Well adapted to dry zone in Sri Lanka. Takes 85- 90 days to mature the crop. The yield is about 15-20 mt/ha with better storability. light rose in colour, High pungency
- Agri found light red - Variety developed at India by mass selection well adapted to dry zone to cultivate as a yala crop under irrigation. Pink in colour and it takes about 90-100 days to mature. average yield is about 15-20 mt/ha with good storability.
- Nasic red-Mainly cultivate as vegetable. Dark red in colour poor storability.

Kalpitiya Selection and MI Pusa Red are two of the selections by the Department of Agriculture. Dambulu Red is a farmer selection of MI Pusa Red.

According to field information, Nasic Red has the highest production, but lacks the storing quality. Rampur Red on the other hand has a higher keeping quality though its yield is somewhat low. The Dambulu selection has both yield as well as keeping quality.

Seeds are produced in the country during the maha season by a process of vernalisation. Until the government supported true seed production program had actively implemented since 2005, imported varieties; RampurRed and Nasic Red were widely cultivated. in main producing areas (Table 4.20).

Big Onion Seed Production in Sri Lanka

One of the main factors that determine the yield of big onion is the quality of seeds. In order to supply good quality seeds with high keeping quality at a lower price both government and private sector developed seed production programs.

Government Supported Big onion True Seed Production Program

Though true seed production programme started in 1984/85 maha season, it has shown a considerable progress only in 2005 in the Matale district. In the Matale district, the highest production level was recorded in 2009/10 maha season (4,500kg). Galewela and

Dambulla are the major big onion seed producing ASCs in the Matale district. Also considerable production is recorded in Kimbissa, Kongahawela and Naulla ASC areas of the district. In Anuradhapura and Mahaweli areas, the seed production only takes place in maha season and the seed production was at a low level before 2008. In the Anuradhapura district, seed production started in 2004/05 maha season. A significant production was recorded in 2009/10 maha season.

Private Sector Big Onion True Seed Production

In addition to the government supported big onion true seed productions, few private sector companies have engaged in seed production in the Matale and Anuradhapura districts. CIC, Hayleys, Onesh and Agstra are the private sector big onion seed production companies in the Matale district.

CIC is the leading big onion true seed producer producing 3000 kg of seed during the financial year of 2009/ 10. Seed production is done in the maha season using poly tunnel with high technology. They have enough cold storage facilities for mother bulbs. The cold storage was built with the collaboration of the Regional Economic Advancement project (REAP). They have their own mother bulb production programmes and out grower system for mother bulbs. Produced seeds are tested in the company laboratory which has ISO quality certification. Agri Found light red ("Galewela light Red") and "Pusa Red" (Dambulu Red) are the varieties of seed produced by CIC. Produced seeds are packed in aluminum packages. Lack of foundation seed and lack of technical support by the DOA are pointed as the major problems in producing big onion seeds by the CIC.

Hayles started big onion true seed production in 2009/ 10 maha season. They had bought mother bulbs from the farmers within the area on the recommendation of the Agriculture Instructor (AI). They have produced only 132 kg of seeds and have distributed them to farmers through dealers. Before releasing the seeds they had tested for germination in their own labs. Produced seeds are packed in aluminum packets. Lack of foundation seeds and skilled labour shortage are the major problems they had faced in seed production process.

2012 - Big Onion seed production was started in Govt. seed farm MI for the first time.

Below figure shows the government seed production and imports quantities (Figure 4.63).

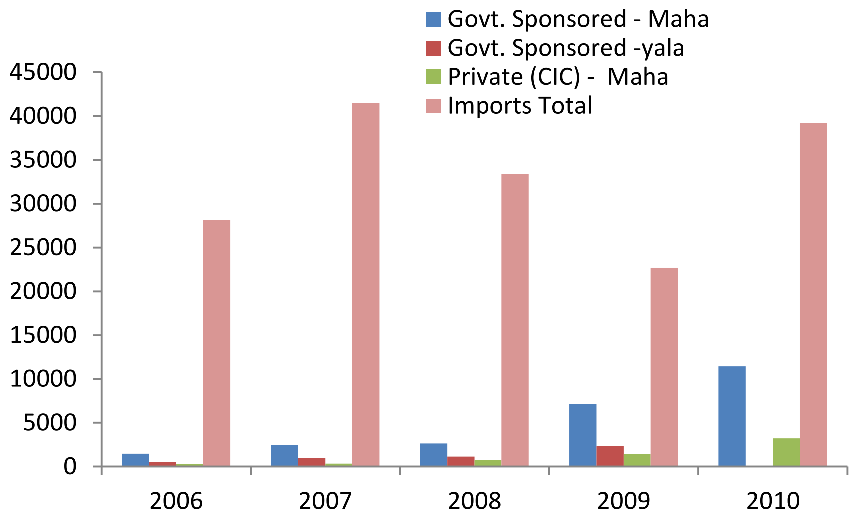


Figure 4.63: Government seed production and imports, Mt
Source: DOA, Department of customs

Table 4.20: Adoption of Big Onion Varieties

		%			%
2005 Yala	Rampur	80	2011 Yala	Rampur	60
	Nasik red	16		**Local**	40
	Poona red	4	2012 Yala	**Dambulu red**	74
2006 Yala	Rampur	90		Imported	26
	Nasik red	10	2013 Yala	**Dambulu red**	58
2007 Yala	Rampur	78		Nasik	33
	Nasik red	14		other	9
	Dambulu red	8	2014 Yala	Nasik	54
2008 Yala	Rampur	60		Rampoor	17
	Dambulu red-	26		**Local**	29
	Nasik red	14	2015 Yala	**Local**	98
2009 Yala	Nask red	30		Nasik	2
	Dambulu red	27	2016 Yala	**Lanka seed**	96
	Galewela red	19		Nasik	4
	Rampur	13	2017 Yala	**Lanka seed**	97
	Other	11		Rampur	3
2010 Yala	Rampur	59	2018 Yala		
	Local	40			
	Nasik red	1			

Source: DOA

Effect of trade policies on big onion cultivation decisions and the investment decision on seed production by private sector

Big onion cultivation is primarily determined by the import policy of the govemmcnt. Significant increases in cultivated extents are observed if favourable producer prices prevailed during the preceding season.

The availability of supplementary irrigation for cultivation

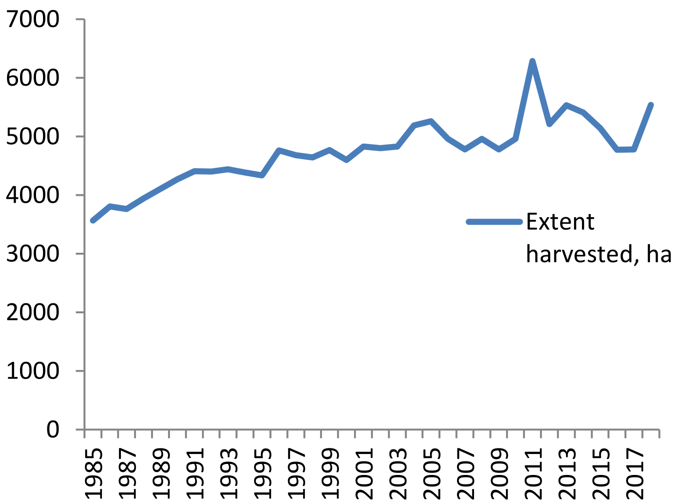
In a productivity development program supplementary irrigation should be an essential component as is an important input in big onion cultivation.

4.2 EXPORT PROMOTING DOMESTIC FOOD CROP SECTOR

4.2.1 Pineapple

Pineapple was initially a home grown fruit which later became one of the leading commercial fruit crops grown in Sri Lanka. Now it is mainly grown by smallholders (less than 10 acres) and a few large-scale farmers. The two types of pineapples grown in Sri Lanka are Mauritius and Kew. Despite being Sri Lanka a small producer with less than 1% of the world production, Sri Lankan pineapple has a high demand in the world market. Mauritius variety, one of the tastiest pineapple varieties fetching high price in the world market is grown in Sri Lanka.

Pineapples are normally intercropped with mature coconut trees or cultivated as a mixed crop. The majority of pineapples are grown on leased coconut or bare land in Gampaha and Kurunegala districts. However due to unavailability of larger plots of land for leasing, pineapple cultivation is often fragmented. Extent under pineapple crop has increased in the last few decades and shows a setback after 2013 (Figure 4.64). The decline in extent cultivated is attributed to a number of reasons including access difficulties to suitable land due to land parceling for commercial and residential purposes, volatility of prices and spread of diseases harming cultivation.



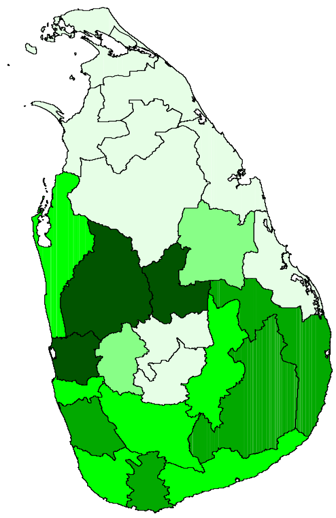


Figure 4.64: Pineapple Extent harvested
Source: Department of Census and statistics

Of the total cultivated extent, Kurunegala and Gampaha now occupy 50 % of the extent. There is either little or no irrigation for pineapple farming in these two districts and therefore farmers depend fully on rainfall. Cultivation in Kurunegala district has declined in the last few years while cultivation has spread into other districts. Mauritius variety is mainly cultivated in Gampaha and Kurunegala districts while Kew variety which is used for processing is cultivated in districts like Moneragala, Badulla and Hambantota.

According to the FAO statistics, production has been gradually decreasing after mid 90's although extent under pineapple increased until 2013 causing continuous declining of pineapple yield. Country produced 58,460 mt of pineapple in 2005 which dropped to 34,651 mt in 2018 (Figure 4.65 & figure 4.66).

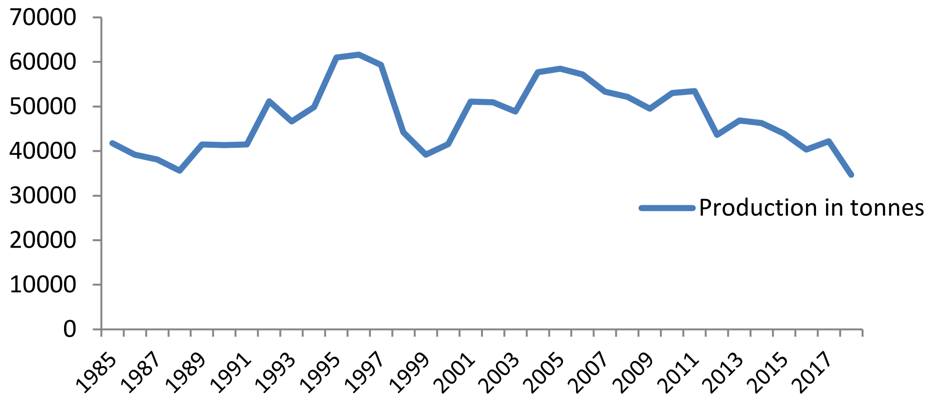


Figure 4.65: Total pineapple production
Source: FAO

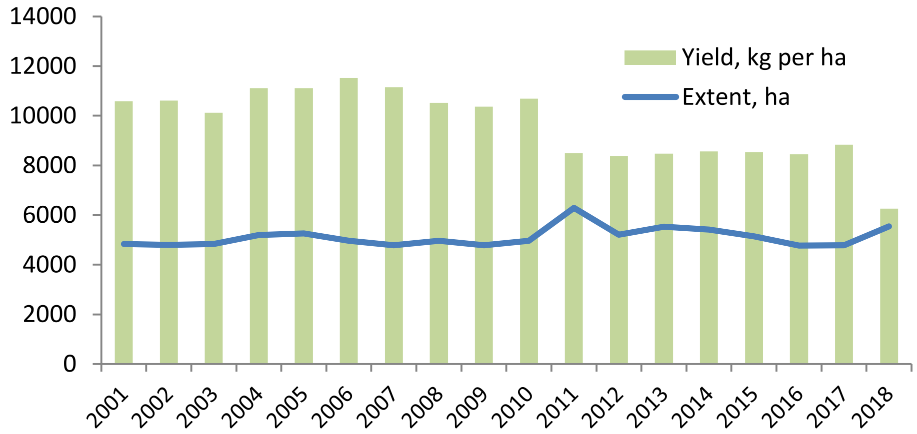


Figure 4.66: Extent and yield of pineapple, 2001 to 2018
Source: FAO

Pineapple has a high demand locally and in the export market in the form of fresh, juice, dried or preserved. Sri Lanka export only 2-6 % of the production to its main export destinations. However, according exporters this figure should be higher as pineapples are exported in crates mixed with other fruits and vegetables under a separate HS code. Nevertheless, local demand has been rising with the rapidly expanding tourism sector which demands exotic fruits. Fresh pineapple exports have increased up to 2004 by volume and have decreased sharply until 2012. During this period Sri Lankan main export destination has shifted from Maldives to Germany with a high value exports. Currently, Germany, USA and UAE are main export destinations for fresh pineapple and processed pineapple (Figure 4.67, figure 4.68 & figure 4.69).

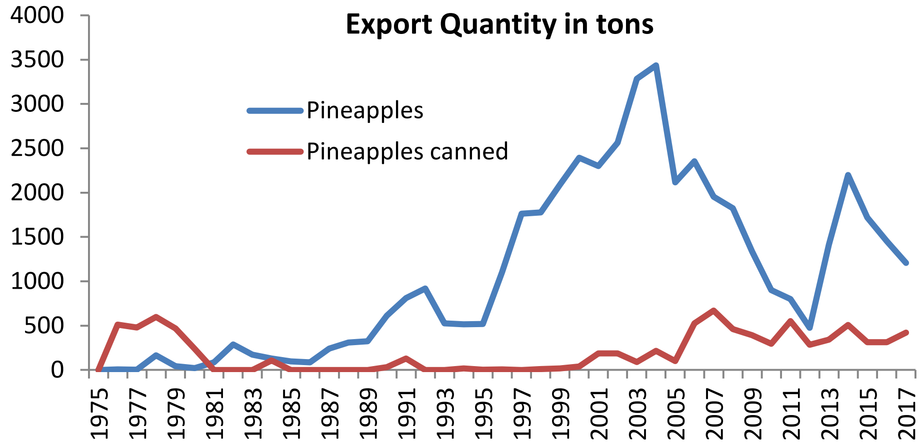


Figure 4.67: Pineapple exports in quantities by type of export
Source: FAO, ITC trademap

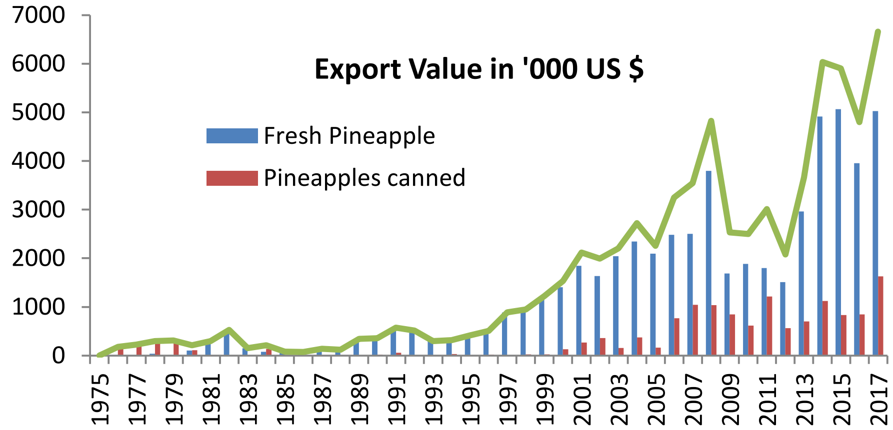


Figure 4.68: Pineapple exports in value by type of export
Source: FAO, ITC trademap

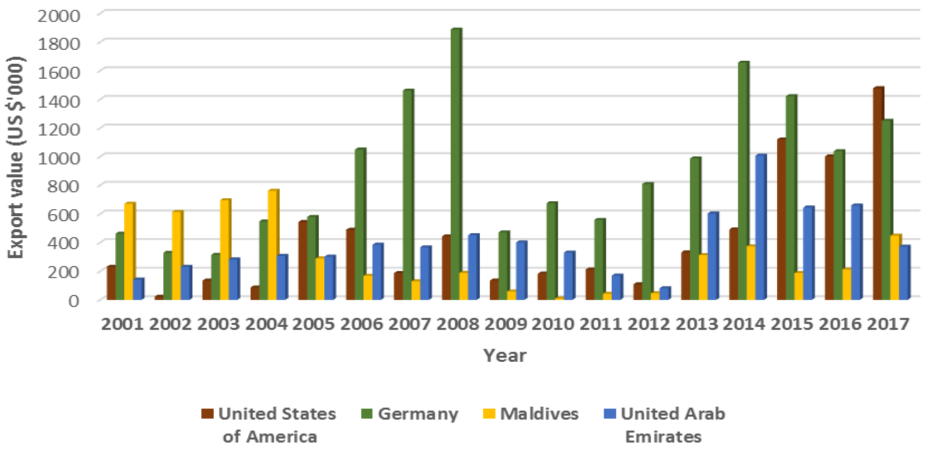


Figure 4.69: Value of fresh pineapple exports by export destination
Source: FAO, ITC trademap

Export of fresh pineapple was significantly determined by the average exchange rate and the domestic price of pineapple. Price difference between FOB and wholesale price in 2018 (Figure 4.70) shows that new markets in EU and USA are appealing to exporters although finding exportable quality pineapples in sufficient quantities is a problem. Pineapple fetches a relatively lower price in UAE markets than EU and USA markets. Pineapples grown in Sri Lanka has an increasing demand both locally and in internationally.

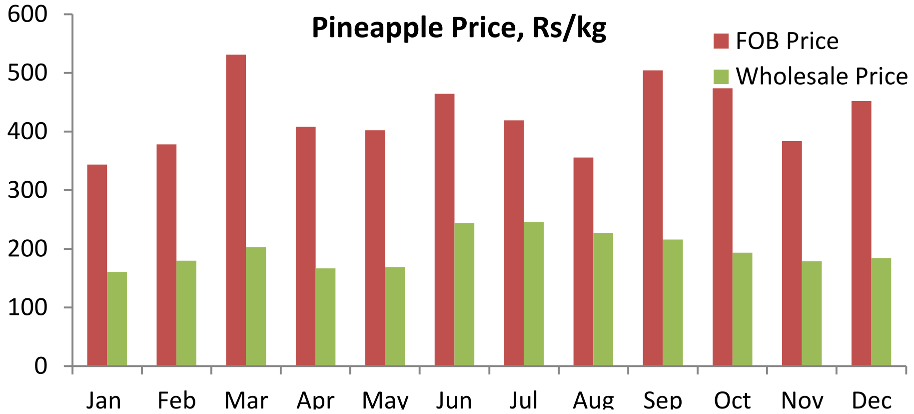


Figure 4.70: FOB and wholesale prices of Pineapple
Source: HARTI

4.2.1.a Land productivity

When the yield of pineapple is compared with neighbouring countries, Sri Lankan yield is very low, although its distinct taste has captured high price in the international market. Also it is noted that Sri Lankan yield are stagnating and declining while other countries' yields are increasing (Table 4.21).

Table 4.21: Area harvested, yield and production in Sri Lanka and neighbouring countries

	2016			2017		
	Area harvested ha	Yield kg/ha	Production tonnes	Area harvested ha	Yield kg/ha	Production tonnes
Bangladesh	13561	14800	200701	14359	14753	211833
India	110000	17491	1924000	111000	16766	1861000
Sri Lanka	5136	8757	44977	4783	8829	42229
Thailand	73228	24286	1778439	86454	24558	2123177
Viet Nam	34642	16033	555407	36658	16857	617944

Source: FAO

Despite Thailand being a large producer of pineapple, it is not a top exporter of fresh pineapples but a top exporter of canned pineapples. Quality pineapple of medium size is preferred in fresh pineapple trade whilst pineapple used for processing needn't such specifications. Pineapple yield in Thailand and Philippine is 3 to 5 times higher than Sri Lankan yield where multinational companies grow pineapple as mono crop plantations (Figure 4.71).

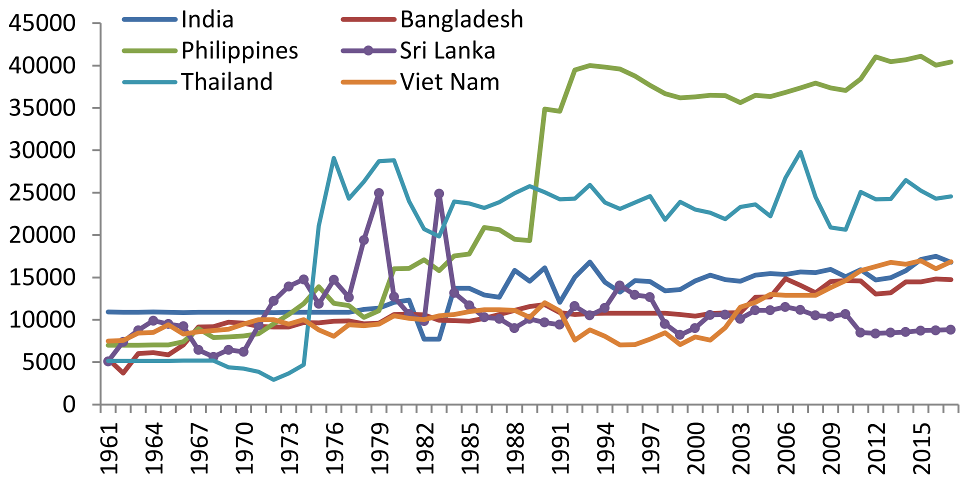


Figure 4.71: Pineapple average yield in Sri Lanka and neighbouring countries (kg/ha)
Source: FAO

Pineapple yield estimated from sample data by DOA and the study shows that pineapple in major growing areas either stagnating or declining that range from 12000 to 15000 kg per ha.

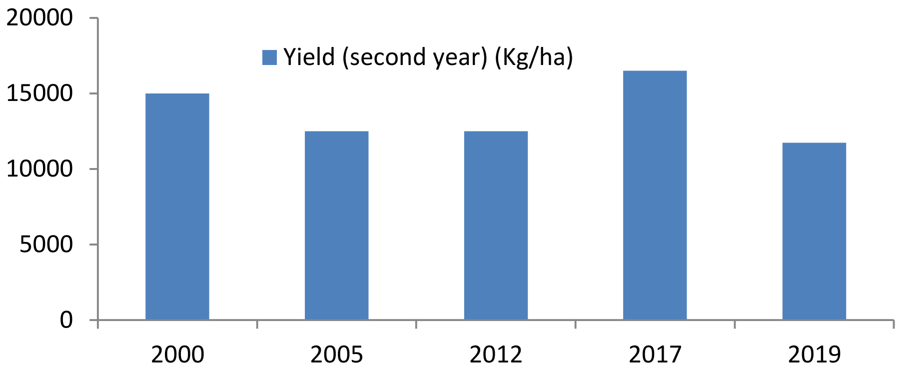


Figure 4.72: Pineapple yield in major producing areas
Source: DOA and sample survey 2019

Land productivity related factors

Variety

The two types of pineapples grown in Sri Lanka are Mauritius and Kew. These two varieties are medium size varieties. Since Sri Lanka go by quality for size of the fruit, increasing land productivity has limitations.

Planting density

Limited land resource is one the main problems faced. To better utilize land, plant density is increased by growing the pineapples in double and triple rows and reducing the spacing between them. Most of the sample farmers had planted an average of 5000 – 7500 suckers in an acre in double rows (12350 – 18525 per ha) (Figure 4.73). Some farmers had planted in triple rows. This planting density is higher compared to their earlier practice of planting less number of plants. However, companies such as Dole plant between 27000 – 33000 pineapple plants per acre (mono cropping) in Thailand and Philippine. The Department of Agriculture, Sri Lanka now recommends that 10,000 plants be planted per acre. Also FCRDC of DOA has developed new varieties with leaves having no thorns to ease the management of the crop between plants. This overcomes the problem of getting pricked and to allow cultivation with a reduced spacing more practical. However, the availability of such varieties is unknown to many growers.

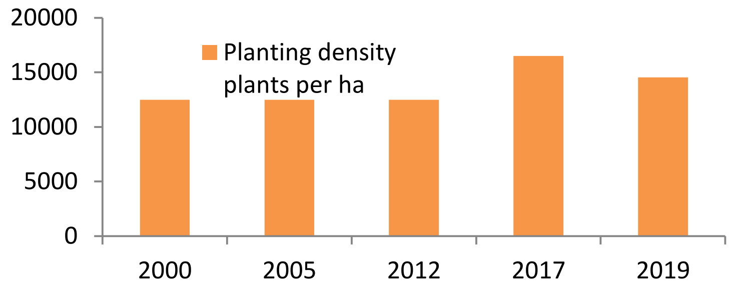


Figure 4.73: Planting density maintained in pineapple farming
Source: DOA, sample survey 2019

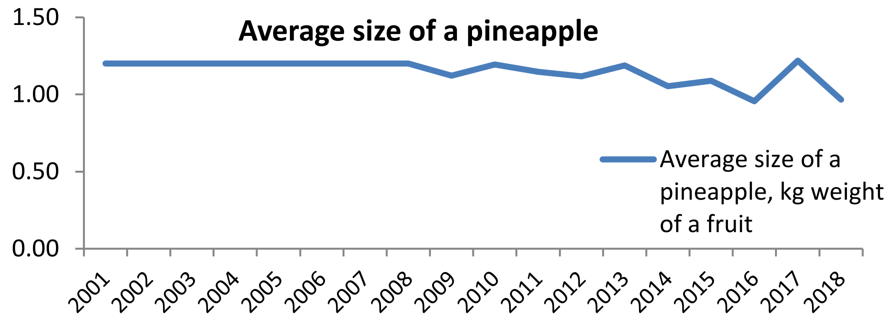


Figure 4.74: Average fruit size of pineapple
Source: FAO

The requirement of fruits for freight is the size of the fruit to be between 1-1.25 Kg and no bigger. By having more plants per acre, the size of the fruit gets smaller. It is observed, national average size of the pineapple has decreased over time depicting the grower's practice of planting suckers more closely (Figure 4.74).

Tenure period of the leased land

Since finding quality land to cultivate is a difficulty, most lands are taken in lease agreements. Lands were taken for 5 years (44%) earlier but now it has subsided to 3 (12%) (Figure 4.76). This has implications for long term sustainability of the land resource as farmers would grow the crop for three years and move from the land creating more land scarcity and leaving an unfertile land for rehabilitation.

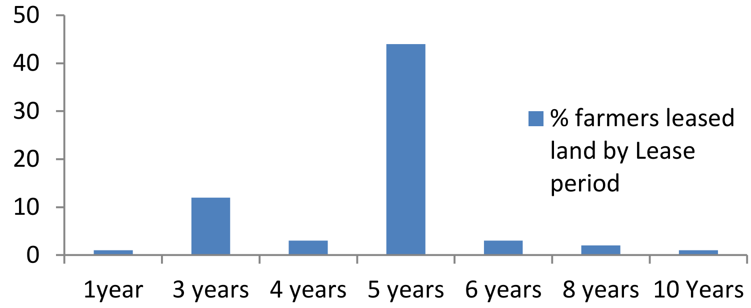


Figure 4.75: Percentage of farmers who leased land by lease period
Source: Sample survey 2019

Although the economic life of a pineapple plot is around 4-5 years with one plant crop and 2-3 ratoon crops, now there is a tendency to harvest the "plant crop" and 1-2 "ratoon crops" that is abide with the leasing period.

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Per annum leasing cost is around Rs 10,000 that ranges from Rs. 5000 to Rs. 20,000 for land leased in mature coconut lands for under cultivation.

Moving farmer from traditional areas to new areas

Traditionally, pineapple was grown mainly in Kurunegala and Gampaha districts but now with land parcelling, the area of cultivation has reduced particularly in Kurunegala district (Figure 4.76). Hence some growers have moved to newer areas which are less productive. Pineapple yield in Kurunegala district is declining. Also sample farmers have moved to rubber uprooting areas in other nearby districts such as Ratnapura on a lease agreement basis to grow pineapple as an intercrop.

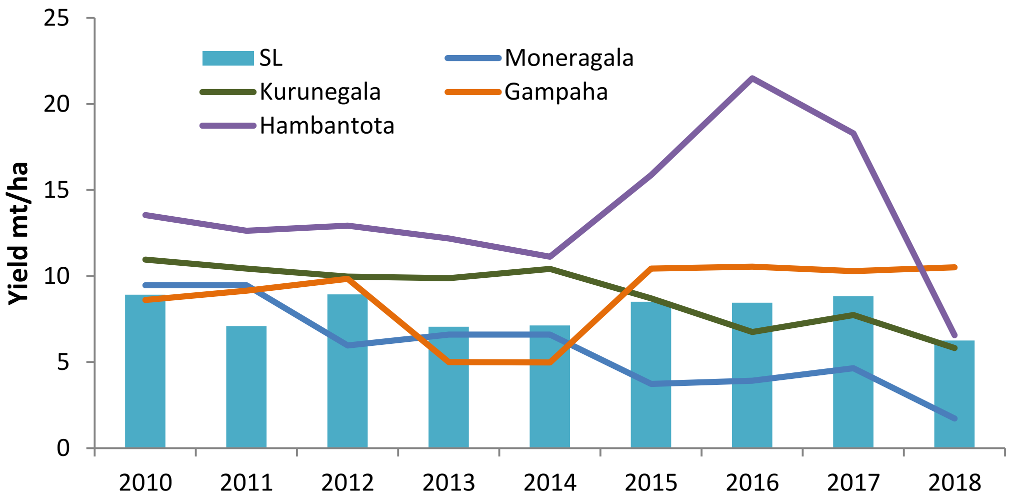


Figure 4.76: Average yield of pineapple by main cultivating districts
Source: Department of Census and Statistics

Good quality planting material

Pineapples are normally propagated from "slips" or "suckers". Suckers arise from the underground parts of the plant or the stem suckers are used mainly by sample farmers although propagation can also be done through slips that arise from the fruiting stem and from the crown on top of the fruit. However these methods are rarely used in Sri Lanka.

Nearly 50% of the growers have used their own planting material for new planting and the others have used suckers from their friends or neighbours. Only one farmer had purchased through farmer organization.

When the quality planting material production in formal sector is considered it is only DOA produces pineapple suckers in very small quantities to disseminate new technology. From 2014 to 2018 DOA has issued 173,784 suckers (requirement of nearly 10 ha). Although it was promoted to produce tissue cultured pineapple plants through various programs as an alternative technology to produce disease free planting materials, the technology was not proper that tissue cultured pineapple plants did not guarantee flowering and also deformities in fruits are also observed in pineapple in the field.

All farmers practice fungicide treatment before planting.

Fertiliser Use

Pineapple consume a heavy dose of NPK amounting to about 2000 kg per ha (Figure 4.77). The practice of use of liquid fertilizers is now low. This is attributed to the decreased quality of pineapples upon heavy use of the liquid fertilizers. This application is above the department recommendation. Irrational use of fertilizer depletes the soil quality further and the requirement become more. No reports of soil testing being done in the sample locations. Fertilizer mixtures with micronutrients are on the trend.

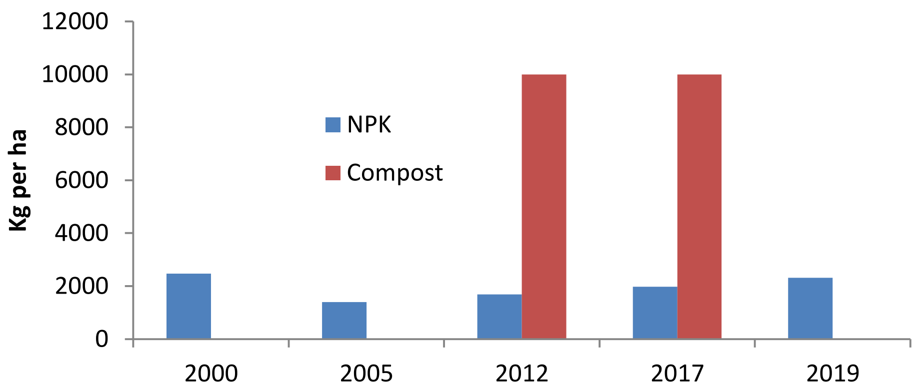


Figure 4.77: Fertiliser use in pineapple farming
Source: DOA, sample survey 2019

Hormone application

Currently farmers are able to better control the harvesting periods through the application of hormones. Therefore pineapples can be grown throughout the year. The hormones stimulate flowering and pineapples can be harvested 3.5 to 4 months from the time of application.

Agrochemical Use

Growers are using high concentrations of weedicide in each harvest. There is no proper regulation of weedicide application. The increase use of the weedicide by the growers is to increase the yield in new lands. The practice of mulching is almost none.

The place of mechanization in pineapple cultivation although minimal apart from land preparation, irrational use of the weedicides can be replaced by introducing adjustable weeders.

Extension and dissemination of new technology

Despite pineapple being an important economic crop, the attentiveness given to its cultivation by the authorities is not significant. Services provided and role of AI as extension agents are little or no effective. Experienced farmers have limited involvement with extension officers. New farmers source know-how information and input information from other growers, experienced farmers, friends, the local input shop owner and through programs conducted by chemical supplying companies. Experienced farmers get information about new fertilizers and other agrochemicals mainly from the local shop or through programs conducted by chemical supplying companies. For new farmers information flows to them from experienced farmers and not government agriculture extension officers

Collector also plays a role in providing information to farmers since majority of growers sell to local collectors who provide transport and warehousing for pineapples and then re sells them to either exporters, processors or other collectors/wholesalers who distribute pineapples to other parts of the country. A networking is seen among the collectors as well. Information on export quality parameters are passed on to farmers through collectors. Some input suppliers function as the collectors.

There are programs by the DOA to introduce new pineapple areas with new farmers. Research knowledge is disseminated as a package in these programs.

Quality of Pineapple harvest

According to the sample information, the quality of pineapple harvest gets lowered of the ratoon crop in subsequent harvests as below presented.

	Year 1	Year 2	Year 3
Grade 1	60%	50%	38%
Grade 2	26%	30%	34%

Also the stem suckers harvested in initial crop has more vigor than the stem suckers harvested in subsequent ratoon crops. Farmers find it more economical to go for only one to two ratoon crops and not further.

4.2.1.b Labour productivity

Most operation in pineapple farming is by labour except land preparation which is done by four wheel tractors. There is either little or no irrigation for pineapple farming in main pineapple growing districts and therefore farmers depend fully on rainfall. The highest labour requirement is for planting of suckers. Considering one plant crop and two ratoon crops, 1/3 rd of establishment labour is added to crop maintenance labour per year to calculate the labour requirement for one crop harvest in the sample study. According to the DOA crop enterprise budgets, more than 200 man days have been used per one crop in 2005, 2012 and 2017. In 2019 only 107 labour days have been used as study finds. Accordingly the labour productivity ranges from 150 to 230 kg per man day over the period from 2000- 2019.

	2000	2005	2012	2017	2019
Yield (second year) (Kg/ha)	15000	12500	12500	16500	11730
Crop Establishment labour (md/ha) –	62	135	153	182	49
Crop Maintenance and harvesting Labour (md/ha)	65	79	66	87	58
Total Labour per one crop harvest md/ha	127	214	219	269	107
Labour productivity	231	158	189	190	202

Table 4.22: Labour use in pineapple farming and labour productivity

Source: DOA, sample survey 2019

4.2.1.c Total factor productivity

Due to the limitation of time series data, productivity gains through technical change cannot be estimated. It is also the fact that much technical changes in pineapple farming has not happened. Technical efficiency estimated in previous study shows that mean technical efficiency in intercropped pineapple production in Kurunegala district is 85 per cent, a relatively higher technical efficiency.

TFP gaps between pineapple farmers due to differences in efficiency of resource are the focus of pineapple crop sector productivity analysis. Using cross sectional data from the primary data collected in the field survey stochastic frontier function was derived.

TFP measurement: results from the Stochastic Frontier model

The specification of the empirical model requires the choice of an appropriate functional form. In this study, the Cobb-Douglas functional form was chosen since a more general functional form to identify the impact of each input on pineapple production.

The OLS estimates of the production function in Cobb- Douglas form id given by:

$$In\ Y_i = \beta_0 + \beta_1 In(land) + \beta_2 In(Labour) + \beta_3 In(Establishment) + \beta_4 In(Pesticide) + \beta_5 In(Fertilizer) + \beta_6 In(Hormone) + \beta_7 In(Weed) + \beta_8 In(Machinery) + \beta_9 In(Other\ costs)$$

In the below table (table 4.23) suggests that, out of nine explanatory variables area of land statistically significant impact on production of pineapple followed by weedicide other factor which determines the production of pine apple.

Table 4.23: Results of Cobb – Douglas production function

Variable	Coefficient	Standard error	t - ratio
Constant	8.596	0.428	20.06
Ln land	0.988	0.052	18.96***
Ln labour	0.066	0.036	1.799*
Ln establishment	-0.024	0.024	-1.012
Ln pesticide	-0.017	0.041	-0.423
Ln fertilizer	0.0071	0.018	0.390
Ln hormone	-0.0035	0.017	-0.202
Ln weed	0.031	0.012	2.50**
Ln machinery	0.0030	0.0039	0.77
Ln other costs	0.0036	0.0038	0.962

Note: ***.**and * represents the 1%, 5% and 10% significant levels respectively

As size of extent land increases by one acre, on average production of pine apple will increase by 98% assuming that other factors held constant. Similarly, 1% increase in weedicide cost will enhance the average production of pine apple by 0.031% while 1% increase in usage of labour, it will raise the production by 0.066% in the study. However, rest of other inputs used in production of pine apple were not significant in the model.

In addition to the OLS estimation of the Cobb – Douglas function, the stochastic frontier production function for pineapple farmers is assumed to be:

$$\ln Y_i = \beta_0 + \beta_1 \ln(\text{land}) + \beta_2 \ln(\text{Labour}) + \beta_3 \ln(\text{Establishment}) + \beta_4 \ln(\text{Pesticide}) + \beta_5 \ln(\text{Fertilizer}) + \beta_6 \ln(\text{Hormone}) + \beta_7 \ln(\text{Weed}) + \beta_8 \ln(\text{Machinery}) + \beta_9 \ln(\text{Other costs}) + V_i - U_i$$

Where, V_i are assumed to be independently distributed normal random variables with zero mean and variance, σ^2 independently distributed of U_i and U_i are non-negative technical inefficiency effects, which are assumed to be independently distributed.

Table 4.24: Results of maximum-likelihood estimates for parameters of the stochastic frontier

Variable	Coefficient	Standard error	t - ratio
Constant	8.83	47.95	0.184
Ln land	0.949	0.048	19.62***
Ln labour	0.019	0.033	0.588
Ln establishment	-0.023	0.020	-1.133
Ln pesticide	0.0321	0.034	0.927
Ln fertilizer	0.021	0.016	1.34*
Ln hormone	-0.0049	0.014	-0.54
Ln weed	0.036	0.011	3.24**
Ln machinery	0.0018	0.0035	0.52
Ln other costs	0.0040	0.0030	1.33*

Note: ***, **and * represents the 1%, 5% and 10% significant levels respectively

Sigma-squared 0.0117 Sig value = 6.71

Gamma (λ) 0.575 Sig value = 0.032

Log- likelihood function = 72.08

Maximum likelihood estimate of the frontier production function were obtained using the Frontier 4.1 program and its results presented in the above table (Table 4.24). The signs of all the variables in the production function conform to a priori expectations except costs of establishment and hormone. The gamma (λ) parameter value is 0.575 implies that the technical inefficiency effects are significant in the stochastic frontier model and that the traditional production function, with no technical inefficiency effects, is not an adequate representation of the data.

Likelihood ratio test for the null hypothesis that all the coefficients of the inefficiency model are equal to zero was also rejected which implies that the explanatory variables have a significant effect on the level of the technical inefficiency in the model.

Results of maximum-likelihood estimates proved that, logs of land extent, has more contributes to the pineapple production followed by weedicide and usage. Also, fertilizer and other costs also influencing the production of pine apple in the model.

Results from the technical efficiency analysis reveal that on an average, the pine apple farmers in Gampaha district are operating with 53% of technical efficiency and there is a 47% of possibility to improve in efficiency with the given inputs and technology.

With such magnitude of inefficiency level, an investigation of the factors that may cause such level of inefficiency can help for policy making and thus, primary aim of the inefficiency models was to identify those socioeconomic and other characteristics, which contribute to technical inefficiency.

Table 4.25: Determinants of technical inefficiency

Variable	Coefficient	Standard error	t - ratio
Dolomite use	0.047	0.028	1.66*
Ownership of land	-0.028	0.026	-1.09
Age	0.0006	0.0011	0.532
Education	0.031	0.027	1.11
Type of planting material	0.069	0.051	1.18
Agric service centre	-0.075	0.026	-2.87***
Planting density	-0.000059	0.000012	-4.71***

Note: *** and * represents the 1% and 10% significant levels respectively

Out of 7 factors that determine the technical inefficiency, dolomite use, agric service centre and Planting density are the major determinants in the model (Table 4.25). Dolomite use has positive sign indicates that, uses of more dolomite in pine apple farming contributed to more inefficiency at 10% significant level. The coefficient of agrarian service centre has negative sign reveals that, the Urapola farmers are relatively more efficient than other farmers in the study. The coefficient of planting density has negative sign, but its value very close to zero shows that higher the density will reduce the technical inefficiency. In other words, higher the planting density, higher the technical efficiency but its impact is very low in the production of pine apple. All other variables included in the technical inefficiency model were insignificant.

Results from the Factor Productivity Index calculation

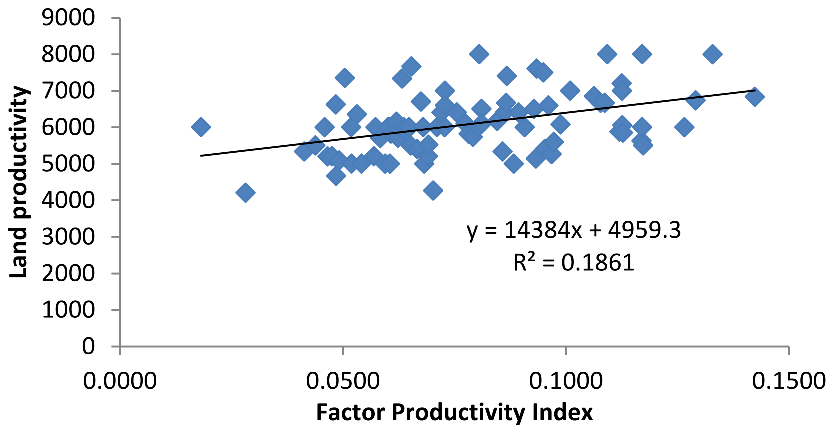
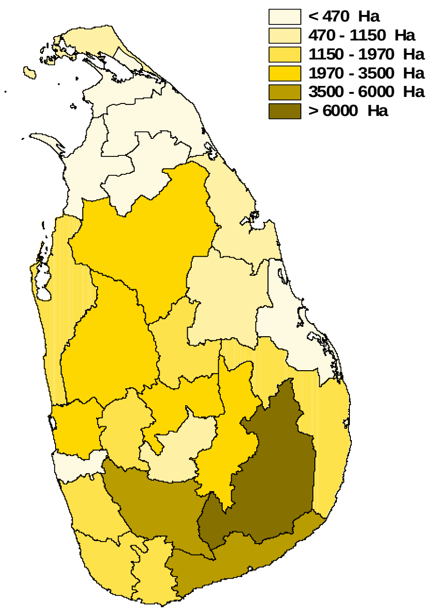


Figure 4.78: The relationship between land productivity and factor productivity index

The above relationship between land productivity and factor productivity shows that there is a higher variability of factor productivity compared to land productivity. In order to obtain same yield, while some farmers are using less resources the other farmers are using resources abundantly. May be it is due to the fact that technically efficient farmers practise better management practices while other are not adopting. Other factors may be that farmers are moving to marginal lands for cultivation due to land availability issues and land degradation because of continuous cultivation on same land. This establishes the findings from the above stochastic frontier analysis that the technical efficiency of pineapple farming has decreased compared to the finding of the study done earlier. In order to get higher yields farmers are resorted to apply non-optimal level of fertiliser and weedicides. None of the farmers practice mulching and use the fertiliser recommendation. Soil testing has not been done in these farm lands.

4.2.2 Banana

Banana *{Musa spp.)* is the most widely cultivated and consumed fruit in Sri Lanka and also the most popular fruit globally. It covers nearly 55% of fruit cultivation area in Sri Lanka. It is also an attractive perennial fruit crop for farmers as it gives economic gains throughout the year. Currently, nearly 45,000 ha (20,000 ha and 25,000 ha in wet zone and dry + intermediate zones respectively) of land is under banana cultivation in Sri Lanka. Annual banana production is around 674,000 mt and average yield is 11.5 mt/ha.



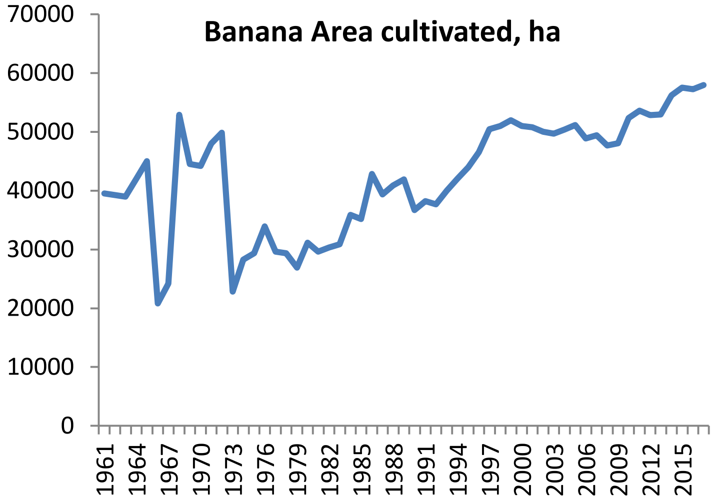


Figure 4.79: Total banana cultivated extent and cultivated extent by district
Source: Department of Census and Statistics, FAO

Banana Cultivation is widely spread in the districts Moneragala, Hambantota and Ratnapura and can be grown all over the island (Figure 4.79). In Moneragala more than 6000 ha are under banana cultivation. Since banana is said to be originated in the Indo-Malaysian region of Southwest Asia, several indigenous/local varieties are spread all over the Island. Of that, Ambul, Seeni, Kolikuttu and, Ambun are the most popular varieties growing in the country as a fruit. Varieties that are grown for curry making also constitutes a significant area. Recently introduced Cavendish variety is on the increase of its cultivation.

The drought years experienced a drastic drop of banana cultivation until banana cultivation became a crop under irrigated schemes. Due to severe drought in 1972 banana area dropped drastically. Paddy lands under Mahaweli Authority of Sri Lanka (MASL), farmers were allowed to cultivate OFC other than paddy and banana and papaya are cultivated in crop rotations. Recent increase in area and production is mainly attributed to the large scale cultivation of banana by Dole company with supplementary irrigation.

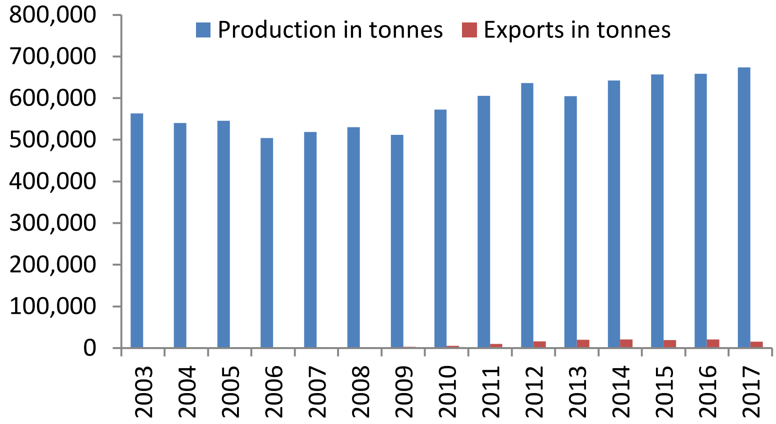


Figure 4.80: Production and export of banana

Out of the total production only around 5 percent is exported (figure 4.80). The main production is consumed locally. The recently introduced Cavendish variety has an increasing demand in the export market due to the consumer preference in the world market for its quality and taste of the fruit. It is estimated that yield of banana can be increased to the range 45-50 MT per hectare with the use of proper management systems, and the extensive use of high-yield varieties such as Cavendish bananas, which are the most popular (and sometimes the only) variety in most countries in the world. Except for very thin niche markets, local varieties serve the local demand.

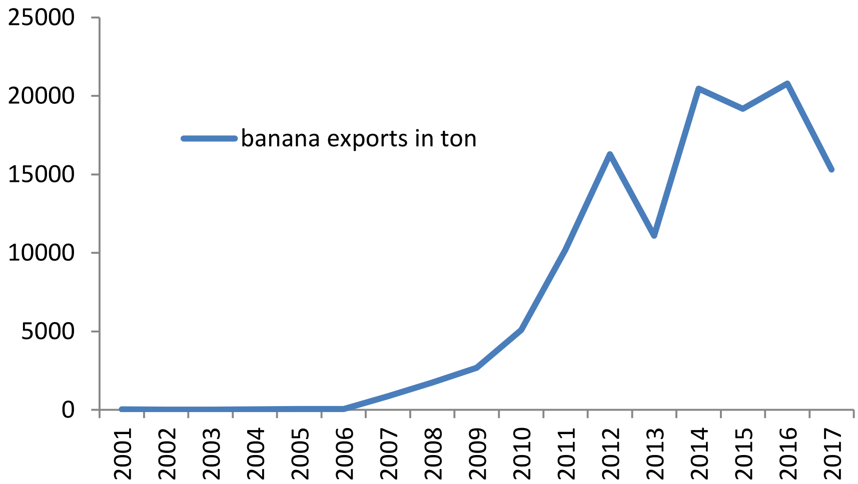


Figure 4.81: Banana exports from 2001 to 2017

Exports grew sharply after cultivation began in Sri Lanka by a giant global partner in world trade entering into an agreement under BOI (Figure 4.81). Over 80 percent of the world banana trade is controlled by five companies, including DOLE, the largest fresh fruit producer in the world accounts for quarter of banana production in the world. Dole Lanka Pvt. Ltd. is a subsidiary of Dole Asia Holdings Pte. Ltd. Founded in Hawaii in 1851, Dole Asia Holdings Pte. Ltd., based in Singapore, is the global operating headquarters of the Dole Group of companies owned by the ITOCHU Corporation and does business in more than 70 countries. Dole is one of the world's largest producers and marketers of high-quality fresh fruit and fresh vegetables and produces and markets a worldwide line of packaged and frozen foods. Dole Lanka operates several banana farms in the country from 2005, primarily located in Buttala, Demodara, Embilipitiya, Kuda Oya, and Mahiyanganaya. Like most tropical fruits, bananas are highly perishable, which need efficient harvesting, packing and transportation systems when export markets are targeted.

At the early stages of introducing Cavendish to Sri Lanka, CIC was collaboratively linked with DOLE Food Company for five years of time. More overly policies enacted to quarantine process, severely affected on initial steps of the Cavendish banana introduction to Sri Lanka, where the public sector interference was provided to loosen those restrictions by allowing import of disease free planting materials, and released after a period of one month.

Bananas for export are shipped green in refrigerated vessels that prevent them from ripening before arrival. Once they reach the destination they are ripened in special facilities.

The Cavendish type banana is cultivated in CIC farms, located in Hingurakgoda and Pelwehera. The Hingurakgoda farm owns 50-acres of Cavendish banana plantation where banana is planted under strict international conditions and the processing plant of banana exports. The packing house of banana was built to process banana for export market as per the agreement with one of the world’s largest fruit exporter DOLE. This pack house has capacity of handling and storing 20 MT of banana per day under controlled temperatures. High quality bananas are grown for the export markets using modern technology and the latest agricultural methods. The farm uses a high-tech sprinkler system for the supply of water and fertilizer. Pelwehera farm has a banana plantation of 150 acres where the cultivation is irrigated with micro-irrigation techniques.

CIC produces and sells approximately 3,000 MT of Cavendish bananas every year (exports and local markets included). Another initiative taken by CIC is to embark on contracted orchards to grow Cavendish bananas to meet the demands of this growing market. CIC produces around 175,000 planting material per annum. CIC exports between 25 to 50 metric tons of Banana every month to European Countries. In addition, the company also supplies the export quality banana to all leading supermarkets in Sri Lanka and is also available at all Fresheez and Juiceez outlets. Demand for high quality bananas has been on the increase, and CIC seeks to collaborate with exporters and out-growers to grow Cavendish bananas.

This Cavendish fruit has an increasing demand in the export market, generated by the non- destructive quality of the fruit in exporting and the high food quality and taste of the fruit. The Middle East is a prime export market for CIC bananas. Banana Export destinations - Saudi Arabia Qatar United Arab Emirates

There are plans to extend the plantation of bananas to other parts of the island.

Sri Lanka records the lowest national yield among the countries studied (Table 4.26). Average yield is mostly determined by the type of banana variety cultivated.

Table 4.26: Area harvested, yield and production of banana in Sri Lanka and neighbouring countries

	2016			2017		
	Area harvested ha	Yield kg/ha	Production tonnes	Area harvested ha	Yield kg/ha	Production tonnes
Bangladesh	47432	16824	798012	48644	16592	807104
India	841000	34643	29135000	860000	35438	30477000
Sri Lanka	57256	11499	658389	57976	11621	673764
Thailand	42606	23258	990926	43000	23256	1000000
Vietnam	120041	16177	1941935	125456	16303	2045352

Source: FAO

4.2.2.a Land productivity and labour productivity

Land productivity and labour productivity of main banana varieties cultivated by local farmers for domestic market are presented below from the study. *Ambul* variety has the highest yield compared to *Seeni* and *Kolikuttu* varieties when the first crop harvest is concerned. *Kolikuttu* variety is susceptible to *Panama* disease and therefore *kolikuttu* cultivation is kept only up to its first crop harvest in most instances. It is therefore a common practice in *mahaweli* areas to practice crop rotation. After cultivation of *kolikuttu* variety, farmers will grow paddy for few seasons. *Ambul* variety is resistance to the diseases. Usually *ambul* and *seeni* cultivations will go for few years. P*anama wilt,* banana streak virus disease, yellow sigatoka, and banana bunchy top are common diseases. Fusarium wilt of banana, popularly known as Panama disease, is a lethal fungal disease caused by the soil-borne fungus Fusarium oxysporum f. sp. cubense (Foc).

Compared to *Kolikuttu* and *Seeni* varieties, *Ambul* has a high yield. Above 40 mt/ha yield can be obtained from properly maintained *Ambul* cultivation. *Cavendish* bananas can go up to 45-50 mt per hectare yield with the use of proper management systems (Table 4.27)

2019	Ambul	Kolikuttu	Seeni
Planting density (Plants/ha)	1191	2543	1156
NPK (kg/ha)	4425*	3520*	2708*
Compost (kg/ha)			
Crop Establishment labour (md/ha)	36	45	37
Crop Maintenance and harvesting Labour (md/ha)	187	197	169
Yield (Kg/ha)	**43041**	**21129**	**32143**
Establishment Cost	76653	99228	80981
Maintenance Cost	557572	616757	467158
Labour productivity	230	107	190

Table 4.27: Input use, yield and labour productivity by type of banana variety

Source: Sample survey 2019

4.2.2.b Factor productivity analysis

The results of the factor productivity gaps arising from efficiency of resource use through technical and allocative efficiency by farmers in response to better information and education are presented here. A proxy variable measures the efficiency i.e. quantity production per Rs spent by banana farmer. This proxy variable was regressed with variables given below. In constructing the dependent variable; quantity production per Rs spent, cost of cultivation was calculated. Cost of cultivation included two cost components, the establishment cost and the maintenance cost. Kolikuttu banana usually stays in the field for 14 months. Harvesting starts from 13-14 months after planting and is grown as annual crop. Ambul and Seeni banana varieties are considered as perennials having harvest every year. Of these varieties the second year harvest was taken as the output for the productivity analysis. The establishment cost is considered as a fixed cost and the fixed cost component of a year was taken as the establishment cost. The variable cost of the second year was taken as the maintenance cost. With this information, the dependent variable was constructed by dividing banana output/harvest by total cost per year.

The farmers chosen in this study are from Uda Walawa irrigation scheme, the main banana growing area in the country. Once in 1982 the management of Uda Walawe project came under administration of Mahaweli Authority of Sri Lanka (MASL), farmers were allowed to cultivate OFC other than paddy. It was revealed later that since 1986 until 2001, an increase in part of land occupied by OFC increased from 5 % to 40 %, out of which 30 % were bananas. These southern Dry Zone soils were well suited to OFC cultivation. Apart from Banana, papaya is grown in crop rotations with paddy.

Table 4.28: Socio-economic characteristics, different agricultural practices and technology adopted by sample farmers

Factors	Attribute	% Respondents
Age of the HH	Above 40 years	77%
	40 years or below	23%
Level of Education HH	GCE (O/L) and above	30%
	Below GCE(O/L)	70%
Land Extent	< = 1 Ac	3%
	>1 Ac	97%
Land ownership	Own	37%
	Other	63%
Experience in farming	> 40	10%
	< = 40	90%
Experience in Banana farming	< = 5 years	45%
	> 5 years	55%
Banana Variety	Ambul=1	36%
	kolikuttu=2	32%
	Seeni=3	32%
Planting density	> 600 plants per ac	35%
	< = 600 plants per ac	65%
Micronutrients	Yes	30%
	No	70%
Mechanical land preparation	Yes	47%
	No	53%
Mechanical weeding	Yes	35%
	No	65%
Training on banana cultivation	Yes	20%
	No	80%

Technical advices on banana cultivation	Yes	74%
	No	26%

Source: Sample survey 2019

A descriptive analysis is given in the table above

Analytical Model

The independent variables of the factor productivity gap analysis were the selected socio-economic characteristics and agricultural practices and technologies farmers have adopted in their cultivation.

The multiple regression model is expressed implicitly as:

$$FPi = \beta 0+ \beta 1X1+ \beta 2X2+ \beta 3X3+ \beta 4X4+ \beta 5X5+ \beta 6X6+ \beta 7X7+ \beta 8X8+ \beta 9X9+ \beta 10X10+ \beta 11X11+ \beta 12X12+ \beta 13X13$$

Where, FPi = Quantity produced per Rs

β0 = Constant term

βk = Coefficient to be estimated

X1 = Age of banana farmers in years

X2 = Education level in years

X3 = Land size

X4 = Ownership

X5 = Experience in farming

X6 = Experience in Banana farming

X7 = Banana Variety

X8 = Planting density

X9 = Micronutrients

X10 = Mechanized land preparation

X11 = Machinery Weeding

X12 = Technical Advice

X13 = Trainings on Banana cultivation

In the sample there are 10 % farmers who have more than 40 years of farming experience. There were the few original new settlers who occupied these lands in 80's. Most farmers have more than 5 years of banana farming experience. These farmers are technically efficient that factor productivity significantly increased with experience. Education is highly significant that educated farmers use resources efficiently. Highest resource use efficiency is observed in *Seenikesel* cultivation. Educated experienced farmers can act as extension agents who have wider knowledge on better management practices.

Table 4.29: Results of the regression analysis of banana (Method: Least Squares)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Age of HH	-0.0000573	0.000713	-0.080382	0.9361
Level of Education HH	0.011613	0.003615	3.212461	0.0019
Land Extent	0.003633	0.002894	1.255344	0.2128
Land Ownership	0.013224	0.008938	1.479466	0.1427
Experience in farming	0.00119	0.000678	1.755714	0.0827
Experience in Banana farming	-0.000177	0.00072	-0.246462	0.8059
Variety : Ambul	-0.052047	0.009516	-5.469343	0
Kolikuttu	-0.079123	0.020198	-3.917469	0.0002
Seeni	0.028075	0.040203	0.698341	0.4869
Planting Density	0.0000233	3.02E-05	0.772388	0.442
Application of Micronutrients	-0.007208	0.008754	-0.823387	0.4126
Mechanized Land Preparation	-0.011019	0.007914	-1.392391	0.1674
Machinery Weeding	-0.002606	0.008412	-0.30981	0.7575
Technical Advices	0.005739	0.009044	0.634549	0.5274
Trainings on Banana cultivation	-0.005476	0.011379	-0.481199	0.6316
R-squared	0.547598			
Adjusted R-squared	0.473084			
S.E. of regression	0.036654			
Durbin-Watson stat	2.085494			

4.2.3 Papaya

Papaya has been cultivated in Sri Lanka primarily as a home garden crop. Due to viral infections home garden cultivation dropped in wet zone areas. Disease problem and cultivators getting a very high percentage of "male" or non-bearing trees were a perennial problem with papaya growing.

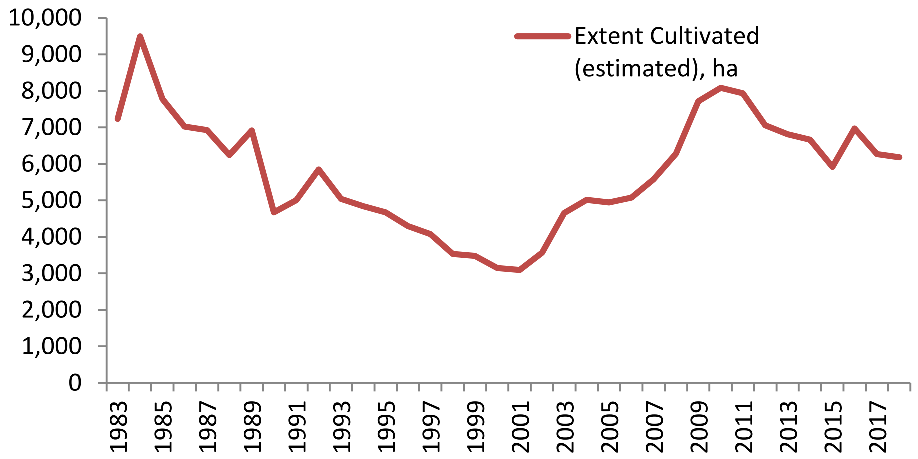


Figure 4.82: Total cultivated extent of papaya, 1983 - 2018
Source: Department of Census and Statistics

In 1999 the Department of Agriculture recommended first papaya variety “Ratna”, a self-pollinated composite variety with good quality fruit which was developed by HORDI from a Malaysian inbred line. However, this variety did not assure 100% fruit-bearing trees and was not resistant to virus diseases.

Sooner Department of agriculture recommended the importation of hybrid variety Red lady after successful trials in Mahaweli areas. Introduction of this variety made a breakthrough in papaya production that extent under cultivation and the commercial cultivation increased sharply. This variety has several superior characteristics. It is an extra dwarf, early bearing and vigorous and productive crop that is tolerant to ring-spot virus. The flesh of the fruit is thick red, hard, with a good aroma and has good keeping and serving quality and the best papaya variety for transport. This variety fetches a good market internationally. Fruits weighing 2-5 kilos are commonly obtained under Sri Lankan conditions.

With the introduction of new varieties initially Ratna and then Red lady, cultivation revived and spread into dry zone areas. At present the extent of papaya cultivation is 6178 ha (2018). Papaya extent has increased from 3000 ha in 2001 to 8080 ha in 2010 which dropped again after 2010 (Figure 4.82). Kurunegala district is the highest producer in the country by 2018. Cultivation in the wet zone districts has gown down. Hambanthota Anuradapura and Gampah, districts cultivated more than 370 ha (figure 4.83).

Cultivated Extent of Papaya, 2018

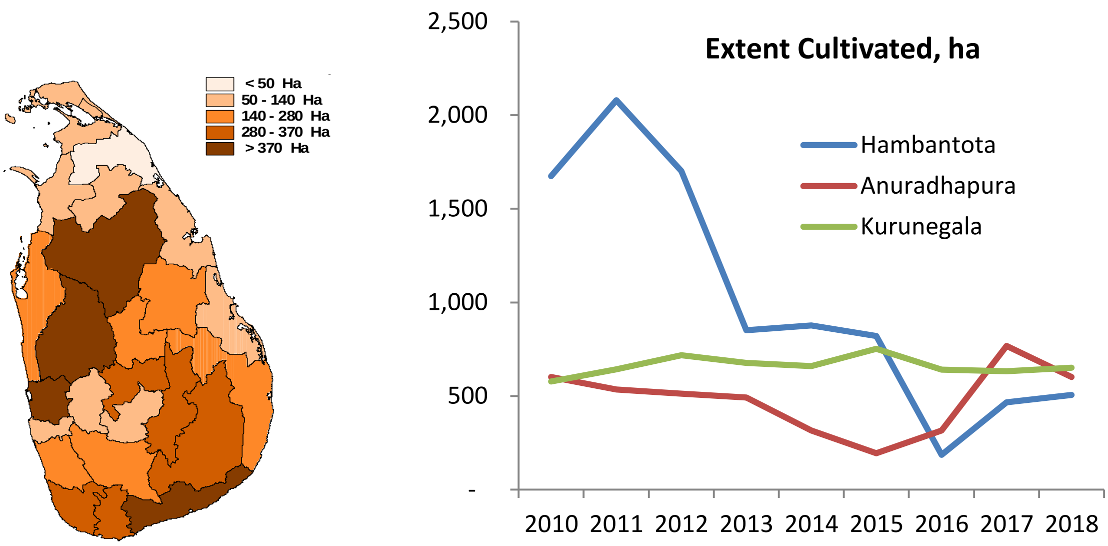


Figure 4.83: Cultivated extent of papaya by main districts
Source: Department of Census and Statistics

Papaya has a very high demand in the local market. Before introducing the new varieties, there had been some papaya imports from Thailand and Singapore to meet the local papaya demand. Although international trade statistics show two digit values of papaya exports from 2000 (Figure 4.84), papaya had been exported to Germany, Bangladesh, Bahrain and Maldives in small quantities. The fruit is used as fresh fruit as well as for other processed products. Exporting papaya shows an increasing trend with the introduction of new improved exotic varieties, particularly "Red Lady" which has a very high demand in the international market.

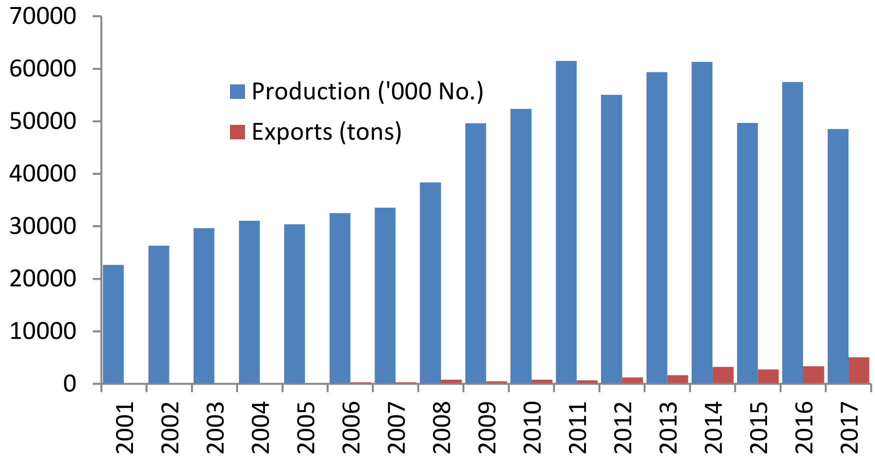


Figure 4.84: Production and exports of papaya 2001 - 2017
Source: FAO, ITC

However papaya demand in the local market is still competitive that papaya FOB prices are lower than local market wholesale prices during some period of the year making it profitable for farmers to supply to local market (Figure 4.85). Papaya has a good demand for local as well as export markets.

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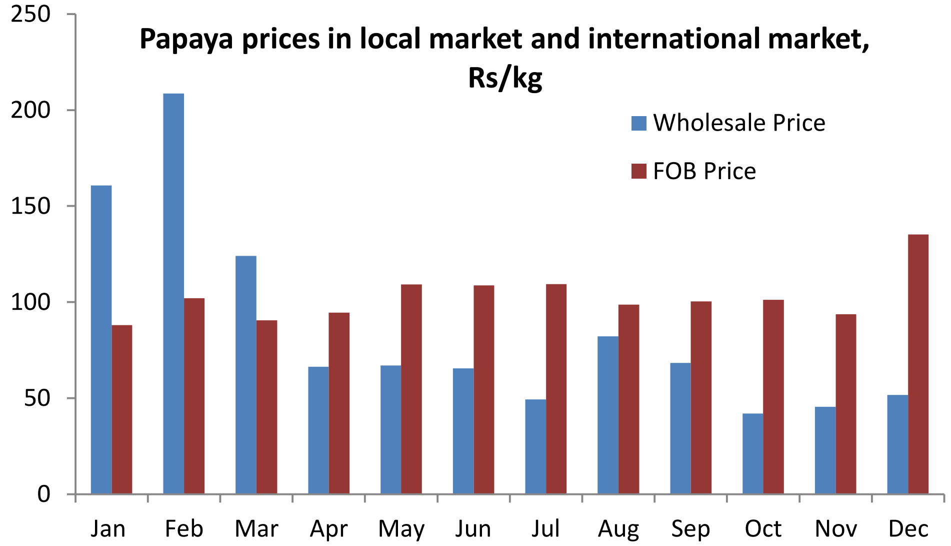


Figure 4.85: FOB and wholesale price of papaya, 2018
Source: HARTI

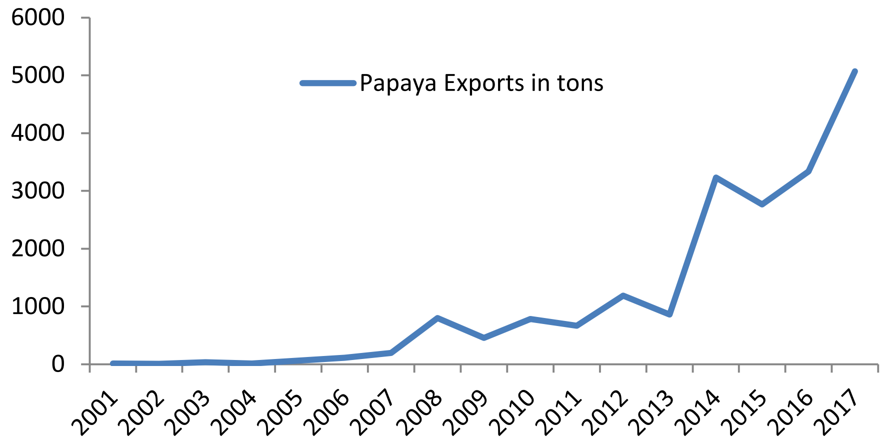


Figure 4.86: Papaya exports from 2001 to 2017
Source: FAO, ITC

Papaya exports show a continuous increase after 2013 bringing in some 3.5 million dollars to the country by exporting 5,072 mt of fresh papaya. UAE is the main destination of papaya exports (Figure 4.86 and figure 4.87).

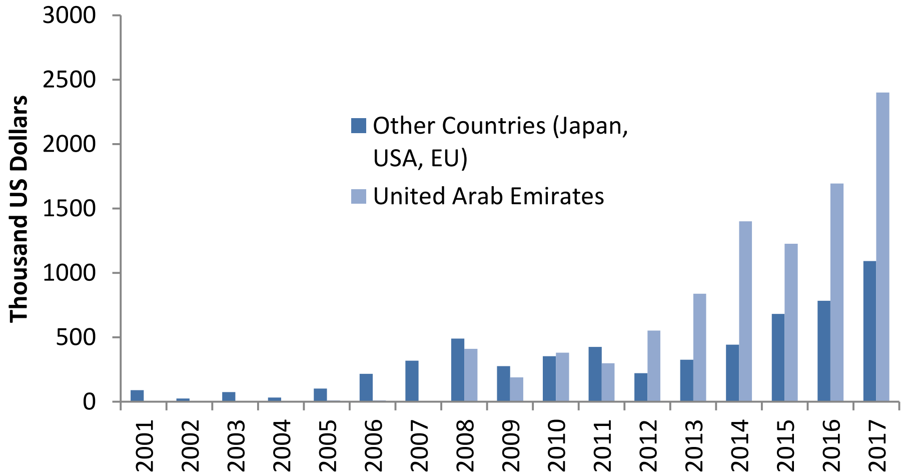


Figure 4.87: Papaya exports by export destination
Source: FAO & ITC

4.2.3.a Land productivity and labour productivity

When the average yield of neighboring countries are concerned, Sri Lankan yield is only higher than Bangladesh (if one nut is assumed to be 1.5 -2 kg) (Figure 4.88). India produces 45% of the world production and Indian papaya yield is 120 times the South Asian yield. Sri Lanka has to compete with India for the international market particularly UAE market.

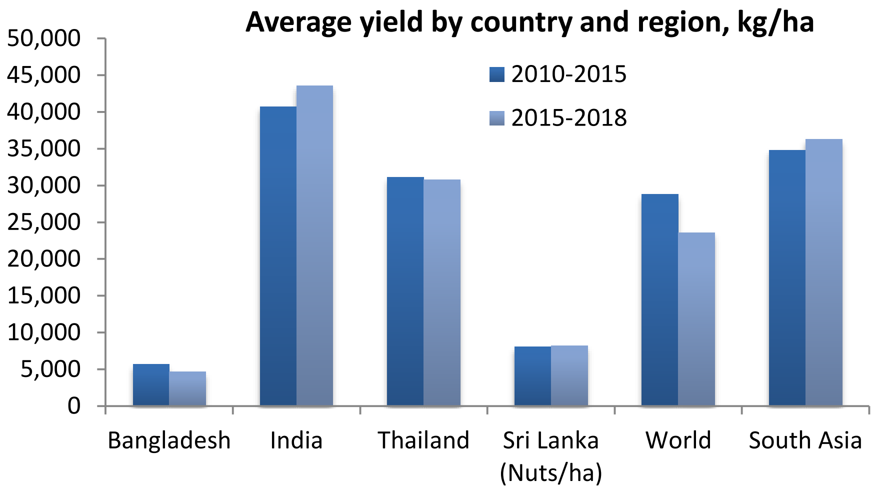


Figure 4.88: Average yield of papaya in Sri Lanka and in neighbouring countries
Source: FAO

As farmer adopting the new varieties, significant average yield increases of papaya is seen (Figure 4.89). Quality seed production of *Ratna* variety and availability of quality hybrid imports are the contributory factors for adoption of this technology.

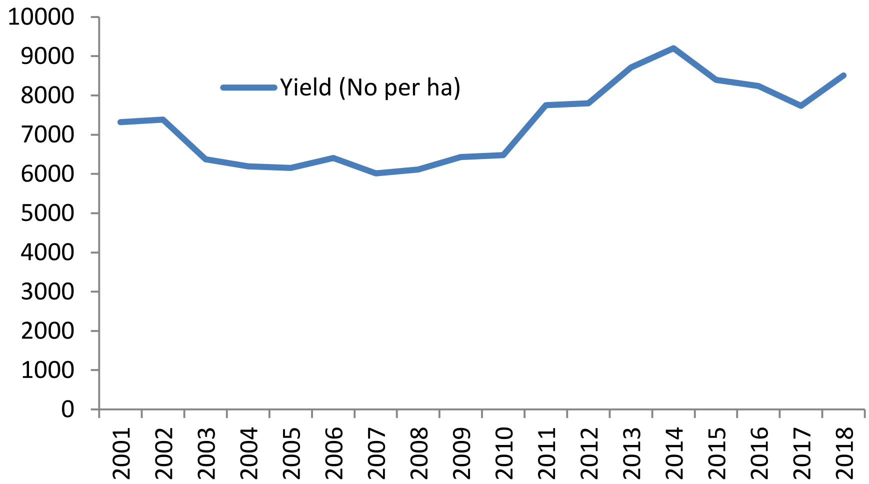


Figure 4.89: Average yield of papaya 2001 - 2018
Source: Department of Census and Statistics

There is a drop in extent cultivated after 2011 and a yield increase is observed since then up to 2014 depicting more efficient farmers to remain in commercial cultivation (Figure 4.90).

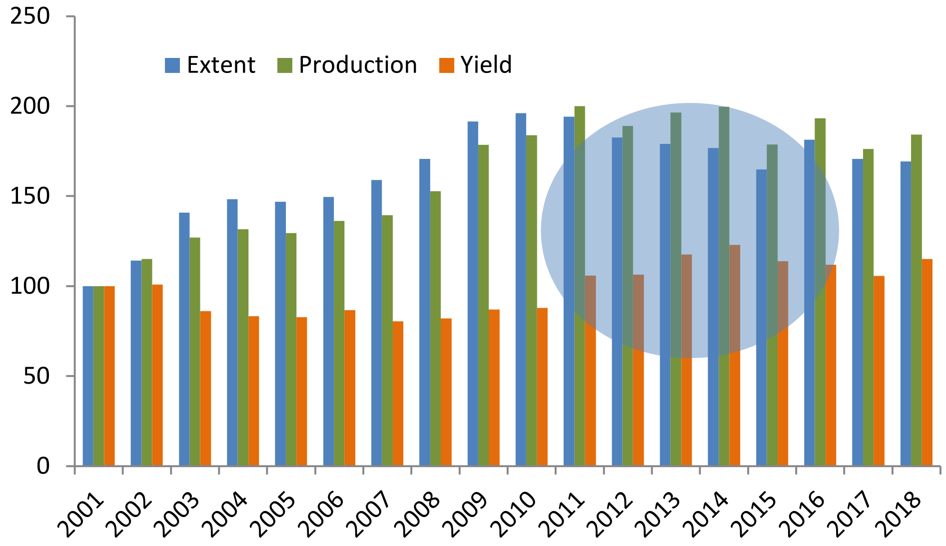


Figure 4.90: Extent, yield and production base year 2001= 100
Source: FAO

The size of the fruit is also an important quality parameter that leads to farmer's selection of variety apart from the yield. The market failure with large size fruit supplies coming to market due to cultivation of Red Lady variety, farmers tend to cultivate alternative varieties. In 2014-15, 'Horana Papaya Hybrid' variety was recommended and released by the FCDRI of DOA. It is a medium size variety with high yield. It is still being popularized among farmers through various programs. Apart from locally promoted varieties, varieties such as Solo Sun Rise, Tainung are on the adoption by farmers. Tainung is an important hybrid developed in Taiwan that has resistance to papaya ring-spot virus disease which was developed from a cross between Florida (FL-77-5) and the Costa Rica Red.

The land productivity and labour productivity across years are compared based on statistics from DOA crop enterprise budgets, DCS estimates and the sample of the study and are given below for the years 2005, 2012, 2017 and 2019. It shows very high yield variability across years and across main producing areas. Potential average yield at farmers level are comparable to international high yields. Varieties such as Red Lady have yields to the level of average yield of India. Nevertheless, farmer's choice of variety is determined by not only yield but also the size of the fruit is an important parameter.

Table 4.30: Land productivity, labour use and labour productivity of papaya by variety

	2005[1]	2012[1]	2017[1]	2019[2]	2019[2]
District	**Puttlam**	**Puttlam**	**Puttlam**	**Kurunegala**	**Vavuniya**
Variety	Ratna	Red Lady	Red Lady	Tainung/Red Lady	Red Lady
Land productivity (Yield)					
DOA and study sample estimates kg per ha	42778	42778	128000	34762	74849
DCS district average estimates number of fruits per ha	7760	15929	10522	7710	10524
Kg per ha Range*					
Minimum	11640	31858	21045	15421	21048
Maximum	15520	79644	52612	23131	52619
Labour Use (DOA and study estimates)					
Crop Establishment labour (md/ha)	150	125	135	98	85
Crop Maintenance and harvesting Labour (md/ha)	147	147	158	306	227
Labour Productivity (kg/md)	193	204	568	98	278

*2 kg & 5 kg per ha for Red Lady and 1.5 kg &2.5 kg per ha for Ratna & Tainung

[1] DOA crop enterprise budgets, [2] Study estimates

Crop establishment labour component is calculated considering economic life of papaya crop is two years.

4.2.3.b Total Factor Productivity Gap among Papaya Farmers: Findings from the cross section study

The factors affecting farmer's efficiency of using resources and choosing the existing technology for increasing productivity was estimated by developing a regression model. A proxy variable was constructed to measure the efficiency i.e. quantity production per Rs spent by farmer. This measure is approximated to Factor Productivity. This proxy variable is used to analyse the total factor productivity gap among farmers within a year due to efficiency and was regressed with variables that are determinants of productivity across a year. If farmer gets more output from money he spent on production, farmer is considered to be more efficient in using resources and choosing the existing technology. Factors determining productivity are variables representing the farmers' level of technical knowledge (a number of agronomic practices in crop establishment) and socioeconomic status (education, tenure, and income).

In constructing the dependent variable; quantity production per Rs spent, cost of cultivation was calculated. Cost of cultivation included two cost components, the establishment cost and the maintenance cost. Usually one papaya crop stays in the field for 3 years. Harvesting starts from 7-8 months after planting. The second year harvest was taken as the output for the productivity analysis. The establishment cost is considered as a fixed cost and the fixed cost component of a year was taken as the establishment cost. The variable cost of the second year was taken as the maintenance cost. With this information, the dependent variable was constructed by dividing papaya output/harvest by total cost per year.

The independent variables of the analysis were the selected socio-economic characteristics and agricultural practices and technologies farmers have adopted in their cultivation.

Analytical Model

The multiple regression model is expressed implicitly as:

$FPi = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \beta 6X6 + \beta 7X7 + \beta 8X8 + \beta 9X9 + \beta 10X10 + \beta 11X11 + \beta 12X12 + \beta 13X13 + \beta 14X14 + \beta 15X15 + \beta 16X16 + E$

Where, FPi = Quantity produced per Rs

$\beta 0$ = Constant term

βk = Coefficient to be estimated

X1 = Age of papaya farmers in years

X2 = Education level in years

X3 = Income

X4 = Experience in Papaya farming

X5 = Land size

X6 = District (dummy variable)

X7 = Type of Cultivation (dummy variable)

X8 = Papaw Variety (dummy variable)

X9 = Planting density

X10 =Type of Planting Material (dummy variable)

X11 = Type of Fertiliser Applied (dummy variable)

X12 = Compost Applied (dummy variable)

X13 = Mulching (dummy variable)

X14 = Weedicide Applied (dummy variable)

X15 = Machinery Weeding (dummy variable)

X16 = Selling Papaya to export companies (dummy variable)

E = Independent error term

A descriptive analysis is given in the table below.

Table 4.31: Socio-economic characteristics, different agricultural practices and technology adopted by sample farmers

Factors	Attribute	% Respondents
Age (Years) of the HH	Above 40 years	73%
	40 years or below	27%
Level of Education HH	GCE (O/L) and above	36%
	Below GCE(O/L)	64%
Monthly Income of the family	> 40000 Rs /month	36%
	< 40000 Rs /month	64%
Experience in Papaya farming	< = 5 years	86%
	> 5 years	14%
Land Extent (Ac)	< = 1 Ac	57%
	>1 Ac	43%
District	Kurunegala	57%
	Jaffna	43%
Type of Cultivation	Mono Cultivation	70%
	As an Under Crop	30%
Papaw Variety	Red Lady	64%
	Taninug	36%
Planting density	> 600 plants per ac	20%
	< = 600 plants per ac	80%
Type of Planting Material	Plants/seedlings	50%
	Seeds	50%
Type of Fertiliser Applied	Straight	41%
	Mixed	59%
Compost Applied	Yes	36%
	Not	64%
Mulching	Yes	55%
	No	45%
Weedicide Applied	Yes	20%
	No	80%
Machinery Weeding	Yes	34%
	No	66%
Selling Papaya to export companies	Yes	20%
	No	80%

Results of the regression analysis of papaya are given in table 4.32. Of the main socio-economic factors, age and education are somewhat significant. Although majority farmers are above 40 years of age, most farmers are new to papaya farming.

All sample farmers use supplementary irrigation during drought periods. Studies (Aheer et al 2005) have shown that papaya cultivation under micro-irrigation has higher economic viability and adopting micro irrigation technology by papaya farmers can increase productivity and profitability.

Having the district variable significant it shows that Jaffna farmers have used resources efficiently. Land size is a significant factor. In the sample, 57% of farmers are cultivating less than 1 Ac. In order to increase the efficiency of production at least more than one acre of cultivation is advisable.

Table 4.32: Results of the regression analysis of papaya (Method: Least Squares)

Variable	Coefficient	Std. Error	t-Statistic	Prob.	
C	-0.382	0.131	-2.913	0.007	***
Combine Variable (Age, Education level, Experience)	0.022	0.008	2.624	0.014	**
Monthly Income of the family	0.0006	0.000	-1.589	0.123	
Land Size	0.060	0.016	3.708	0.001	***
District	0.169	0.043	3.925	0.000	***
Type of Cultivation	-0.051	0.026	-1.983	0.057	*
Papaw Variety	0.049	0.033	1.506	0.143	
Planting density	0.000	0.000	2.033	0.051	*
Type of Planting Material	-0.045	0.031	-1.465	0.154	
Type of Fertiliser Applied	0.003	0.041	-0.078	0.938	
Compost Applied	-0.036	0.019	-1.927	0.064	*
Mulching	0.147	0.032	4.599	0.000	***
Weedicide Applied	-0.024	0.024	-0.967	0.341	
Machinery Weeding	0.091	0.021	4.304	0.000	***
Selling Papaya to export companies	-0.009	0.028	-0.320	0.751	

R-squared	0.782
Adjusted R-squared	0.677
S.E. of regression	0.05556
Durbin-Watson stat F-statistic	1.787

Good management practices such as mulching, machinery weeding are increasing the factor use efficiency of papaya farmers.

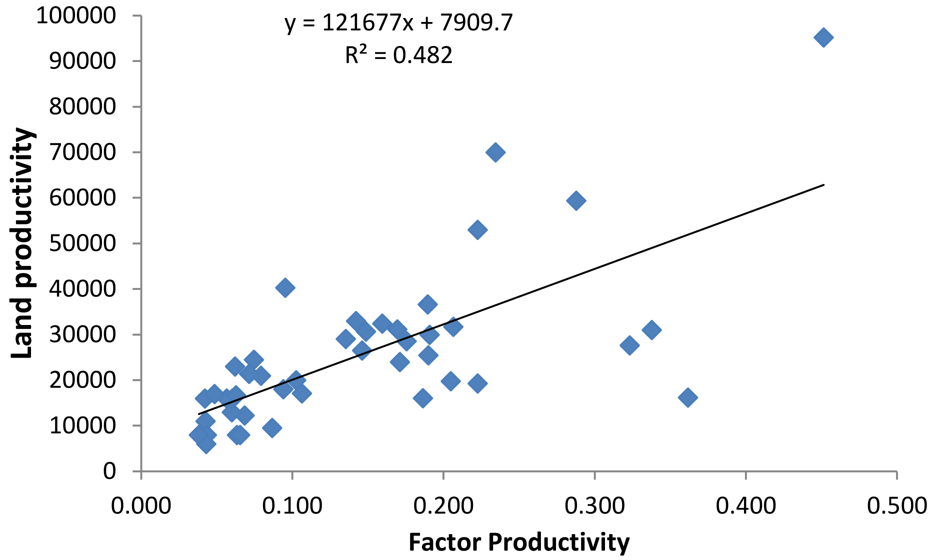


Figure 4.91: relationship between land productivity and factor productivity

The above relationship between land productivity and factor productivity (land is not included as a factor) of papaya farming shows that farmers those who use resource efficiently by adopting good management practices have increased their land productivity. Higher the efficiency of resource use the higher the land productivity (Figure 4.91).

Land productivity = TE + initial fertility and other conditions +input use → cross sectional analysis

4.2.4 Passion fruit

- Mostly cultivated in homesteads
- Most farmers interviewed are new entrants to the cultivation. There are farmers who have traditionally been in passion fruit cultivation have dropped cultivation for years and stated again. There is no consistency/constancy.
- NGOs have promoted passion fruit cultivation as an additional income support
- Private sector such as Elpitiya plantation has started commercial cultivation in small scale.
- Planting density varies around 400 plants per acre.
- Harvesting quantity varies around 150 kg/ 200 kg per week.
- Harvesting begins 6 months after planting and can have the crop for about 4-5 years.

4.2.4.a Land productivity and labour productivity

Yield estimated by the study is significantly lower than the DOA estimates for the first three years of the crop (figure 4.92). Passion fruit cultivation is a mostly a sub commercial cultivation that management of the crop is important determinant of yield which is determined by price of passion fruit.

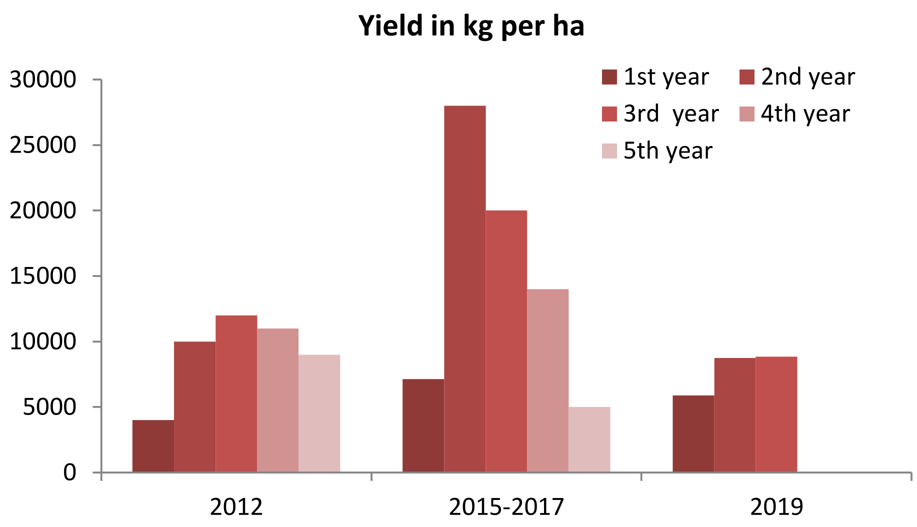


Figure 4.92: Passion fruit yield in kg per ha.

Note: 2012, 2015 and 2017 yield estimates were from crop enterprise budget of DOA. Study 2019 estimates records only up to the 3rd year of harvest as sample consisted of new farmers.

Planting density and the fertilizer application do not show much variation across the years. Farmers had followed the recommendations of the DOA since most cultivation had guided by the support of the extension officer. Most farmers are new to the cultivation.

The data does not provide adequate concrete information on productivity parameters (Table 4.33). Therefore a qualitative assessment has been done on productivity of passion fruit cultivation.

	Gampaha	Kalutara			
	2000[1]	2005[1]	2012[1]	2017[1]	2019[2]
Planting density (Plants/ha)	1100	1125	1125	1125	1059
NPK (kg/ha)	759	776	866	866	1022
Compost (kg/ha)		7500	5625	11250	1792
Crop Establishment labour (md/ha)	39	215	216	216	278
Crop Maintenance and harvesting Labour (md/ha)	245	190	105	105	278
Yield (second year) (Kg/ha)	**10000**	**28000**	**28000**	**28000**	**8736**
Establishment Cost (Rs)	66,675	330550	607220	1078700	565320
Maintenance Cost (Rs)	67,804	112984	178382	389872	466657
Labour productivity (kg/md)	40	120	189	189	26

Table 4.33: Factor use and productivity information in passion fruit farming

Crop establishment cost and labour component was accounted by assuming economic life of passion fruit crop as five years.

[1] DOA Crop Enterprise Budgets, [2] Study estimates

4.2.4.b Productivity related factors

1. Output price – farmers tend to use better management practices when the prices are attractive. However, there is high price volatility in the market (Figure 4.93). Passion fruit cultivation is a viably profitable cultivation when price fluctuates between, Rs. 60.00 and Rs. 120.00. Growers will be more benefitted when the output price ranges in between Rs. 80.00 and Rs.120.00.

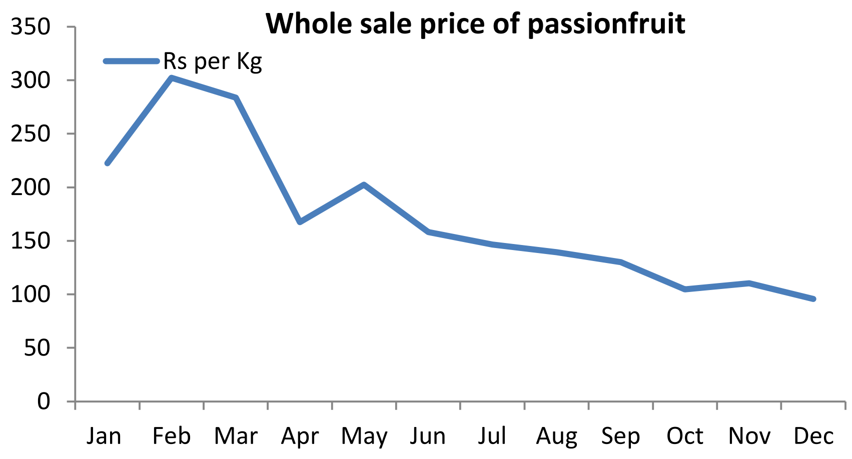
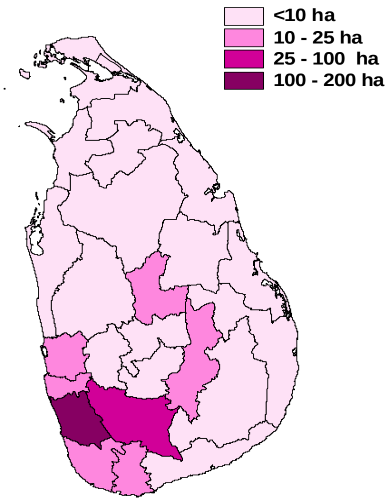
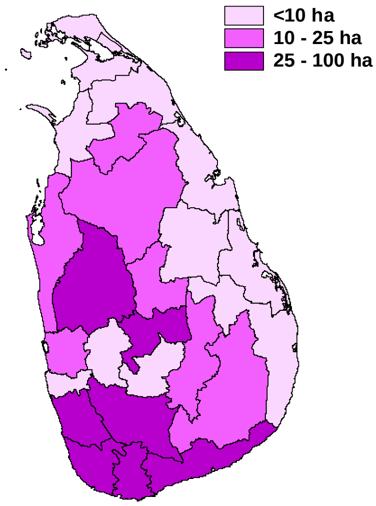


Figure 4.93: Wholesale price of passion fruit

Source: HARTI

2. Shift in area of cultivation





2002 2018

3. Better Management Practices - Management practices like as pruning and trellising of wines increases the yield of the crop. Trellising is being practiced by establishing a poll in between two wines. The yield can be increased using some techniques such as encouraging the crop to grow downward by cutting down the tendrils, where the crop tends to grow upward and that technique may result in plant stress, and will stimulate the growing pattern, and decrease the foliage cover. It may affect the emerging of flowers, hence pollination should be used to encourage flowering rate. Hand pollination should be done in the case of less pollinators. NPK and less amount of Borax or liquid fertilizer application are necessary for the growth. (Passion fruit requires less amount of fertilizer for the growth). Passion fruit is less affected crop by pests, where shoot shallowing caused by the deficiency of nutrients, bat attacks and porcupine attacks could be observed.

4. Better Varieties – Horana Gold, virus free passion fruits variety, released by the FCRDC, in 2017 is getting popular presently as some early varieties like Mahaweli, failed due to less yield capacity. Extension agents promote growers to produce and maintain the stock of “Horana Gold” seeds through hand pollination.

5. Financial Assistance – New passion fruit cultivations introduced in some instances has happened as a donor assisted partnership, out growing, and buyback programs. The donor agencies tend to offer micro finance assistance for the passion fruit growers. For instance, Microfinance Berendina Institute (Gte) Ltd (BMI), a leading poverty-alleviation agency in the Microfinance Sector is extending assistance for passion fruit cultivation under its microfinance initiative in popularizing this cultivation in the Ipalogama area in

Anuradhapura district, and IFAD funded partnership programs implemented under National Agribusiness Development Program, in Northern area for Passion fruit cultivation was embedded with a micro finance assistance.

6. Partnerships and Buy-back Programs – Passion fruit that are cultivated as a partnership program or under buyback programs, stakeholders in those programs supply facilitates like; technical training, extension services and assists with selected inputs such as micro irrigation systems and water pumps to manage water as well as other equipment required for passion fruit cultivation (Pruning tools). In buyback programs, the particular company buys the harvest from the grower. Presently, Cargills Ceylon PLC, and Lanka Canneries (Pvt) Ltd as collectors, plays a prominent role in these programs and the collected harvest used for processing. Various ranges of market products can be observed as ready to drink juices and cordials. As highlight bulletins, Cargills (Ceylon) PLC together with SOLID a project by USAID ceremonially handed over equipment to farmers in Anuradhapura and Vavuniya recently as part of the 100 acre fruit cultivation project that was initiated in 2015. Cargills in collaboration with USAID has mobilised 250 farmers from Mahavilachchiya, Anuradhapura and Kilinochchi wherein each farmer is supported to cultivate half an acre of land with passion fruit. Cargills has entered into a buy-back agreement with the participating farmers with a minimum price pre-agreed yet offering higher prices as market fluctuates. Cargills also provides extension services to the farmers to enhance product quality and productivity. SOLID under USAID facilitates technical training and assists with selected inputs such as micro irrigation systems and water pumps to manage water as well as other equipment required for passion fruit cultivation. And also, cultivation of passion fruit in immature areas of rubber grown lands was proposed as a pilot project in Devitura. Project commenced in end 2015 on a 2 Hectare land in Kirimatiya Division in Elpitiya. Project is on a buy back agreement with Lanka Canneries (Pvt) Ltd. (LCPL). Technical advice is being provided by Department of Agriculture, Sri Lanka.

Success Story:

The World Bank report published in February 2014, stated the success story of Mrs. D.M. Sumanawathie from Siyambalanduwa who has empowered by the Second Community Development and Livelihood Improvement Project (Gemidiriya) funded by World Bank. She was initially engaged with paddy cultivation where in somedays herself and her husband earned only Rs.125.00 per day. By moving in to passion fruit cultivation she was able to earn around Rs. 62,400.00 by selling passion fruit trees. The total investment by the project in her passion fruit cultivation was Rs.4700, which included 100 passion fruit plants, wire and technological inputs. Today, Sumanawathie earns over Rs. 18,000 a month from her passion fruit cultivation per week alone." it states.

CHAPTER 5

FINDINGS, CONCLUSION AND RECOMMENDATIONS

In this analysis, efficiency of domestic food crop sector was measured by calculating Total Factor Productivity (TFP). TFP measures how efficiently agricultural land, labor, capital, and materials (agricultural inputs) are used to produce agricultural output. Land productivity and labour productivity were also calculated which are used to measure agricultural productivity performances. Source of output growth was decomposed in to growth due to input growth and TFP growth (growth of efficiency of input) and source of growth was further decomposed in to land expansion growth, growth of factor intensification on land and TFP growth.

This chapter summarizes the findings of the study encompassing productivity growth of ten crop sectors studied over the period from 1990 to 2018 and the determinants of productivity growth. Study proposes the required changes in policies and the changes required in prioritizing government expenditure allocations and essential changes in regulations as recommendations.

Study examined the TFP determinants by reviewing the sector in detail. Due to inadequacy of data, especially the lagged data on research and development no quantitative analysis was performed for developing a model in order to examine how these determinants may have contributed to agricultural TFP growth. This is one of the limitations of the analysis that it is not possible to quantify the effect of different public expenditure allocations on TFP growth. Nevertheless, results of some studies that had analysed the impact of public expenditure using cost benefit analysis have been discussed in various chapters. Simple regression models have been developed in other countries with lagged variables according to the data availability.

5.1 FINDINGS

1. No significant structural changes in domestic food crop farming

Sri Lankan domestic food crop sector is characterized by less land and less labour abundant small farmer dominated sector. There has been no or negligible structural change in farming. Food crop production is predominantly carried out by small farmers in the informal sector.

According to department of census and statistics, small holder sector is classified as consisting of farmers owning less than 20 ac and holdings comprising more than 20 ac are considered as estates. Generally estate sector represents the plantation crops in Sri Lanka. Except the Dole Lanka operations, food crop sector does not operate at large scale. In the small holding sector, more than 66% of farmers are having less than 2 ac land plots. In the older settlement schemes in Ampara and Polonnaruwa, farmers own/operate farms larger than 2 ac.

	Number of Farmers	Extent
< 1 Ac	937,195	442,057
1 - 2 Ac	590,256	749,168
< 2 Ac	1,527,451	1,191,225

Food crop production involves a large number of individuals making decision based on the available information and resources.

In the main OFC cultivating areas, semi-subsistence family labour dependant farming is predominant. Yet sub-commercial systems with cultivation based on market signals are emerging (Wickramasinghe, 2013).

2. Share and the role of the public sector, private sector (corporate sector), farmers (commercial/subsistence) and international agencies including NGOs in the Sri Lankan agriculture have changed

Policies after liberalizing the economy in various stages have focused on getting increased participation of the private sector for activities of the food crop sector partially withdrawing government from activities such as input supply, output purchasing. Policies reviewed in chapter 2 deals with a detail account of this.

Government sector's involvement is mainly on the provision of irrigation and other infrastructure, implementing regulatory measures and research and development functions. Seed production, fertilizer delivery, credit and insurance continue to be part of functions of the government.

The strength of department of agriculture as the main government institute for research and development of the domestic food crop sector has been diluted by not recognizing its pivotal role for food crop sector development. Existence of large vacuum of human resources is weakening the entire research system of the department of agriculture.

Engagement with international agencies for germplasm exchange, technology transfers, human resource training has gradually declined. The involvement of international agencies in India and Bangladesh is comparatively significant.

Private sector is mainly involved in importing fertilizer, agro chemicals, machinery and improved/hybrid seeds. Corporate sector is also involved in seed and planting material production, research and development and diffusion of machinery technology in varying scales. Main determinants of private sector investment in domestic food crop sector are market size, available option to share risk, incentives, and their involvement in stakeholder dialog for decision making. The private sector engagement in India, Bangladesh, and Vietnam in developing new varieties/ hybrids, manufacturing machineries is remarkable. These countries have large markets.

Sri Lankan environmental laws and regulations and the social acceptance have not been conducive for large scale operations of multinational companies like Dole Lanka in Sri Lanka unlike in other countries in Asia for the production in the crop sector. Contract grower system is most effective in terms of expansion of area. Eg. Contract grower system of maize.

Farming community represents both commercial and semi-subsistence farmers. Although semi-subsistence farmers do not respond adequately to market signals, commercial orientated farmers are in need of information and market signals.

3. Country continues to adopt import substitution strategy for field crops while export promotion strategy for fruit crops

Domestic food crop sector is hardly competitive in the international trade that Sri Lanka is not efficiently using resources as Sri Lankan TFP in the domestic food crop sector is low compared to neighboring countries. Therefore trade policy instruments such as tariffs have been used in Sri Lanka to maintain import substitution strategy for cereals and other food crops.

With the opening of the economy in 1977, doors were open for technology transfer in terms of technology products; improved seeds, machinery, agrochemicals which positively impacted and crop sector was not opened for competition. When Structural Adjustment Policies were implemented in 1989 and the fertilizer subsidy was removed abruptly, farmers' response as a reaction to this shock affected the TFP of paddy sector. Subsequently, subsidy scheme was reinstated in 1991 that up to now fertilizer subsidy is implemented in various forms and degrees. In 1996 when the other field crop sector was opened, it affected the other field crop sector that farmers abandoned dry chili production midst the already affected production due to prevalence of diseases. From 1998, country started implementing a seasonal tariff imposition method to protect the seasonal local supplies from import competition.

Export promotion strategy has been adopted for fruit crops to benefit from tropical fruit demand in the world. This sector is stagnating in the recent years.

4. Government expenditure is mainly diverted to input intensification

Government expenditure on irrigation investments and fertilizer subsidy transfers constitute the main budgetary allocations and investment on research and development which has very high returns is less than 2% of the total agriculture and irrigation expenditure (Figure 5.1).

Irrigation investment and fertilizer subsidy accounted to about 75 % of the total investment on agriculture and irrigation after 2011. It is widely held opinion that monitory benefits of these transfers and investments have trickled down the line. Although irrigation and fertilizer are essential inputs for realization of yields of new varieties, it was found in 80's, 90's that paddy yields were stagnating and were declining in the absence of new technology. This leads to unnecessary resource use and inefficient production. If the technology frontier cannot be shifted upward by introducing new varieties and technologies, intensification of inputs or adding more capital on land would lead to diminishing returns like what was observed in 80's and 90's in paddy sector. The growth in output due to factor accumulation will eventually taper off, making the growth process unsustainable in the long run. Therefore, investment on research and development is essential for long-term growth.

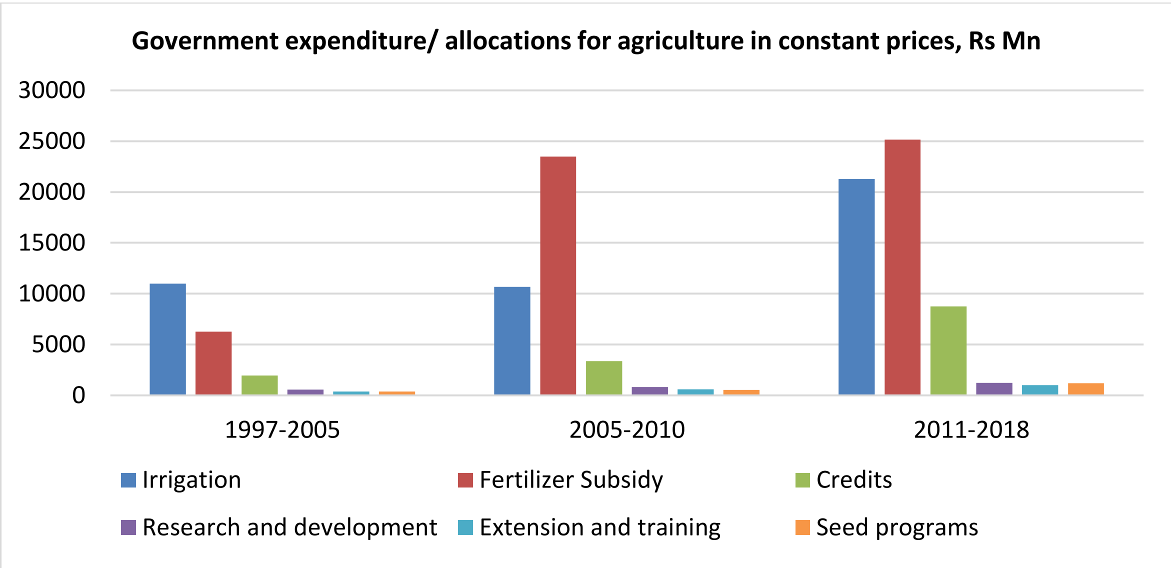


Figure 5.1: Government expenditure/allocation for agriculture by type of item
Source: Central bank, budget estimates

5. Spending on research and human resources development has been below the regional trends

When the national research expenditure by government in the neighbouring countries is compared, Sri Lanka's investment in agriculture research and development is diverging within the region (Figure 5.2 & figure 5.3). In measured in 2011 PPP dollar terms, investment in agriculture research has been declining until 2010 and rose to the same level of 2000 in 2016, mostly to the corresponding employees' salary increase in the state and statutory research institutes.

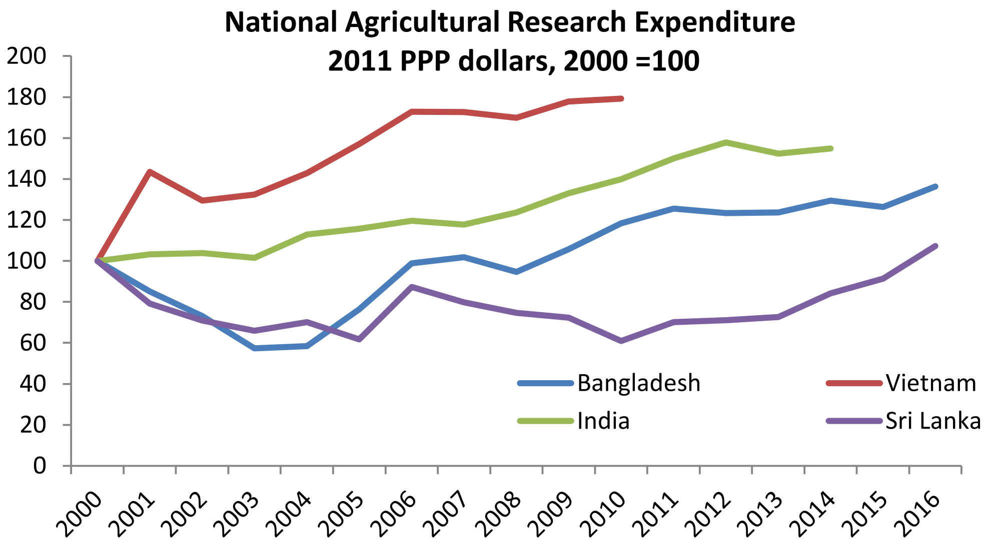


Figure 5.2: Agricultural research expenditure in Sri Lanka and neighbouring countries as base year 2000 =100

Source: ASTI, IFPRI

ASTI's national agricultural research expenditure data is categorized as salary-related expenses, operating and program costs, and capital investments by government, non-profit, and higher education agencies. Data on spending by private entities are excluded, due to lack of availability

Research expenditure given in constant 2011 US dollars term further confirms that Sri Lanka has not made a progress in allocating funds to this sector.

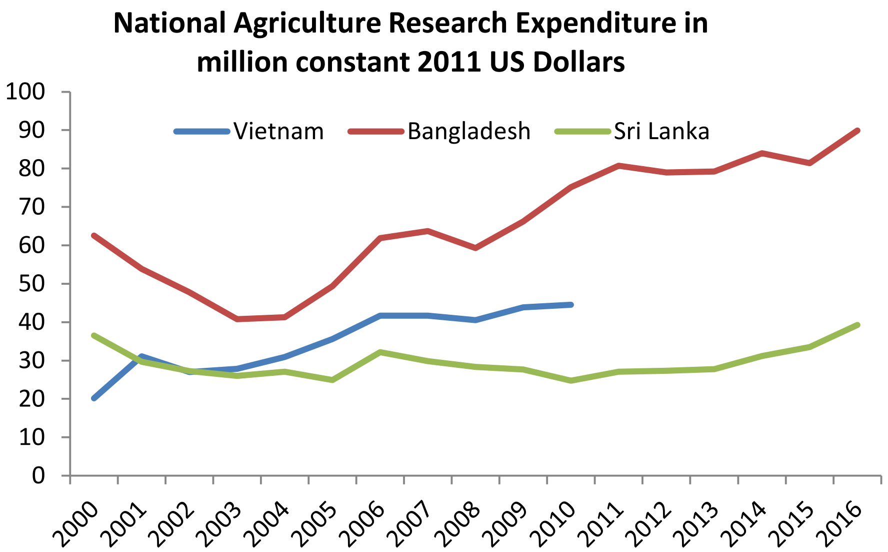


Figure 5.3: Agricultural research expenditure in Sri Lanka and neighbouring countries in constant dollar terms

Source: ASTI, IFPRI

However, research expenditure as a percentage of GDP is highest in Sri Lanka which is nearly 0.5% of agricultural GDP. In India, Bangladesh and Vietnam research expenditure as a percentage of GDP are around 0.3, 0.4 and 0.2 respectively. Nevertheless agriculture GDP in these countries are many time higher than Sri Lankan GDP.

In India, funding comes from four main sources: the central government provides about 50 per cent; state governments, about 20 per cent; private companies and cooperatives, 16 per cent; and foreign donors provide the rest. Private- sector research consisted primarily of research on crop management and processing technology. Private companies have also been in investing on exploiting hybrid vigor.

Researchers, total (FTEs)

ASTI's data on national agricultural researchers are expressed in full-time equivalent (FTE) researchers (with official researcher status) employed at government, nonprofit, and higher education agencies. Data on agricultural researchers employed by the private sector are excluded due to lack of availability. FTE calculations take into account the proportion of time scientists actually spend on research as opposed to other activities (Table 5.1).

Table 5.1: No of researchers employed in agricultural research system in Sri Lanka and neighbouring countries in FTE units

	Bangladesh	India	Sri Lanka	Vietnam
2000	1,590.4	13,106.6	517.7	2,461.4
2001	1,531.0	12,816.3	540.1	2,561.0
2002	1,580.8	12,643.9	543.4	2,715.8
2003	1,630.6	12,495.1	512.8	2,934.2
2004	1,669.1	12,346.9	501.7	2,933.3
2005	1,745.5	12,391.1	525.0	3,206.3
2006	1,792.4	12,003.6	582.9	3,250.8
2007	1,817.3	11,866.4	625.7	3,322.6
2008	1,841.7	11,811.3	652.4	3,513.8
2009	1,855.1	11,786.6	618.8	3,703.0
2010	1,960.8	12,042.3		3,744.2
2011	1,999.6	12,311.6		
2012	2,121.0	12,674.2		
2013		12,784.2		
2014		12,746.6		

Source: ASTI, IFPRI

6. Rate of technological innovations have been low

This is mainly due to the limited availability of technology particularly in terms of new varieties with high yield and with better adaptability to farmers to adopt. 'Research potential' (RP) yield attained as a result of a successful applied research program directed toward these crops and the "science potential' yield increase attainable if new scientific discoveries (e.g., in biotechnology) are made and utilized in an applied research program are concerning issues in this regard.

Sri Lanka still cultivate varieties that were produced or introduced in its early adoption up to today and in some instances it is the only promising variety grown for years.

Sri Lanka has not been able to exploit the science in technology development in the recent past although Sri Lanka is the one of the earliest countries produced new improved varieties through hybridization during green revolution, and adopted breeding method such as mutation breeding

Soybean variety PB 1 is cultivated now for 40 years.
Dambulu Red selection, one selection of Pusa red emerged as a promising cultivar of Big onion after 30 years of its cultivation
Chilli –Late but promising hybrid has been developed superior to imported hybrids.
Granola is only promising variety cultivated in potato farming
Pineapple -'Mauritius'

Eg. Yield Increase through Heterosis/hybrid vigor -Countries in the region have exploited the heterosis/hybrid vigor of chilli, maize and other cross pollinated crops about many decades ago. Sri Lanka was able produce chilli hybrid variety in 2015 a country that has a very high genetic variability. We are late adopters of this technology.

Tissue culture technology – only successful in potato propagation and banana propagation

Until the bio safety policy is formulated, Bt technology cannot be tested in the fields.

Also there are issues related to adoption of available varieties.

<u>Semi-subsistence nature of farming and low innovations</u>

Food crop production involves large number of individuals making decision based on the available information and resources. Most peasant farmers do not respond adequately to market signals. Absence of a commercial orientation

<u>Land ownership issues and adoption</u>

Land fragmentation is common and there are second generation and third generation land right issues particularly in settlement schemes. Cultivation on short-term lease agreements (1 to 5 years) is found in settlement schemes as well as in fruit crop cultivation. All this land related issues have hindered adopting most advanced technologies available and better management practices that affects the productivity.

7. Increasing wage rate has led to mechanization and adoption of other labour saving management practices

Machinery use and application of weedicide are common practices farmers adopted due to high wage rate of farm labour. Use of machinery and weedicides has contributed to the TFP growth for their disembodied technology component although it involves a part of technology embodied in capital. Therefore these two operations have been widely adopted by farmers.

Rising wage rates in agriculture sector in response to rising wage rates in the non-agricultural sector is made it increasing returns for mechanization. Mechanization technology has a capital - embodied component and TFP increasing component. Therefore both farmer and the input supplier are benefited from this technology adoption. The other important consideration is that lately developed machineries in Japan are better suited to small farm size in Sri Lanka. Early adoption of large tractors and harvesters were replaced later with small-sized, light-weight tractors and harvesters

Sri Lanka has a largely mechanized agriculture sector next to Bangladesh in South Asia. Machinery use in land preparation and harvesting is common in most food crop faming. There is a large scope opened to mechanization in several management practices with banning of some chemicals for weeding and due to scarcity of labour.

One of the important management practices that is being abundantly practiced by farmers to overcome the shortage of labour and the rising wage rates is the weedicide application which is commonly observed particularly after 2007. This technology is also having two components that beneficial for farmer and the input supplier. However the TFP increasing component of weedicide application which is a financial benefit to farmers has a social cost that is latent; environmental cost and health cost. These costs are needed to be taken for consideration when polices are designed.

Use of machine transplanter and weeder for crop establishment and weeding is the next stage of mechanization in the paddy sector. However this technology is so far not yet perfect. It has not been widely adopted. This combined technology can reduce the weedicide application and transplanting can increase the land productivity by 10%. Private sector is more likely to invest in diffusing this technology as this innovation is embodied in capital goods that private sector finds a large market. Due to the market size the private sector has in the other field crop sector for mechanization they are less likely to invest in the mechanization in OFC sector other than maize. Therefore public sector needs to take steps to develop or to be supplied machineries in the small crops sectors.

8. Contract grower system emerged as an institutional innovation that ensures greater participation of the farmers in the free market system

Contract grower system which was introduced in late 90's by the government can be considered as an important institutional innovation that organized farmers to a buyer or to a processor who is competitively trading in business. Mostly processors operate in monopolistic competition having a brand for their products, have been able to organize farmers for quality and efficient production. Buyers themselves provide quality inputs, knowhow and credit. This is experienced not only in Sri Lanka but also other neighboring countries.

Eg. Maize contract grower program in Sri Lanka and Bangladesh

This innovation has been able to fill the extension gap that yield gap between average farmer and the best performing farmer has converged within short period of time. If this system can couple with information system it is easier to bring in new technology to farm.

9. **Climate disturbances are increasingly affecting the sector productivity**

Erratic rainfall pattern, climate changes in the agro-climatic regions and resultant deviation in the typical maha and yala seasons have made the crop production more vulnerable in the country. The drought has become a recurrent phenomenon and farmers have to undergo either to abandon cultivation, shift to alternative crops, or to incur crop losses. Significant drought occurrences were observed during 1986/1987, 1992, 1996, 2001, and 2004 and consecutively for 3 years from 2015 to 2018 in the country and 2011 is a flood year.

Government has introduced various insurance schemes for addressing the impact of crop losses due to drought, floods, pest and disease attacks and other wild animal damages. Operations of the crop insurance programme for paddy sector shows that in the recent years AAIB continues pay larger indemnities against insured paddy crop making crop insurance alone as a risk sharing strategy against the climate disturbances an unsustainable policy.

Research on seasonal rainfall patterns and the shift of seasons, drought assessment, timing of cultivation, introducing alternative crops and other various areas are open for policy consideration apart from insurance schemes.

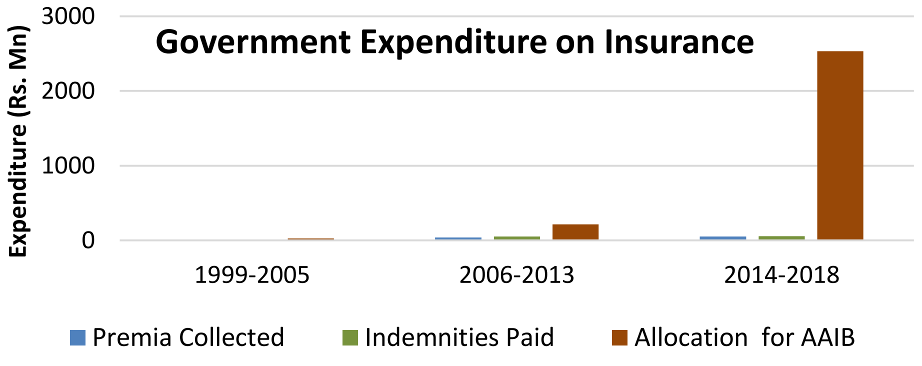


Figure 5.4: Premia collected, indemnities paid and allocation for AAIB
Source: Central Bank, Budget estimates

5.1.1 Findings from the crop sector specific productivity analysis

Paddy

Total Factor Productivity in the paddy sector shows a stable growth of 1.56% per annum after 1996 except bad weathered years, 2011, 2017. Adoption of new varieties released by the DOA and use of weedicide embodied yield increasing technology are the main determinants of TFP growth in the paddy sector after 1996. Fertiliser policy revision to include micronutrients, quality seed production and adoption of transplanting for direct seeding are also contributory factors.

Total factor productivity growth contributed to the land productivity growth amidst declining factor intensification on land. However, adoption of hybrid technology in Vietnam made Vietnam paddy yield to surpass the Sri Lankan paddy yield since the beginning of 90's. Rice breeding program of Sri Lanka initially attempted to elevate the genetic potential of rice varieties that gives high yields. Next, the objective of many breeding program were to develop varieties to withstand biotic and abiotic stress. Also varieties developed for quality improvement of rice. Irrigation and fetiliser were essential factors for realizing the yield potentials. Breeding programs on obtaining the highbred vigor is still not a perfect technology. Tapping hybrid vigor is important to increase yields.

The machine transplanting method of crop establishment which was introduced under Yaya II program launched by DOA and Korea Project on International Agriculture (KOPIA) didn't drive a momentum as farmers didn't take up this technology widely. This transplanting machinery was introduced to reduce weedicide usage, to promote mechanical weeding and to increase the yield. According to a study done in Rajanganaya area, varieties such as BW367, AT362, BG359 and BG370 are found to be better varieties that can adopt machine transplanter in the dry zone. Transplanting is found to be giving more than 10% yield increase and weed free cultivation will increase the yield by 30%.

This phenomenon is common in developed countries in their agriculture development.

Through mechanization, tillage, harvesting and threshing technologies were brought to paddy farming that increased the labour productivity registering 4.7 % growth of labour productivity p.a. The highest labour productivity achievement in agriculture sector is in the paddy sector. Private sector was instrumental in diffusing this technology. This embodied technology has a non-price component that led to benefit farmers and largely adoption.

Breeding programs on obtaining the hybrid vigor is still not a perfect technology. RRDI released the hybrid BG 252 in 2015 which has a 10 % yield increase compared to high yielding OPVs. However hybrid seed production has limitation due to low F1 yields in seed production. This is how when China first developed their hybrid seeds which they overcame later. Therefore, FAO, in collaboration with IRRI, Japanese scientists, the China National Hybrid Rice Research and Development Centre (CNHRRDC) and other selected national research centres, initiated its global hybrid rice programme in 1986 to expedite the widespread use of hybrid rice technologies outside China. Sri Lanka's hybrid rice research programme started in the 1980s and by late 90's evaluation of promising CMS lines introduced from IRRI and from other countries and the transfer of cytoplasmic male sterility from IRRI-developed lines to Sri Lankan lines had started (Abeysiriwardena, Abeysekera and Dhanapala, 1997).

Currently used weedicides are solito and sofit.

Maize

Maize, the second important cereal crop in Sri Lanka in terms of cultivation extent and production by now brought institutional innovation in agriculture that extent cultivation expanded from 23,000 ha in 2005 to 70,000 ha 2017 through contract grower system. Assured market, imported hybrid varieties, organised input supply and extension are key components of this innovation. Maize mainly has a growing derived demand in the feed industry and processed food industry. During initial innovation period from 2005 to 2010, TFP grew at 13.5 % p.a. Land and labour productivity are comparable within the region. Bangladesh has the highest yield in the region owing to their breeding program. Bangladesh has produced several hybrid varieties. Sri Lankan hybrid program has not been able to produce hybrids that are adopted by local farmers. More than 95% of the area is cultivated with exotic hybrids. The current yield level of 3.4 mt per ha can be further increased exploiting the hybrid vigor by incorporating new germplasm to the breeding program. In Bangladesh, 100% of maize germplasm has been introduced through multilateral agreement with CIMMYT and maize breeding is largely dependent on international cooperation and assistance.

Chilli

Chilli is one of the traditional Chena crops of which cultivation was affected during mid-90's with the implementation of the liberalization policies. Sri Lanka couldn't compete with Indian imports. Dried chilli production gradually dropped and farmers cultivated chilli only for green chillie production. Although chilli germplasm has high variability within the country next to India, it was late that country was able to achieve its potential yield by exploiting hybrid vigor. After 2010, there is a revival of chilli sector with area expansion and land productivity increase owing to the development few high yielding OP varieties and 2 hybrids registering 12 % TFP growth p.a. during 2010 to 2015.

Chilli being a highly cross pollinated crop significant high level of exploitable heterosis is reported. Hybrids are highly productive and respond very well to hitech management practices and always assure a uniform quality produce to the market.

Exploitation of heterosis by developing hybrids is the best way of achieving higher yield and other quality characters. Most of the chilli growing countries in the world have increased the productivity using hybrid chilli varieties along with high-tech agriculture (green house, drip and sprinkler irrigation). The productivity has increased by about 51.39% from 1.44 ton ha^{-1} in 2000 to 2.18 ton in 2016 globally due to the cultivation of high yielding hybrid cultivars in place of the traditional open pollinated cultivars.

Although hybrid program in Sri Lanka was delayed, the hybrid varieties developed by FCRDI of DOA are superior to many exotic hybrid varieties. The price of imported hybrid seeds is very high and most of the exotic chilli hybrids are highly susceptible to major pest and diseases in chilli showing less adaptability under local condition. There is a scope for harnessing hybrid vigor further through varietal development program. F 1 seed production program should be given priority in the research agenda of DOA.

Potato

Potato crop receives the importance in the up country region for its high land and labour (physical) productivity. Nevertheless, Sri Lanka's land productivity and labour productivity of potato are very low compared to India and Bangladesh. Labour productivity of Indian potato farming is more than twice the Sri Lankan labour productivity, since Indian potato farming employees less labour and land productivity of potato farming is higher in India.

The only promising variety grown in Sri Lanka is Granola and farmers have been cultivating this variety throughout. Countries in the region like India and Bangladesh have advanced breeding programs and have released new improved OPV, hybrid and varieties using advanced Bio technology for commercial cultivation with the support of private sector, international agencies. The use of input in the potato farming is declining at a rate of -0.005 p.a. while TFP growth is reporting 1.3% per annum.

Soybean

Soybean yield shows a clear shift after 2002 as private sector engaged with farmers on contract basis for soybean cultivation since soybean has a derived demand in the processed food industry in Sri Lanka and open market sales are risky. This assured marketing of farmers produce and the input supply and extension caused to better adoption good management practices by farmers. These technology embodied inputs and the use of good quality seeds for planting are contributory factors for increased TFP with the private sector coming into venturing in soybean production Sri Lankan yields are comparable with India nevertheless the labour productivity is low in spite of tillage and threshing is 100% mechanized.

The negative TFP growth experiencing before 2002 was changed with the intervention by private sector. Based on TFP index values it shows that TFP growth after 2010 is more or less stagnating. The closest reason for this is the cultivation of one variety for 40 years. PB 1 is the mostly grown variety as a promising variety which is the first exotic variety introduced to the country. Although the extension gap has been filled by realizing the potential best farmer yields with contract grower system, research gap and science gap are needed to be filled.

Big Onion

A TFP growth of 4.5 p.a. was observed after big onion farming brought under protection after 1998. Although land productivity now is comparable with India, Sri Lanka uses more labour for various crop management activities. A closer look at TFP growth shows that the TFP growth achievement owing to the adoption of Dambulu Red variety, a selection of Pusa Red variety and the use of true seed for cultivation has now reached its potential.

Export food crop sector

Export promotion strategy that has been adopted for fruit crops can benefit from tropical fruit demand in the world and the tariff regime for imports in those countries. Of the main fruit crops focused in this study, pineapple, banana and papaya are exported to main destination market with 0% tariff. Fewer restrictions on sanitary and phyto-sanitory requirements are the other advantages in the importing destinations.

Most Sri Lanka fruit exports happen outside the global supply chain except banana. Export performances of the three crops considered in this study constitute about 30 -40 % of fruit and nut exports in the country over the last 10 years. Export value has increased and the significance of banana exports is seen that pineapple is losing its export share and banana is gaining its share as Dole Lanka started its operation in Sri Lanka entering Sri Lanka to the global supply chain. Sri Lanka is competing with India in the Middle East papaya export market. India is one of the largest papaya producers in the world.

Table 5.2: Tariff applied on Sri Lanka fruit exports, 2019

	MFN tariffs	Effectively applied tariffs	Pref. Margin
Papaya			
UAE/Middle East	0%	0%	0%
Maldives	15%	15%	0%
EU/ Scandinavian	0%	0%	0%
Russian Federation	3%	2.25%	0.75%
Pineapple			
Maldives	0%	0%	0%
UAE/Middle East	0%	0%	0%
EU	5.80%	0%	5.80%
United States of America	1%	1%	0%
Japan	12.10%	12.10%	0%
Banana			
UAE/Middle East	0%	0%	0%
EU/ Scandinavian	16.32%	4.32%	12%
Maldives	7.50%	7.50%	0%
United States of America	0.35%	0%	0.35%

Source: ITC

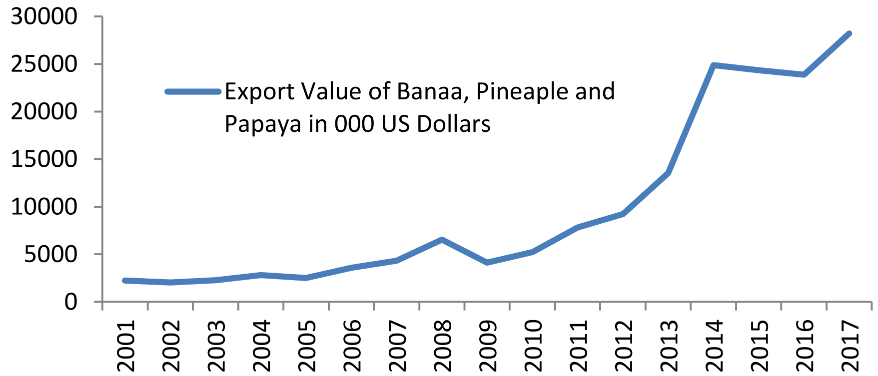


Figure 5.5: FAO, ITC

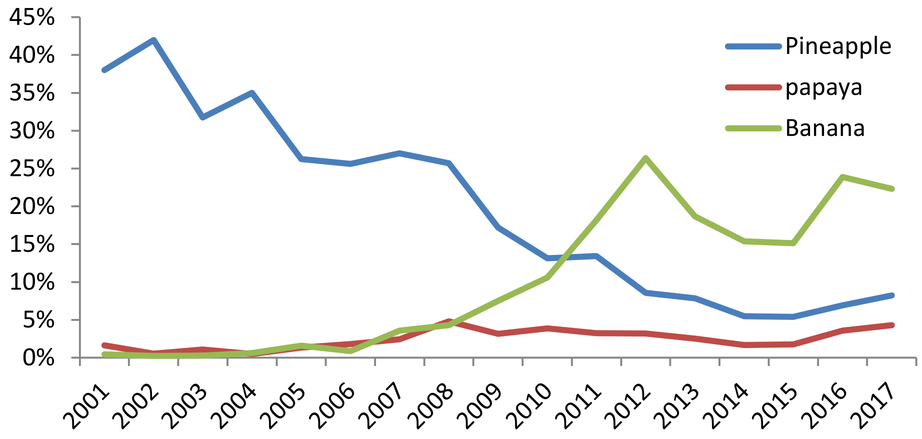


Figure 5.6: Export value contribution of main fruit exports relative to total fruit & nut export value
Source: FAO, ITC

In the export market, quality is an important parameter that increasing physical productivity alone does not guarantee the exploitation of the increased share of the market. Size, appearance, taste are some of the important quality parameters that are specific to these fruit crops. Recent exploitation of the export market of banana and papaya is due to the new varieties introduced to the country. Cavendish and Red Lady varieties are preferred in the banana and papaya export markets. Also these two exotic varieties have yields higher than the local varieties. More value added pineapple exports are picking up the market.

Expansion of Cavendish cultivation in Sri Lanka is as a result of technology transfer through foreign direct investment program. With this FDI, new variety, tissue culture technology for planting material production, new management practices, technology and protocols for quality and standards maintenance, post-harvest operations were brought. Operation of large scale banana cultivations by multi-national companies is subject serious challenges from environmental front. The second stage of transferring the new technology happened as a result of the agreement CIC had with Dole Lanka. CIC started Cavendish cultivation in their farms and with contract growers establishing processing unit for post-harvest preparation. Cavendish suckers are produced in the CIC tissue culture labs. This technology is further disseminated through DOA intervention to the farmers in small scale. However the export market share of Dole is many times higher than the CIC for Cavendish grown in Sri Lanka.

Contract grower system is also common among papaya export farmers that private sector exporters have contract growers for papaya production. Pineapple growers sell their harvest to collectors who sort and sell again to exporters and local wholesalers. Collector is the main contact person for information and technology. Services provided and role of AI as extension agents was found to be least effective and collector plays his role instead. At present scope of the input suppliers/collectors are limited to few information including export quality parameters, which can be widened through training as in the case of Bangladesh retailer training program. The existing network in the private sector among collectors can be encompassed to the government system.

There are lots of new entrants to papaya farming and passion fruit farming who are either introduced by specific development programs of the government or NGO's or private sector. There exists an extension gap that needs to be filled in these sectors. Also experienced farmers growing banana and pineapple can be identified as important partners of extension programs.

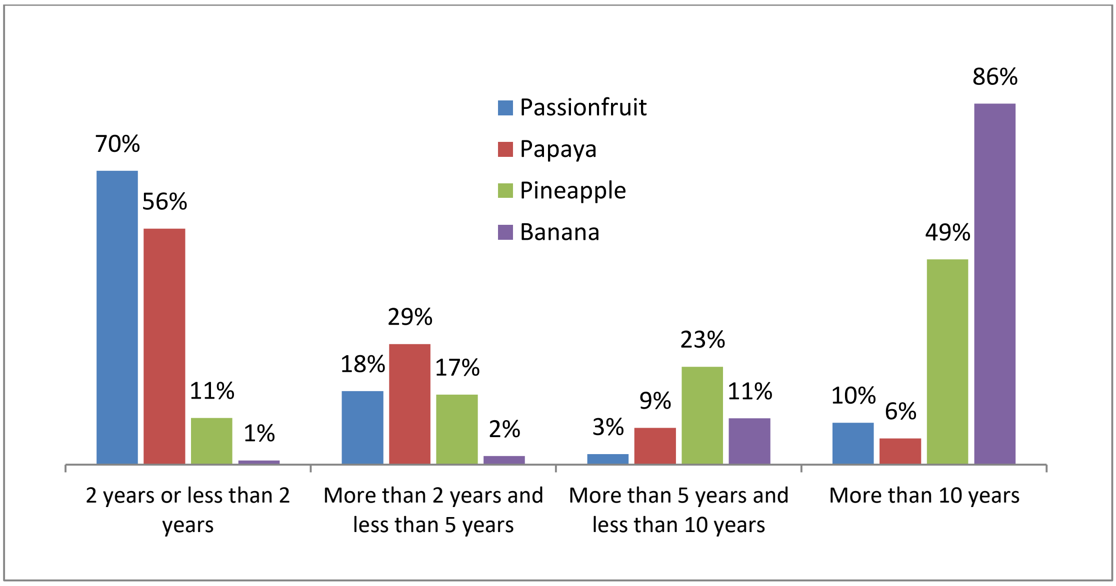


Figure 5.7: Farming experience of fruit farmers by fruit
Source: Sample survey 2019

Factor/resource use efficiency gaps existing among farmers provides useful information on the prevailing gaps of farmers' level of technical knowledge (a number of agronomic practices in crop establishment), socioeconomic status (education, tenure, and nonfarm income) and accessibility to information and markets. When the efficiency gaps of factor/resource use among farmers who are cultivating fruit crops are concerned, pineapple farmers shows the lowest gap. The gap between average farm yield and best practice farmers yield is less for pineapple. It is only Mauritius and Kiwi varieties are being cultivated in Sri Lanka and most farmers in main producing areas in Gampaha are cultivating variety Mauritius and are getting an average yield of 11.7 Mt/ha. However there exists higher variability of factor productivity compared to land productivity.

When banana farming is considered, the variability of land productivity and factor productivity are less among *Embul* farmers compared to *Seeni* and *Kolikutu* farmers. *Kolikuttu* farmers have the highest variability in yield. Variability in *Kolikuttu* yield is mainly due to its susceptibility to diseases.

Factor productivity of papaya farming in Vavuniya is more than double the factor productivity of Kurunegala farmers due to yield difference. The high variability of papaya farming in the producing areas shows the information gap among farmers on technical knowledge. Huge extension gap exist among papaya farmers as many of them are new entrants to papaya farming. Accessibility to information and markets is important.

Table 5.3: Mean and coefficient of variation of average yield and factor productivity of fruit growing farmers

	Average Yield		Factor Productivity	
	mt/ha	CV	kg/Rs	CV
Pineapple	15.15	11%	0.115	30%
Banana				
Seeni	32.14	36%	0.114	57%
Kolikuttuu	21.13	48%	0.038	52%
Embul	43.14	27%	0.123	24%
Papaya			0.144	68%
Kurunegala	39.18	47%	0.072	43%
Vavuniya	75.81	63%	0.198	49%

Source: Sample survey 2019

5.2 CONCLUSION

Most of these crops cultivated in the region are not native to this region, mostly introduced in various times in the recent history. Nevertheless, countries have adopted new technology for better utilizing the genetic potential of these crops to achieve agricultural productivity to produce more food to feed people and to generate foreign exchange. Vision, bringing in technology through research and development and partnering with international agencies, bringing capital for development through private sector participation and multinational investments are striking features of their success in achieving growth in their food crop sectors in their countries. The size of the Indian and Bangladesh economies and the stage of the development of their economies are considerable factors in this comparison.

Sri Lanka has somewhat drifted away from the global research and development programs since mid 80's. Several reasons can be attributed to this including the political instability after 1983, the gradual distancing from working collaboratively with International NGO and other international agencies with the development of distrust on NGO activities in Sri Lanka, flow of technology and technology products at a lower price from international markets after opening the economy and for others.

Changing development paradigm also played a significant role in agricultural productivity improvement in developing countries. CGIAR played an important role in agricultural productivity improvement during the green revolution period. Sri Lanka was successfully engaged in collaborations with international partners during this period. Gene transfers for paddy NIV during green revolution period is a historical breakthrough in technology generation.

With Globalization, technology products transferred through imports became more accessible and inexpensive.

International development assistance also took a different dimension that multinational companies that are themselves became part of development assistance. Bangladesh and India are working with these organizations.

The emerging private seed sector in Bangladesh includes both multinational companies and domestic seed businesses. The leading seed companies in Bangladesh are Monsanto (Bangladesh) Limited, Syngenta (Bangladesh) Limited, BRAC, Pioneer, Advanta, National Agri Care, CP seed, Alfa Seed International, Rashel Seed, Lal Teer Seed Limited, ACI Seed, Auto Equipment Ltd., Kushtia Seed Store, Siddiquis Seeds, Supreme Seed Company Ltd., Alpha Agro Limited, Getco Agro Vision Ltd., United Seed Store, Agri Concern, etc. Most of the world‟s seed multinationals get cultivars into Bangladesh through locally owned collaborating companies.

Apart from that, internal factors such as less funds allocated for research and development, less human resource training opportunities given, adopting more inward looking perspective are attributable factors of low innovations.

Most public expenditure was allocated to irrigation investments and as transfers in terms subsidies particularly fertilizer subsidy. Rural infrastructure development reduced largely the transaction cost of input supply that famer's accessibility to agrochemicals, seeds and other inputs was vastly improved.

With regard to the institutional factors that science and technology adoption to improve agricultural productivity, two important changes can be highlighted.

1. Orientation of DOA as a professional organization was gradually converted to a more an administrative set up. During this period other apex bodies like CARP, NASTEC were set up for research administration.

   (In 1994, the prime role of formulating science and technology policy was assigned to NASTEC, which also had been assigned the task of advising the government on policies and plans for the development of science and technology, and their application in facilitating economic growth, improvement of efficiency and competitiveness of industry, agriculture and services. NASTEC was also expected to advice and assist the government in formulating policies and plans for the development of the science and technology human resource base, allocation of funds for research and its proper management, and promotion of conditions necessary for the advancement of science and technology in the country. Other important functions assigned to this organization included prioritization of scientific issues of national significance, evaluation of performances of science and technology institutions, and organizing a biennial convention to review and assess the scientific and technological needs of the country.)
2. Extension became under provincial administration with less technical more administrative set up and coupling poverty alleviation intervention implementations with the extension system.

Rising wage rates in agriculture sector in response to rising wage rates in the non-agricultural sector made it increasing returns for mechanization. Private sector captured this market and played a significant role. Nevertheless, Sri Lanka had not been quite successful in benefiting from the multiplier effects of backward linkages of mechanization through establishing machinery plants, assembling units and some innovations.

5.3 RECOMMENDATIONS

Recommendations given in this section include the policy instruments proposed by the study to increase the productivity of the domestic food crop sector within the framework of a more competitive, market demand responsive, sustainable and resilient agriculture sector. Policies or the plans of action initiated by the government to guide decisions and achieve specified objectives are implemented through various policy instruments. They can be a legislation, executive decrees, investment projects, development programs or collaborations among institutions. Instruments may be combined; a program may have an investment component, or may require an executive decree before it can be carried out. Legislation and decrees define the rules of the game and establish programs, such as guarantee funds, subsidies, and formation of associations, among many other activities. Policy instruments proposed in the study include interventions/strategies to address the policy gaps existing in the current policies and the policy instruments to address new challenges to increase the productivity of the domestic food crop sector.

Study identifies following priority areas for policy intervention.

1. Bridging the research gap and science gap
2. Developing cost-effective and labour saving farm technologies and to benefit from technology transfer imports and technology spill-overs
3. Bridging the extension gap and up-scaling of technology
4. Increase the space for private sector/Corporate sector for productivity enhancement through mechanization, machinery production, quality seed production
5. Managing price volatility arising due to greater global integration of Sri Lankan food crop sector
6. Integration of agriculture policy with other related policies enabling productivity growth within the framework of market demand responsive, sustainable and resilient agriculture sector
7. Develop a mechanism for prioritization of investments ear marked for productivity improvement within the fiscal space of the government
8. Develop a mechanism to adjust policy instruments to the changes in the rules of the game and regulations of international institution.

Bridging the research gap and science gap

As the study surfaced, developing countries' collective effort in search of new technology is now mostly bound to state capacity to invest in technology generation and hence innovation. The primary reason is changes in the supply and demand for agricultural technologies in the world's richest countries, which have been the main producers of agricultural technologies. These countries will no longer provide the same levels of productivity-enhancing technologies, suitable for adaptation and adoption in food-deficit countries, as they did in the past. This trend has been compounded by a reduction of rich-country support for the international agricultural research system, which had already diverted its own attention away from productivity-enhancing technologies. These changes mean that developing countries will have to become more self-reliant in the development of applicable agricultural technologies. To achieve complete self-reliance will be beyond the ability of many countries, especially given recent and ongoing structural changes in science and scientific institutions—in particular the rise of modern biotechnologies and other high-tech agriculture, and the associated roles of intellectual property. The largest developing countries— Brazil, China, and India—are making the transition (Pardey, 2006). Nevertheless countries like Sri Lanka have a limited scope to benefit from agricultural research developments in the technology advanced countries in the future as it has in the past for productivity-enhancing technologies, suitable for adaptation. Open access to genetic resources and technology spill overs are becoming more constrained. Certain imported technologies are becoming costly and not adaptive. Therefore country will need to become more self-reliant in the provision of agricultural R&D. Public research system has the vital share in creating new knowledge and technology as private, corporate and non-governmental sectors have limited incentives for innovations.

Therefore the study makes a strong case that effective public sector research system is critical in bridging the science and research gap for technology generation. Strengthening research and development in the field crop sector through increased resource allocation and the improvement of the allied institutional setup in the public sector is vital. Of the main technological innovations, bio chemical technology innovation is mainly in the hand of public sector as mechanised technology is largely being diffused by private/corporate sector in Sri Lanka.

The role of Department of Agriculture (DOA) is crucial as the apex body in research and development in the food crop sector and DOA is needed to be repositioned as scientifically- orientated, autonomous and accountable institute to lead the research program in the food crop sector. Adequate funds and resources, focus, trained staff, internal incentive system, flexible institutional arrangements are important pre-requisites for effective and efficient functioning of DOA.

Stable budgetary support consistent with the needs of the evolving research programmes should be ensured following the norms of the developing and developed countries. Strong political forces still support subsidies for irrigation and fertiliser which continue to divert funds from long-term agricultural investments with greater impacts of agricultural productivity.

Although the traditional funding method of block grants to research institutes is said to be no consideration of research priorities, research productivity, or research planning in general by some literature (Pardey et al 2006), India considers block grant is still relevant than competitive grants in commodity based research. Government funding to the Indian NARS is mostly in the form of block grants to different institutes under the successive Five Year Plans Pal, 2017).

Under the restricted funding scenario, regional research institutes of DOA can collaboratively design focussed research programs with universities and international agencies by sharing resources. DOA can develop comprehensive food crop sector development medium term research and development programs with resource plans (state support, private sector, international agencies).

SLCARP can play a facilitating role for research and development from its current functioning as an administrator in research funding and monitoring of research. NARP competitive research funding program can focus only on collaborative research programs partnering many institutes.

Devise modalities for training which can be coupled with science and technology transfer is one of the ways to regain the technology innovations within the research system. The opportunities given in these programs should aim to bridge the 'science gap'; new developments in science and technology. Ministry of Agriculture can strengthen the coordination activities with the international agencies such as IRRI, CYMMIT, ICRISAT, EU, UN agencies.

Not filling the DOA staff vacancies for many years creating large staff vacuum is a grave concern in developing any program for intervention which should be addressed immediately. It is important to reduce AR/FR restrictions for the effective functioning of DOA. Also devising modalities to retain the scientists at DOA is important.

Unlike the conventional scientific methods, when modern scientific methods are adopted in research and development it involves several procedures, protocols and safety mechanisms apart from modern scientific infrastructure. This is another area that scientific community has to work together to develop an effective public research system.

Sri Lanka does not produce genetically engineered (GE) crops. The National Science Foundation (NSF) established a Steering Committee for Biotechnology in 1992 to promote and support biotechnology research in universities and research institutions. In 1997, the Ministry of Science & Technology (MoST) identified biotechnology as a thrust area for development in Sri Lanka and a loan from Asian Development Bank (ADB) was made available for the development of human resources and capabilities in some selected universities and research.

Some GE research is carried out at the laboratory level, but no development exists at a commercial level. Sri Lanka signed and ratified the Cartagena Protocol on Biosafety in 2004. Sri Lanka is in the process of developing policies to regulate and promote biotechnology. Most of the policies are incomplete, or not fully implemented. Sri Lanka is developing multiple policies to regulate and promote biotechnology. However, these policies are still at various stages of development or implementation.

Developing cost-effective and labour saving farm technologies and to benefit from technology transfer imports and technology spill-overs

Under the scenario of negligible private-sector involvement in agricultural R&D and a scarce public-sector resource, one of the policy choices for Sri Lanka will be to make enabling environment to make the best of the available resources to capitalize on international technology spillovers and to maximize payoffs by utilizing available genetic resources for segmented markets (eg. health, taste parameters).

Importing of technology also plays a pivotal role in the present context of globalization. It is impossible and uneconomic for a country to be "self-sufficient" in technology where it is cheaper to import commercially or gain access through international cooperation. Therefore replicating the foreign technology directly or after necessary adaptability research is important in the modern context. Especially the high level technology which is not feasible or uneconomic to be generated within the country belongs to this category. It is important that trade regulatory and administrative bottlenecks to be lessened for free movement of technology transfer, testing for local conditions, setting standards (particularly for machinery).

With regard to the import of Genetically Engineered (GE) plants, Plant Protection Act No 35 of 1999 does not contain restrictions on the import of GE plants. Nevertheless the general quarantine procedure for importing plants and plant products states that Genetically Modified Organisms (GMOs) and Living Modified Organisms (LMOs) are not allowed to be imported to the country. Due to the absence of a functioning approval mechanism in effect for bio technology related imports, low tech bio technology imports such as tissue cultured plants import has also been restricted. This was experienced when banana tissue culture plants were first imported. Import of hybrid seeds is free of such restriction and they are in adoption.

On the other hand, OFC sector is still predominantly a semi-subsistence family labour dependant farming system although few farming systems have evolved as sub-commercial systems based on market signals. Therefore less input demanding technologies are still needed to be developed. Genetic improvement of local varieties that are adapted to local conditions is also vital. While more affluent farmer groups to be benefited by modern technologies, smaller producers can benefit from local varieties that require less input by producing for niche markets. It is a prerequisite to preserve the locally adapted varieties and seed production and to improve the genetic potential of local varieties and maintain a seed stock in the region by promoting seed growing farmers.

In order to exploit the locally available genetic variability of crops, there should be a mechanism to protect the existing gene pool. Regulatory provisions should be established to protect such varieties. The program of collection and preservation of germplasm in-situ or ex-situ needs to be given the importance in the DOA priorities. Farmers who are protecting and preserving these genes

It is timely to bring in policies and institutions for harnessing mechanical power, alternative low cost electric power, and automation and information technology for productivity improvement in domestic food crop sector. Specifically third stage of mechanization after tillage and harvesting mainly involves small machinery development fitting to different crop management operations. Backward linkages can lead to innovations with right policies and institutions are in place.

FMRC, DOA, private sector, universities jointly can prepare a strategic plan and initiate programs for mechanization and it should be considered as an investment priority. Lesson can be learnt from India. DOA can take the leadership.

Bridging the extension gap and up- scaling of technology

As mentioned earlier, the effectiveness of public extension service has been weakening since extension became under provincial administration coupling with poverty alleviation programs. On the other hand effectiveness of public agricultural extension is particularly large when it is implemented alongside complementary upstream or downstream interventions (access to seeds and other inputs, assistance in marketing produce) (Waddington et al. 2014). For an example, Yaya programs implemented in 90’s in interprovincial areas that attempted to bridge the yield gap of rice showed significant results. As was found out in the study, some crop sectors such as papaya, passion-fruit have large extension gaps.

Nevertheless study draw some findings related to various forms of value chain innovations that have been introduced by up- and downstream companies or input output companies to overcome constraints and enhance access to adoption of new technologies. In the wake of liberalization, a number of institutional innovations for technology transfer in agricultural value chains were emerged. Value chain innovations include smallholder contracting with interlinked technology transfer, guarantee structures with technology suppliers or financial institutions, and special purpose programs. Contract grower system which was introduced by central bank in 1999 through its Forward Sale Contract (FSC) program made a value chain innovation in commercializing maize to become the second largest field crop in the country. These value chain innovations have been instrumental in transferring hybrid technology. Also study found contract grower system can reduce transaction costs involved in dissemination and adoption of new technology to a large extent.

Diffusion of hybrid maize technology, tissue cultured Cavendish banana, one of the horizontal technology spillover introduced by CIC to their farms through vertical spillovers from FDI program and the improved management practices introduced through Soybean contract grower system by Plenty food are some of these technology transfers caused to increase the productivity significantly as discussed in the study.

Although vertical spillovers from FDI engaging in global value chains are found in many developing countries, the difficulty to acquire land, due to practical (e.g. high population and farm density in fertile areas) or legal constraints (e.g. foreign ownership of land not being allowed) and social pressures (e.g. from surrounding communities or international civil society) that induce large reputational costs from being associated with “land grabbing” are observed (Swinnen & et al, 2016). Sri Lanka is no exception.

It is also observed that value chain partners themselves can act as the extension agent. In some sectors retailers function as extension agents for technology transfer in productivity development of some crop sectors and this is common in countries like Bangladesh (eg. Bangladesh retailer program). The role played by the collectors and input suppliers as extension agents in technological and information transfer should be identified and they can be trained and equipped with new knowledge for productivity development of crop sectors in particular the fruit crop sector. Experienced farmers can also act as extension agents when clustering farmers to farmer organizations. Therefore recognizing these alternative extension methods outside the formal system to reinforce those systems is important. Study identifies contract grower system is an important value chain innovation that can bridge the extension gap.

It is common to observe that these value chain innovations are set in the context of imperfect financial and technology markets and weak contract enforcing institutions as observed in other literature (Swinnen & et al, 2016). Government finance programs and risk sharing institutional arrangements are important. Improving contract enforcement is another promising avenue for improving the enabling environment for technology adoption, as it can reduce the risk of hold-ups. Alternative dispute settlement institutions outside courts, increasing transparency of contracts, training farmers in their rights/obligations as contractors etc are prerequisites.

If the incentive for the up- stream or down- stream companies in these value chains to technology transfer is relatively less especially with technologies with long gestation period or higher risk involved, some farmers will be excluded from private sector programs. Public interventions are needed to focus on those market segments.

Geographical distance between the origin of technology and where it is used should no longer be a factor for non-adoption of technology. Digital technology has several solutions to be merged into technology transfer programs. Public programs could learn from the institutional design of the private sector in bringing different partners to the table. Although the existing formal decentralised extension system to be absorbed to the central government is a step that requires lot of government commitment, a momentum is needed to gather around it. Technology dissemination through development programs implemented by the ministry of agriculture and institutes under the ministry such as DOA, Agrarian Development Department is to be streamlined and qualified agriculture graduates are to be absorbed for these programs.

Increase the space for private sector/corporate sector for productivity enhancement – mechanization, machinery production, quality seed production, become partner of supply/value chain and risk management

Private/corporate sector plays a major role in mechanization of food crop sector in Sri Lanka. Also they play a vital role in quality seed production and import of seeds. Private sector plays several roles as important actor in the supply/value chain. Current formal seed market constitutes about 25 -30% of the total seed requirement and of which corporate sector and registered seed growers have a considerable share with the private sector was called for investing in seed industry.

Unlike the neighbouring India and Bangladesh, Sri Lankan private sector has not considerably invested in research and development to a number of factors including the Intellectual Property Right (IPR) issue and other legislative hindrance. Any expansion in the relative importance of private funding, or public–private partnerships in the provision of agricultural R&D, has been for technologies associated with inputs such as chemicals, seeds, and machines or with off-farm processes.

Private sector involvement in productivity improvement through technology generation, up-scaling and transfer depends on factors for which government needs interventions. Private sector needs to be recognized as a productivity development partner in the stakeholder dialogue. Managing the risk is other important factor that determines the participation of private sector in value chains.

Therefore it is important to introduce risk sharing business modalities that private sector can partnering with farmers and government from quality seed production to output market in the supply/value chain. Formation of direct farmer linkages with supermarkets/retailers, processors and other value chain partners can pass on the market signals from consumer to producer.

Improving contract enforcement is another promising avenue for improving the enabling environment for technology adoption, as it can reduce the risk of hold-ups. Legal issues in the contract grower system are to be considered to address both parties to make sure the legal provisions in the contract agreements to secure the rights of contract partners and proper conduct of the agreements. As it is generally either not possible or too costly to resolve disputes in courts, alternative dispute settlement institutions can play an important role. Other measures can include increasing transparency of contracts, supporting alternative dispute settling arrangements, training farmers in their rights/obligations as contractors etc. Public- Private- Producer Partnerships can be used as a great way of promoting the entities to stimulate investing more in agriculture, where the risk embedded with company itself is low in the venture.

Providing infrastructure and financial market institutions; and facilitating labor markets are important for the functioning of private sector. Ensuring stability and security, improving regulations and taxation are some of the enabling environment for both domestically and for international investments.

Appropriate institutions are to be established for intellectual property rights protection for private investment in the generation of embodied innovations. Seed Act needs to have provisions to protect right of the seed producers at the same time the quality of seed production. It will be very important to have a mechanism to protect and regulate the quality of the seeds and the planting materials production particularly when the F1 seed production program start to implement extensively.

Many of the value chains currently in operation are outside the global value chain. Most fruit crops exported to main destination market with 0% tariff and with fewer restrictions on sanitary and phyto-sanitory requirements. International negotiations for bilateral agreements need to be intensified to harness the space for private sector operation. It is important to strengthen the activities of the division in the ministry of agriculture for international negotiation for bilateral agreements to facilitate finding export markets.

Managing price volatility arising due to greater global integration of Sri Lankan food crop sector

With the opening of the economy in 1977, doors were open for technology transfer in terms of technology products; improved seeds, machinery, agrochemicals which positively impacted since crop sector was not opened for competition. When Structural

Adjustment Policies were implemented in 1989, as the fertilizer subsidy was removed abruptly, it affected the TFP of paddy sector. Until now fertilizer subsidy is implemented in various forms and degrees. In 1996 when the other field crop sector was opened, it affected the other field crop sector that farmers abandoned dry chilli production. From 1998, country started implementing a seasonal tariff imposition method to protect the seasonal local supplies from import competition. It is important to maintain a stable trade policy since most of the crops cultivated are hardly competitive in the international trade that Sri Lanka is not efficiently using resources as Sri Lankan TFP in the domestic food crop sector is low compared to neighboring countries.

With the collapse of the WTO negotiations, the rules for global trade and development has taken a different dimension that global institutes have given serious consideration to the principle of subsidiarity in production and trade - that whatever can be produced locally with reasonable cost should be produced and traded locally - as a way of preserving or enhancing the health of both environment and society.

A 'New Deal' for agriculture in developing countries would be in the direction the integration of trade into a development strategy that will put the emphasis on raising incomes and employment in the agricultural sector, achieving food security through a significant degree of food self-sufficiency, and promoting ecologically sustainable production instead of integration of agriculture into world trade.

Accordingly, Sri Lanka can follow the import substitution strategy for field crop sector that target TFP growth with protection

It is important to minimize the impact of economy-wide and trade policy changes on agriculture. Maintaining a stable trade policy is conducive for private sector investment and continuity of their investment and for adopting better management practices by farmers. Abrupt policy changes are adversely affecting the sector. Therefore it is important to minimize the impact of economy-wide and trade policy changes on agriculture.

Integration of agriculture policy with other related policies enabling productivity growth within the framework of market demand-responsive, sustainable and resilient agriculture sector

Through a consultation with all breeders and scientists in the DOA, universities, international partners and private sector should devise a plan to formulate science and technology policy to benefit from science and technology development in other part of the world for agriculture productivity growth.

TFP growth associated with weedicide application cannot be justified. Therefore health and environmental tax on weedicides to account the environmental and health cost associated with application of weedicides to be introduced.

Upgrade the existing information systems in agriculture sector to a common platform with different algorithms to access information by various stakeholders; farmer, policy makers, input suppliers and other market participants, researchers and other interested groups with the support of IT specialists.

A plan is to be drawn for mechanization and other machinery and equipment (hydroponic systems, poly tunnels, etc) and irrigation technology development in line with the industrial policy. DOA and FMRC can jointly work with industry experts.

Current agriculture insurance policy is to be coupled with other risk minimizing strategies to make the current program to be effective and sustainable in productivity improvement.

Develop a mechanism to investment prioritization for productivity improvement subject to fiscal space of the government

Investment prioritizations are to be implemented as a rolling plan which is reviewed annually with a panel of the experts. Guiding principles are to be laid from the existing knowledge and with support of further research. (Policy models already developed for Sri Lanka can be tested for their validity for the purpose)

It is needed to incorporate the sector investment plan in the national investment program to avoid ad-hoc investment prioritization.

Budget transfers in terms of fertiliser subsidy which is largely transferred to paddy farmers can be reduced by offering a better paddy price for farmers. Also implementing research findings into policies can bring down the subsidy expenditure as it happened in 2013 adopting fertiliser recommendation revision for paddy by reducing 30% of N in basal applications.

New irrigation construction expenditure would taper off in the future as the potential irrigated area has been largely exploited. The recurrent droughts implies the water use efficiency is important than bringing more lands under irrigation.

This suggests that more financial resources should be diverted to research and development to face the new challenges and to generate new knowledge and technology.

Develop a mechanism to adjust policy instruments to the changes in the rules of the game and regulations of international institutions to benefit from new technology, markets.

Recent development in the world trade and trade agreements, changing shape of the development assistance, role played by multi-national companies are to be studied to identify required changes.

Funding should be allocated for conducting research in this area and for participation in international programs. HARTI has a vital role in contributing in this domain of research.

Division in the ministry of agriculture for international negotiation for bilateral agreements can be expanded to undertake the research activities and this technical body of the ministry is to coordinate relevant research agencies to undertake research.

A high level technical person is to head the division to represent the country and be responsible for designing required changes in policy instruments.

POLICY RECOMMENDATIONS

1. **Increased budgetary allocation for research and development in the sectoral budget for a comprehensive food crop sector development medium term plan**

Responsible Agencies - Ministry of Agriculture, Ministry of Finance, Ministry of Plan Implementation, DOA, SLCARP

Recommendations

- Allocate more funding for research and development
- Allocate of additional funding to the DOA budget as block grant to research and development programs in the medium plans

Guiding principles:

- Adhering to neighboring country standards

Country	Period	Increased Research Expenditure
Vietnam	2000-2010	100 to 180
India	2000-2014	100 to 155
Bangladesh	2000-2018	100 to 136
Sri Lanka	2000-2018	100 to 107

- Compromise transfer payments to investments in agriculture expenditure budget

Expenditure Item	**Year**	**2017**	**2018**
Irrigation (Rs.Mn)	Recurrent	3158	3210
	Capital	10902	11133
	Total	14060	14343
Fertilizer Subsidy (Rs.Mn)	Recurrent	30361	26948
Research and Development (Rs.Mn)	Recurrent	1615	1726
	Capital	382	459
	Total	1996	2185
Extension and Training (Rs.Mn)	Recurrent	1250	1529
	Capital	374	585
	Total	1624	2114
Seed Certification and Plant Protection (Rs.Mn)	Recurrent	1265	1470
	Capital	684	797
	Total	1946	2267

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2. **Reposition of DOA, the largest national food crop research and development institute in Sri Lanka accountable to the national development objectives, as scientifically-orientated, autonomous institute. (DOA strength in terms of institutional capacity and the human resource base is vital to lead the research program in the food crop sector.)**

Responsible Agencies - Ministry of Agriculture, Ministry of Finance, DOA

Recommendations

- Allocation of more funding – Current R&D capital budget of 500 Rs Mn to be increased adhering to the trends of neighbouring countries (DOA is mandated to undertake research to 30% – 32% of Ag GDP (Value added))
- To fill the vacancies immediately for the posts of scientists and technicians at the DOA that have been accumulated for many years and allocate funds in the recurrent budget
- As a policy, the Research Scientist to be absorbed to the DOA research cadre on merit basis. (Scheme of Recruitment)
- Revisit the Agriculture service minute to address human resource development as a prerequisite for institutional capacity development and incorporate post graduate training; MSc, PhD in the promotion scheme of DOA research staff.
- DOA institutional set up to be oriented as more scientific basis than administrative.
- A separate promotion scheme for technical staff to be devised outside the promotion scheme of the research scientists.
- Research managers should be given flexibility to work in a transparent and accountable system.
- Develop more transparent on-line operative financial and administrative regulations/formalities
- Devise incentive system in return to impact of research and other innovative undertakings by scientists

  . – Breeder rights, Professorships like in IFS, private sector partnerships and other benefits and incentives

  Although the Seed Act acknowledges the breeder-rights, mechanism has not been devised to benefit DOA researchers. The Plant Varietal Protection Act been in preparation acknowledges the intellectual property right and patenting of new varieties developed by DOA on institute basis. A mechanism should be devised to trickle down the benefit to the scientists.

- Specific roles and related institution (governing principles) of DOA institutes should be recognized.
- To prepare medium term research and development plans like in India as rolling plans which will be updated annually with impact assessment

3. Agenda for Training

Responsible Agencies - Ministry of Agriculture, Ministry of Finance, DOA, Department of External resources, National Science foundation, SLCARP, Ministry of Higher Education

Recommendations

- Human resource development program to be jointly designed emphasising training to be coupled with DOA research and development program and technology transfer. The opportunities given in these programs should aim to bridge the 'science gap'; new developments in science and technology.
- Introduce mission- mode research and development program to the DOA research program with a component of post graduate training at postgraduate training institute (eg. PGIA) in Sri Lanka (possibly with international collaborations).
  (USDA- land grant universities model in the US and the ICAR – State agricultural universities model in India provide guiding principles)
  Allocate of additional funding to the DOA budget as a block grant to implement the mission-mode R&D program that includes studentships
- Redesign National Science Foundation's research programs and scholarships to cater to research agenda of the DOA
- Regional research institutes of DOA can collaboratively design focussed research programs with universities, and international agencies (eg RRDI – Wayamba University) by sharing existing field and laboratory facilities at the DOA and the universities for research activities.
- Enter MOUs with universities oversees for technology transfer and training
- Promoting sandwich programs with overseas universities
- Entering into joint research programs with International agencies
  Strengthen the coordination activities in the Ministry with the international agencies, IRRI, CYMMIT, ICRISAT, EU, UN agencies such as Commission on Science and Technology for Development of the UNCTAD
- Designate institutes for international collaborations

4. Mainstreaming new/up to date technology to increase land productivity, labour productivity and sustainability

Responsible agencies – DOA, SLCARP, NSF, Universities

- Exploitation of heterosis/ hybrid vigor of F 1 in cross pollinated plants which is globally common.
- Biotechnology Research

  Jones envisages a continuum of technologies within modern biotechnology, existing as a gradient from "lower-tech" processes from biologic nitrogen fixation to tissue culture, to the "higher-tech" recombinant DNA techniques for diagnostics and genetic engineering (Davies 2003).

  Tissue culture and micro-propagation, Marker-assisted breeding, Advanced genetic engineering and transgenic crops

  Transgenic modification confers a number of benefits, including tolerance to biotic stresses (insects and disease), abiotic stresses (drought), suitable plant structure for machinery compliance, improved nutrition, taste and appearance, herbicide tolerance and reduced use of synthetic fertilizers. Given the challenges of increasing water scarcity and land degradation, such technologies potentially increase productivity per area unit or plant.

- Frontier technologies such as Artificial intelligence (AI), Internet of Things (IoT), Big Data, 5G, Drones, Nanotechnology, Solar photovoltaic (Solar PV) for low cost automated small machinery development, plant disease management, early warning of pest outbreaks, developing low-cost diagnostic toolkit for extension workers, market intelligence, risk assessment

5. Legislations, protocols and guidelines for technology innovations

Responsible Agencies - Ministry of Agriculture, Ministry of Science and Technology, Ministry of Environment

Recommendations

- Plant Varietal Protection (PVP) Act been in preparation need to address
  - the legal provisions to safeguard the rights of local farmers and their traditional knowledge.
  - Farmers' rights to receive benefits arising out of farmers' protected plant genetic resources if such resources are used by the breeders to develop new varieties
  - Some of the aspects failed to address in Seed Act and Plant Protection Act
    - Seed Act – breeder rights are acknowledged but no implementation strategy for a rewarding system
    - Plant Protection Act of 1999 – does not exclude GE products import but contradicts with general quarantine procedure for importing plants and plant products states that Genetically Modified Organisms (GMOs) and Living Modified Organisms (LMOs)
  - the possible private-public funding arrangement for research and development with intellectual property rights IPR
- Finalise the National Biosafety Framework which includes the National Biosafety Policy and the National Biosafety Act that has been developed in conformity with the country's commitments to the Cartagena Protocol signed and ratified by Sri Lanka in order to undertake biotechnology research for commercial cultivation
- Active participation in agreements with international partners for genetic materials exchange within the provision of the ge International Treaty on Plant Genetic Resources for Food and Agriculture of FAO
- Strong institutional framework for implementation of seed act, plant protection actor/and plant varietal protection act- Seed Certification and Plant Protection Center can follow the model of Sri Lanka Standards Institute

6. Enabling environment for value chain innovations to technology transfer, extension and up-scaling of technology

Responsible Agencies – Ministry of Agriculture, Ministry of Finance, Ministry of Trade and Commerce

Recommendations

- Recognize private sector/corporate sector as development partner
- Financial support for purchasing new technology – credit, subsidies
- Free Access to information
- Establish a mechanism to implement pilot/project basis outscaling/ upscaling of innovations nationally that are currently being implemented by DOA Institutes, ministry of agriculture as development programs
- Formalize the Central bank implemented Forward Sales Contract program
- Accommodate market demand signals of the value chain to be incorporated in the research and development programs
- Enter into bilateral agreements with trading partners
- Establish contract enforcement and dispute settlement institution
- The need of an institute like AgEnt/ADA to be established by the government
- Design public sector training programs for extension agents in the value chain including retailers, collectors
- Lessen the trade regulatory and administrative bottlenecks for technology import
- Establish a functioning approval mechanism in effect for bio technology related imports
- Maintain stability and consistency of trade and market operation policies
- Facilitate the functioning of value chain through rural infrastructure development

Targeted interventions

Dry chilli production program to be organized in to a value chain from F1 seed supplier to 250g ,500 g dry chilli packet in super markets –Lessons from maize program implemented in Sri Lanka

7. Data and information as necessary prerequisites for productivity improvement

Responsible Agencies – DOA, HARTI, ICTA

Recommendations

- Amalgamating existing information systems with different algorithms to cater the needs of different users
    - Digitised paddy land registry http://www.aginfo.lk which contains Metadata of farmers
    - croplook.net web based crop production related AI level data collection system covering entire country
    - HARTI food information system
- Expand the current data and information collection programs ex. Cost of cultivation
- Developing a geo referenced information system with real time data feeding system using farmer motivated web based application (APP) and develop algorithms to translate as information to users
  Individual farm field is the lowest geo referenced data layer. On top of this layer, information available at other geographical boundaries can be fed to this information system. Farmer can feed real time discrete data using an APP to the system to fill the information gaps. Eg. The rainfall at farm level, drought impact, availability of stocks

- Agriculture Instructor's office at ADCs to be modernized as the interphase for exchange of information and training AIs on information technology and incorporate IT in the curriculum of agriculture schools

8. Institutional support and other interventions for land productivity, labour productivity improvement and sustainability

Responsible Agencies – Ministry of Agriculture, Ministry of Finance, Ministry of Environment

Recommendations

- Imposition of environmental tax on weedicides
- Designing a comprehensive risk management programme which is integrated in a broader programmes for development and climate risk management and considering weather derivative contracts and catastrophic risk in it
- Development of an Index based insurance for farmers which is integrated in a comprehensive risk management programme
- To strengthen the activities of the international relations division in the ministry of agriculture for international negotiation and bilateral agreements
- A high level technical person is to head the international relations division in the ministry of agriculture to represent the country and to coordinate the relevant research agencies such as HARTI, SEPC of the DOA that undertake studies on international relations.
- A separate division at HARTI to carry out research studies on international relations and agriculture
  Changing world order, international treaties, world trade and trade agreements, global value chains, changing shape of the development assistance, role played by multi-national companies are some of the areas to undertake studies. Funding should be allocated for conducting research in this area and for participation in international programs.

- To focus NARP competitive research funding program of SLCARP only on collaborative research programs partnering many institutes.
- SLCARP to establish investment prioritization criteria based on impact of public expenditure on food crop sector output growth.
  Related databases are needed to maintain and the existing models can be explored.

REFERENCES

Abeysekera S.W.Status, D.S. Abeysiriwarden and D.B. Weeratunge (2002) Policies and expectations for the hybrid rice research and development programme in Sri Lanka Adoption of Hybrid Rice in Asia - Policy Support, Proceedings of the workshop on policy support for rapid adoption of hybrid rice on large-scale production in Asia, FAO 2002

Abeyratne F. and H. Takeshima (2020) The evolution of agricultural mechanization in Sri Lanka , An evolving paradigm of agricultural mechanization development: how much can Africa learn from Asia?, IFPRI

Aheeyar, M., H. Manthrithilake, C Ranasinghe, M Rengaraj, Y Gamagedara and J. Barron, (2019) Mechanizing water lifting through pumps: a case study in Sri Lanka. Colombo, Sri Lanka: International Water Management Institute (IWMI). 61p. (IWMI Working Paper 188). doi: 10.5337/2019.206

Aluwihare, P. B. and M. Kikuchi (1991). Irrigation investment trends in Sri Lanka: New construction and beyond, Colombo. Sri Lanka: International Water Management Institute, 1991

Arasasingham, S.R. (1981) Agricultural extension in Sri Lanka, Department of Agriculture, Peradeniya (Sri Lanka) Extension Division

Bangladesh Bureau of Statistics (2015) Report on the Productivity Survey of Maize Crop 2014, Productivity assessment survey of different agricultural crops programme, Statistics and Informatics Division, Ministry of Planning of Bangladesh

Beintema N.M. and Gert-Jan Stads (2008) Diversity in Agricultural Research Resources in the Asia-Pacific Region, Agricultural Science and Technology Indicators Initiative, International Food Policy Research Institute and Asia-Pacific Association of Agricultural Research Institutions

CBSL, Economic and Social Statistics of Sri Lanka, Colombo

CBSL, Annual Report, Central Bank of Sri Lanka, Colombo

Department of Census and Statistics

Dhanapala M.P. (1999) Bridging the rice yield gap in Sri Lanka, Expert Consultation on “Bridging the Rice Yield Gap in Asia and the Pacific”, held in Bangkok, Thailand, 5-7 October, 1999. FAO, Rome, Italy. (FAO/RAP Publication: 1999/41).

Directorate of Economics and Statistics, Department of Agriculture Cooperation and farmers welfare, Ministry of Agriculture and Farmers welfare, Government of India

DOA, Annual Performance Reports, Seed and Planting Material Development Centre (SPMDC), Department of Agriculture

DOA, Annual reports, Department of Agriculture

DOA, Cost of Cultivation, Department of Agriculture

FAO, FAOSTAT

Girihagama P., Rahija M., and Stads Gert-Jan (2012) Recent developments in public agricultural research, ASTI, IFPRI

HARTI, Food Information system

Henegedara, G. M. (2002). Agricultural policy reforms in the paddy sector in Sri Lanka: An overview. https://www.semanticscholar.org/paper/Agricultural-Policy-Reforms-in-the-Paddy-Sector-in-Henegedara/7668cf5748ec1744f10eac6d01b8a92aa02aa7e7. Accessed on 01.05.2020.

Hirimuthugodage, D. (2014). Does Sri Lanka Need a New Seed Act? Institute of Policy Studies (IPS). http://www.ips.lk/talkingeconomics/2014/05/22/does-sri-lanka-need-a-new-seed-act/. Accessed on 09.05.2020.

ICAR

Ilangarathna E.M.G.A (2019) An Ex-ante Assessment of New Rice Breeding Technologies to Sri Lanka, undergraduate thesis submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Agricultural Technology and Management, University of Peradeniya

IPS (2008), "Does Foodflation Call for Agricultural Reforms?", Sri Lanka State of the Economy (SOE) Report 2008, Institute of Policy Studies, Colombo, Sri Lanka.

IPS (2015), "Policy Reforms for Sustained Growth in Agriculture", Sri Lanka State of the Economy (SOE) Report 2015, Institute of Policy Studies, Colombo, Sri Lanka.IPS (2016), "Role of Economic Incentives in Financing Agricultural Investments", Sri Lanka State of the Economy (SOE) Report 2016, Institute of Policy Studies, Colombo, Sri Lanka.

ITC, Trademap

Jagtap, P.P., Shingane U.S. and Kulkarni K.P. (2012) Economics of Chilli Production in India, African Journal of Basic & Applied Sciences 4 (5): 161-164, 2012 ISSN 2079-2034

Karlik J., Bell M., Martin M., Rajcoomar S., and Sisson C. (1996) An Overview of Economic Developments in Sri Lanka, Financial Programming and Policy : The Case of Sri Lanka, IMF

Kikuchi, M., R. Barker; P. Weligamage; and M. Samad. 2002. Irrigation sector in Sri Lanka: Recent investment trends and the development path ahead. Research Report 62, Colombo, Sri Lanka: International Water Management Institute, January 2002

Kumarage A. S. (2003) RURAL ROADS And COMMUNITY ACCESS IN SRI LANKA: AN OVERVIEW, Colombo

Ministry of Finance, Budget Estimates

Ministry of Foreign Affairs

Natesan (1981) Agricultural extension in Sri Lanka, Department of Agriculture, Peradeniya (Sri Lanka) Extension Division

Niranjan F. (2004) Return to agricultural research in Sri Lanka, unpublished PhD Thesis, University of Peradeniya

Pain A. (1986) Agricultural Research in Sri Lanka: An Historical Account, Modern Asian Studies , Volume 20 , Issue 4 , October 1986 , pp. 755 – 778, Cambridge University Press

Quach Ngoc An, (2002) Hybrid rice production in Viet Nam, Adoption of Hybrid Rice in Asia - Policy Support, Proceedings of the workshop on policy support for rapid adoption of hybrid rice on large-scale production in Asia, FAO 2002

Ruttan, Vernon W. (1987) Agricultural research policy and development, FAO

Samaratunga, P.A. (2009), "A Note on Agricultural Development Issues in Sri Lanka", Mimeo, Institute of Policy Studies of Sri lanka, Colombo.

Samaratunga, P., Karunagoda, K. and Thibbotuwawa, M. (2007) "Mapping and Analysis of the South Asian Agricultural Trade Liberalization Efforts & quot; in ESCAP (eds), Agricultural Trade: Planting the Seeds of Regional Liberalization in Asia (pp. 33-74), ARTNeT Studies in Trade and Investment 60, UNESCAP, Bangkok, Thailand.

Schokman, D. (1981) Tropical agriculturist 1881-1981, Tropical agriculture in Lakshman W. D., and C.A. Tisdell (2000) Sri Lanka's Development Since Independence: Socio-economic Perspectives and analyses, Nova Science Publishers

Shurtleff, W. and A. Aoyagi (2004) Sri Lanka: soya pioneer in the third world (1979-1980s), A special report on the history of soy pioneers around the world. A chapter from the unpublished manuscript, history of soybeans and soyfoods: 1100 B.C. to the 1980s.

Turner M. (2001) The role of national seed policies in re-structuring the seed sector in CEEC, CIS and other Countries in Transition, FAO Plant production and protection paper 168, Food and Agriculture Organization of the United Nations, ISSN 0259-2517

Weerahewa J (2017) Modernizing Agriculture in Sri Lanka—Status and Challenges. In: Athukorala P, Ginting E, Hill H, Kumar U (eds) The Sri Lankan economy: charting a new course. Asian Development Bank, Manila

Wickremasinghe, S. (2006) Development of the National Agricultural Research System (NARS) in Sri Lanka with special reference to food crops sub-sector : issues related to science policy, J. Natn. Sci. Foundation Sri Lanka 2006 34(2): 69-83

Wickramasinghe, W., G. Samarasinha, and S. Epasinghe (2010) Fertilizer policy on paddy farming: An Evaluation of 2005 Subsidy Programme. Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo 07. Research report 135, ISBN: 978-955-612-104-9. http://dl.nsf.ac.lk/ohs/harti/23595.pdf.

Wickramasinghe W. D, (2012) Multiple effects and impact of small farmer (FFS based) seed potato production in Badulla district, Dry Zone Livelihood Support & Partnership (DZLiSP) Program, report submitted to Ministry of Agriculture

World Bank. (2007) Reviving Sri Lanka's Agricultural Research and Extension System : Towards More Innovation and Market Orientation. Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/13044 License: CC BY 3.0 IGO."

Appendix 1

TFP Measurements and TFPG Estimation Methods

In general, the TFP measurement methods that have been used in empirical productivity studies can be grouped into two main approaches: conventional or non-frontier methods and frontier analysis. The first approach assumes outputs are efficiently produced on the production frontier while the second allows for outputs being produced off the frontier. The frontier analysis is often applied to cross-sectional or panel data, whereas the conventional approach is mainly applied to time series macro-productivity data sets.

Both the conventional and frontier approaches can be further classified into parametric and nonparametric methods. The nonparametric method does not impose a specific functional form, whereas the parametric method imposes a functional form and employs econometric techniques in estimating a production function, a cost function or a profit function. Table 1 summarizes the principal methods used in measuring TFP and the corresponding data requirements.

Table 1. Summary of TFP measurement methods and data requirements

	Conventional approach		Frontier approach	
	Nonparametric	Parametric	Nonparametric	Parametric
Principal methods	TFP index/ GA	LS/ GA	DEA	SFA
Estimation of specific functional form and statistical tests	no	yes	no	yes
Data used:				
Cross sectional	yes	yes	yes	yes
Time series	yes	yes	no	no
Panel	yes	yes	yes	yes
Basic method requires data on:*				
Input quantities	yes	yes	yes	yes
Output quantities	yes	yes	yes	yes
Input prices	yes	no	no	no
Output prices	yes	no	no	no

Note: * This list applies to production function method only.
Source: adapted from Coelli *et al.* (2005, p.312); GA = Growth Accounting, LS = Least Squares, DEA = Data Envelopment Analysis, SFA = Stochastic Frontier Analysis.

The two TFPG methods used in this study are described here.

Nonparametric Growth Accounting Method

Although there are several approaches for measuring TFP (as shown in Table 1), a suitable approach depends on the objectives of the study and data availability. Since study aims to examine sources of agricultural growth at national level, the growth accounting framework is considered the most appropriate. The competitive equilibrium conditions which are the underlying assumptions of the growth accounting approach are reasonable. It is assumed agricultural sector is well characterised by a perfectly competitive market in the sense that there are a large number of farmers who maximise profit (or minimise cost) and take prices as given. It is generally recognized that farmers are price takers in input and output markets. Compared with other industries, such as manufacturing and services, the agricultural
sector is considered a suitable case study for applying the growth accounting method.

Under the growth accounting framework, the discrete-time Tornqvist approximation to the continuous-time Divisia index is employed. The method implicitly specifies a translog form of the production function but does not explicitly estimate the function. Constant returns to scale (CRS) is assumed, implying that all factor income shares sum to one. It is national income based growth accounting in the sense that most output and input data are obtained from the national accounts.

The growth accounting method begins with the basic production function that explains the relationship between output and input, expressed as follows (Oguchi, 2004):

$Qt = AtF (Lt , Nt ,Kt)$ (1)

where t Q = real output at time t
Lt= labour quantity at time t
Nt = land quantity at time t
Kt = capital quantity at time t
At = level of efficiency at time t

Totally differentiating equation (1) with respect to time gives:

$$\frac{dQ_t}{dt} = \frac{dA_t}{dt} F(L_t, N_t, K_t) + A_t \frac{\partial F}{\partial L_t}\frac{dL_t}{dt} + A_t \frac{\partial F}{\partial N_t}\frac{dN_t}{dt} + A_t \frac{\partial F}{\partial K_t}\frac{dK_t}{dt} \qquad (2)$$

Dividing both sides by Qt gives:

$$\frac{dQ_t}{dt}\frac{1}{Q_t} = \frac{dA_t}{dt}\frac{1}{A_t} + \frac{\partial F}{\partial L_t}\frac{dL_t}{dt}\frac{1}{F(L_t, N_t, K_t)} + \frac{\partial F}{\partial N_t}\frac{dN_t}{dt}\frac{1}{F(L_t, N_t, K_t)} + \frac{\partial F}{\partial K_t}\frac{dK_t}{dt}\frac{1}{F(L_t, N_t, K_t)} \qquad (3)$$

Rearranging equation (3) gives:

$$\frac{dQ_t}{dt}\frac{1}{Q_t} = \frac{dA_t}{dt}\frac{1}{A_t} + \frac{\partial F}{\partial L_t}\frac{dL_t}{dt}\frac{L_t}{Q_t}\frac{1}{L_t} + \frac{\partial F}{\partial N_t}\frac{dN_t}{dt}\frac{N_t}{Q_t}\frac{1}{N_t} + \frac{\partial F}{\partial K_t}\frac{dK_t}{dt}\frac{K_t}{Q_t}\frac{1}{K_t}$$

$$\text{or} \quad \hat{Q}_t = \hat{A}_t + MP_L\left(\frac{L_t}{Q_t}\right)\hat{L}_t + MP_N\left(\frac{N_t}{Q_t}\right)\hat{N}_t + MP_K\left(\frac{K_t}{Q_t}\right)\hat{K}_t \qquad (4)$$

where (^) indicates the instantaneous growth rate of the variable and , , L N K MP MP MP stand for the marginal product of labour, land and capital, respectively. In a perfectly competitive market, producers maximize profit and will employ each input where its marginal product equals its real factor price. That is, the real wage rate (*w*) equals the marginal product of labour ( ) L MP ; the real rate of land rent (*r*) equals the marginal product of land ( ) N MP and the real rate of return(*i*) equals the marginal product of capital ( ) K MP . Hence, replacing marginal products with factor prices, equation (4) can be rewritten as:

$$\hat{Q}_t = \hat{A}_t + S_L \hat{L}_t + S_N \hat{N}_t + S_K \hat{K}_t \qquad (5)$$

where $S_L = wL/Q$ = share of labour income in the value of total output

$S_N = rN/Q$ = share of land income in the value of total output

$S_K = iK/Q$ = share of capital income in the value of total output

Equation (5) indicates that output growth can be decomposed into the growth rate of the efficiency level and the growth rate of labour, land and capital, weighted by their output elasticities or factor income shares. The first component is the shift in the production function (representing technical change) and the latter is the movement along the production function (representing input growth and input substitution).

Rearranging equation (5), the estimation of TFP growth ( ) t TFPG can be expressed as the residual part of output growth that cannot be explained by the combined growth of physical inputs:

$$\hat{A}_t = TFPG_t = \hat{Q}_t - S_L \hat{L}_t - S_N \hat{N}_t - S_K \hat{K}_t \qquad (6)$$

Since the differentiation is applicable only to continuous variables, the growth rate terms in the above equations refer to an instantaneous rate of change. However, in practice, discrete data, especially annual data, are normally used in empirical work. Hence, the discrete annual data can be applied to approximate equation (6) by taking the average of two consecutive periods:

$$\begin{aligned} TFPG_t &= \ln TFP_t - \ln TFP_{t-1} \\ &= (\ln Q_t - \ln Q_{t-1}) - \frac{1}{2}(S_{Lt} + S_{Lt-1})(\ln L_t - \ln L_{t-1}) \qquad (7) \\ &- \frac{1}{2}(S_{Nt} + S_{Nt-1})(\ln N_t - \ln N_{t-1}) - \frac{1}{2}(S_{Kt} + S_{Kt-1})(\ln K_t - \ln K_{t-1}) \end{aligned}$$

The labour and land inputs are adjusted for their quality changes. For labour, the adjustment method accounts for the effect of qualitative changes in age, sex and education. The land input used in crop production is adjusted by the effect of irrigation, to account for multiple cropping.

The Tornqvist-Theil index is a superlative index which is exact for the linear homogeneous translog production function (Diewert). A further advantage of the Tornqvist-Theil index is that it accounts for changes in quality of inputs. Because current factor prices are used in constructing the weights, quality improvements in inputs are incorporated, to the extent that these are reflected in higher wage and rental rates (Capalbo and Vo).

The Tornqvist-Theil index provides consistent aggregation of inputs and outputs under the assumptions of competitive behavior, constant returns to scale, Hicks-neutral technical change, and input-output separability. However, Caves, Christensen and Diewert have shown that Tornqvist-Theil indices are also superlative under very general production structures, i.e., nonhomogeneous and nonconstant returns to scale, so they should provide consistent aggregation across a range of production structures (Antle and Capalb)

Non Parametric Frontier Approach: Malmquist Productivity Index Using DEA

Index captures the TFP Change as efficiency change and technical change between two periods with cross sectional output input information.

Malmquist productivity index depends upon four different distance functions.

$$
\begin{aligned}
m_o(\mathbf{q}_s, \mathbf{q}_t, \mathbf{x}_s, \mathbf{x}_t) &= \left[m_o^s(\mathbf{q}_s, \mathbf{q}_t, \mathbf{x}_s, \mathbf{x}_t) \times m_o^t(\mathbf{q}_s, \mathbf{q}_t, \mathbf{x}_s, \mathbf{x}_t) \right]^{0.5} \\
&= \left[\frac{d_o^s(\mathbf{x}_t, \mathbf{q}_t)}{d_o^s(\mathbf{x}_s, \mathbf{q}_s)} \times \frac{d_o^t(\mathbf{x}_t, \mathbf{q}_t)}{d_o^t(\mathbf{x}_s, \mathbf{q}_s)} \right]^{0.5}
\end{aligned}
$$

Output and input quantity data for a cross-section of firms in periods s and t, the production frontier can be identified using DEA and are used them in computing the distance needed. In general following four linear programming problems are solved:

These four LP’s are solved under CRS assumption

$$
\begin{aligned}
[d_o^t(\mathbf{q}_t, \mathbf{x}_t)]^{-1} &= \max_{\phi,\lambda} \phi, \\
\text{st} \quad & -\phi \mathbf{q}_{it} + \mathbf{Q}_t \boldsymbol{\lambda} \geq \mathbf{0}, \\
& \mathbf{x}_{it} - \mathbf{X}_t \boldsymbol{\lambda} \geq \mathbf{0}, \\
& \boldsymbol{\lambda} \geq \mathbf{0},
\end{aligned}
$$

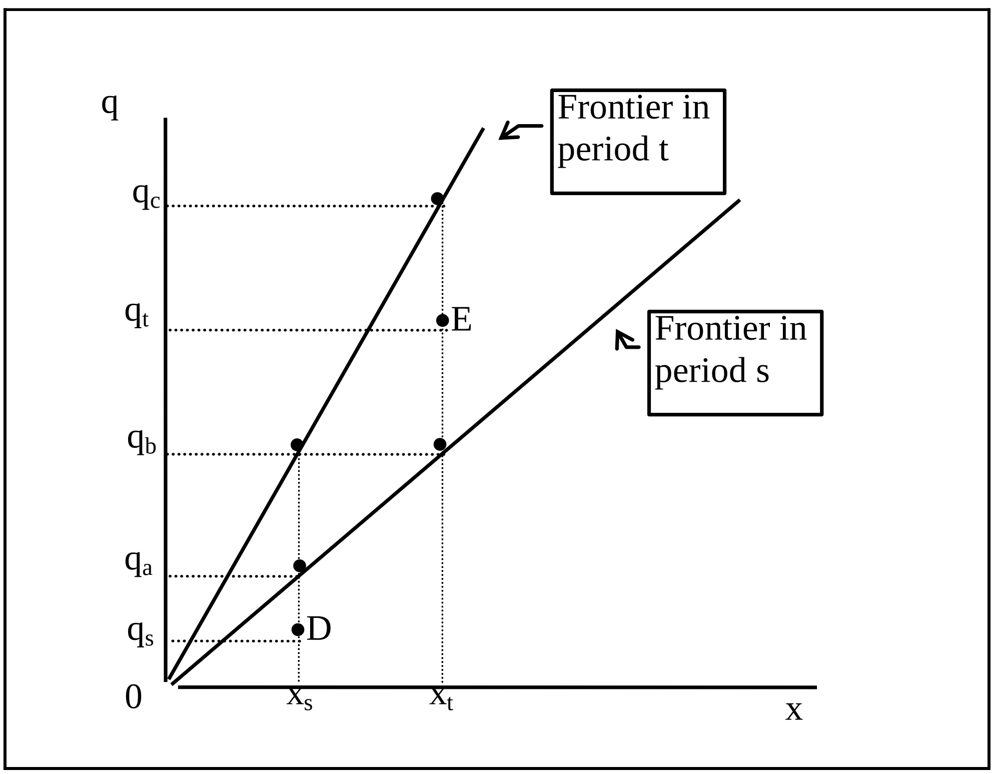
$$
\begin{aligned}
[d_o^s(\mathbf{q}_s, \mathbf{x}_s)]^{-1} &= \max_{\phi,\lambda} \phi, \\
\text{st} \quad & -\phi \mathbf{q}_{is} + \mathbf{Q}_s \boldsymbol{\lambda} \geq \mathbf{0}, \\
& \mathbf{x}_{is} - \mathbf{X}_s \boldsymbol{\lambda} \geq \mathbf{0}, \\
& \boldsymbol{\lambda} \geq \mathbf{0},
\end{aligned}
$$

$$
\begin{aligned}
[d_o^t(\mathbf{q}_s, \mathbf{x}_t)]^{-1} &= \max_{\phi,\lambda} \phi, \\
\text{st} \quad & -\phi \mathbf{q}_{is} + \mathbf{Q}_t \boldsymbol{\lambda} \geq \mathbf{0}, \\
& \mathbf{x}_{is} - \mathbf{X}_t \boldsymbol{\lambda} \geq \mathbf{0}, \\
& \boldsymbol{\lambda} \geq \mathbf{0},
\end{aligned}
$$

$$
\begin{aligned}
[d_o^s(\mathbf{q}_t, \mathbf{x}_t)]^{-1} &= \max_{\phi,\lambda} \phi, \\
\text{st} \quad & -\phi \mathbf{q}_{it} + \mathbf{Q}_s \boldsymbol{\lambda} \geq \mathbf{0}, \\
& \mathbf{x}_{it} - \mathbf{X}_s \boldsymbol{\lambda} \geq \mathbf{0}, \\
& \boldsymbol{\lambda} \geq \mathbf{0},
\end{aligned}
$$

The technical change measure is the geometric mean of 2 technical change measures - TC0 evaluated at the period 0 data point and TC1 evaluated at the period 1 data point. Again, in a more complicated example (more inputs and/or outputs) this need not be the case.

Recall that all these distance functions are CRS - hence any scale efficiency changes will affect the TEC measure.



$$
\textbf{Efficiency change} = \frac{q_t / q_c}{q_s / q_a} \qquad \textbf{Technical change} = \left[\frac{q_t / q_b}{q_t / q_c} \times \frac{q_s / q_a}{q_s / q_b} \right]^{0.5}
$$

It can be decomposed into efficiency change and technical change:

$$m_o\left(\mathbf{q}_s,\mathbf{q}_t,\mathbf{x}_s,\mathbf{x}_s\right)=\underbrace{\frac{d_o^t\left(\mathbf{x}_t,\mathbf{q}_t\right)}{d_o^s\left(\mathbf{x}_s,\mathbf{q}_s\right)}}_{\text{Efficiency change}}\underbrace{\left[\frac{d_o^s\left(\mathbf{x}_t,\mathbf{q}_t\right)}{d_o^t\left(\mathbf{x}_t,\mathbf{q}_t\right)}\times\frac{d_o^s\left(\mathbf{x}_s,\mathbf{q}_s\right)}{d_o^t\left(\mathbf{x}_s,\mathbf{q}_s\right)}\right]^{0.5}}_{\text{Technical change}}$$

The input-orientated Malmquist productivity index is given by:

$$TFPC=\left[\frac{d_s\left(q_s,x_t\right)}{d_s\left(q_t,x_t\right)}\frac{d_t\left(q_s,x_s\right)}{d_t\left(q_t,x_t\right)}\right]^{0.5}$$

Output-orientated and input-orientated Malmquist indexes coincide if the **technology exhibits constant returns to scale.**

The Malmquist Productivity index **does not adequately account for scale change**.

The Malmquist productivity index does not satisfy transitivity property. So we need to use the EKS method to make them transitive.

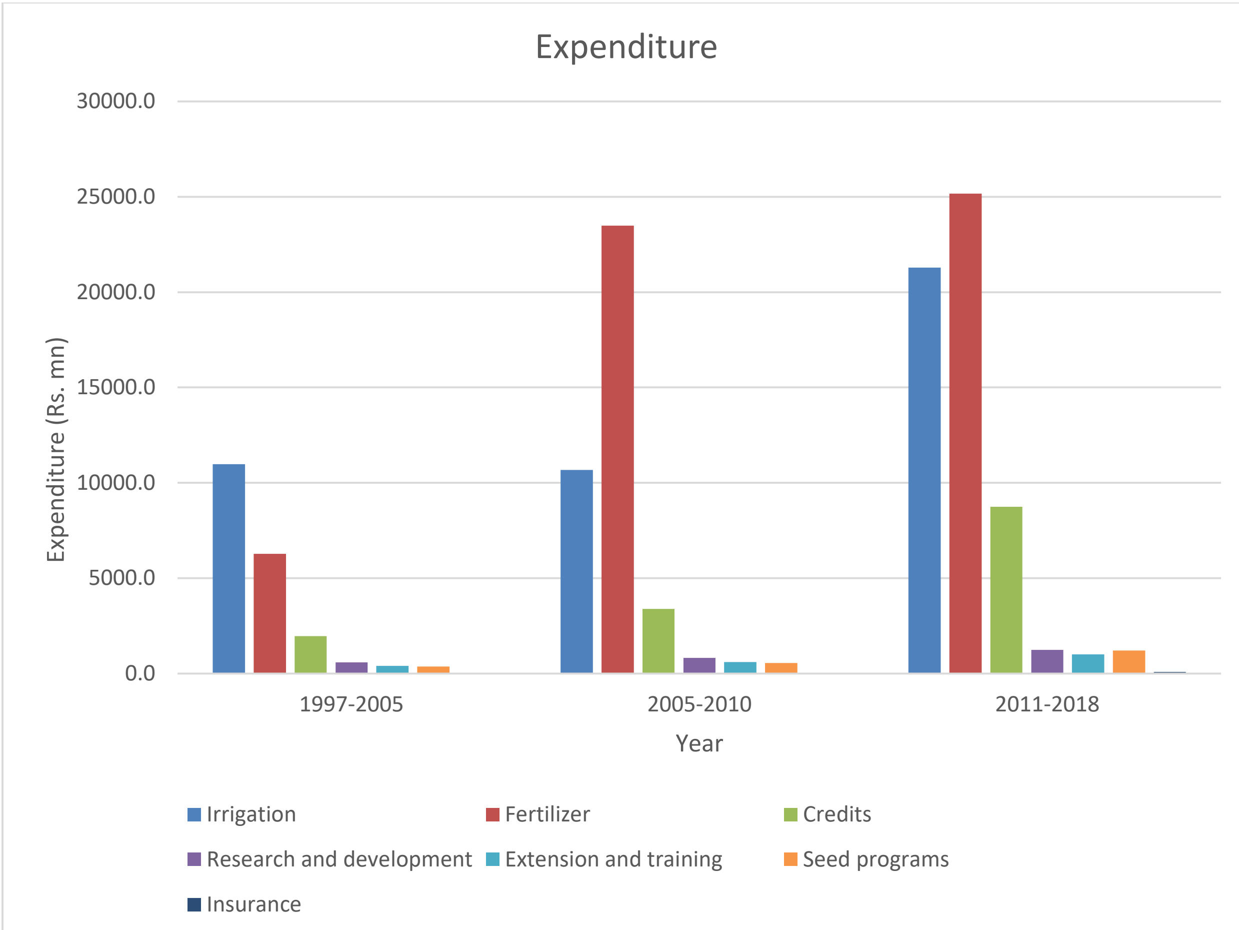
Appendix 2

Supplementary Tables

Source	National Science Foundation						ASTI / CGIAR		Department of Agriculture
				Agricultural sciences (current price Rs. Million)			ASTI data Spending,		Expenditure on Research & Development (Rs Mn)
Year	Research and development (current price Rs. Million)	Agricultural sciences (current price Rs. Million)		Higher education (Rs. Million)	State sector (Rs. Million)	Business enterprise/ Industry (Rs. Million)	(Current Rs. million)	Million 2011 constant PPP dollars	
1997									203.10
1998									191.10
1999									210.00
2000	1810						**1262.1**	104.5	222.20
2001							**1165.8**	84.9	262.10
2002							**1159.2**	78.1	267.90
2003							**1199.9**	74.3	263.00
2004	3807.5	**1003**	26%				**1360.3**	77.4	313.50
2005							**1381.2**	71.2	363.40
2006	5119.2	**1259**	25%				**1985.9**	92.0	558.90
2007							**2100.0**	85.3	658.40
2008	5047.7	**1670**	33%				**2320.0**	81.0	690.70
2009							**2401.0**	79.2	759.80
2010	8778.2	**2926**	33%				**2632.0**	70.7	760.80
2011							**2997.1**	77.5	870.10
2012							**3351.1**	78.2	1256.60
2013	9670	**2693**	28%				**3618.5**	79.5	1310.70
2014	10350	**4078**	39%	501.7	2211.3	1364.8	**4179.2**	89.2	1412.70
2015	11904	**3746**	31%	419.3	2035.1	1291.7	**4527.9**	95.9	1895.10
2016							**5494.9**	112.4	1821.30
2017									1996.20

Total expenditure

Year	Agriculture GDP (Rs.mn)	Irrigation (Rs.mn)	Fertilizer (Rs.mn)	Research and development (Rs.mn)	Extension and training (Rs.mn)	Seed programs (Rs.mn)	Credits (Rs.mn)	Insurance (Rs.mn)
1997	111659		1,895	203.1	104.0	87.2	590	7.4
1998	124370		2,152	191.1	115.5	96.7	479	6.1
1999	137678	5301.8	1,390	210.0	145.9	211.1	463	6.5
2000	156108	5128.1	1,733	222.2	166.2	200.0	517	7.2
2001	175774	6245.3	3,650	262.1	187.7	195.0	736	8.1
2002	192665	7643.8	2,448	267.9	178.3	172.3	934	6.2
2003	205599	8072.1	2,191	263.0	174.9	109.4	1224	7.2
2004	223926	5198.6	3,572	313.5	233.0	141.7	1345	30.6
2005	249790	8599.3	6,946	363.4	273.0	205.0	1949	9.6
2006	287840	6186.5	11,867	558.9	412.5	424.9	1944	19.9
2007	297342	6861.8	11,000	658.4	479.7	470.5	2014	22.7
2008	262271	7890.2	26,450	690.7	516.7	389.0	3162	21.8
2009	289906	13284.5	26,935	759.8	520.9	395.0	3401	15.4
2010	333137	11765.2	26,028	760.8	573.7	578.5	4084	15.3
2011	418104	13852.6	29,802	870.1	643.0	964.5	7171	184.6
2012	590114	28729.0	36,456	1256.6	791.4	1137.2	10070	78.3
2013	613694	36198.8	19,706	1310.7	955.4	1188.2	9872	136.2
2014	717910	46548.7	31,802	1412.7	1024.7	1342.7	8047	55.2
2015	637567	49082.6	49,571	1895.1	1711.5	1783.6	12094	154.7
2016	650510	9326.0	27,771	1821.3	1513.9	1769.7	13554	67.7
2017	735382	14059.7	30,361	1996.2	1624.0	1946.1	12271	8.8
2018		14342.9	26,948	2184.5	2113.8	2266.7	16981	5.1


Expenditure
30000.0
25000.0
20000.0
15000.0
10000.0
5000.0
0.0
Expenditure (Rs. mn)
1997-2005
2005-2010
2011-2018
Year
Irrigation
Fertilizer
Credits
Research and development
Extension and training
Seed programs
Insurance

Year	Irrigation (Rs.Mn)			Fertilizer subsidy (Rs.Mn)	Research and Development (Rs.Mn)			Extension and Training (Rs.Mn)			Seed Certification and Plant Protection (Rs.Mn)		
	Recurrent	Capital	Total	Recurrent	Recurrent	Capital	Total	Recurrent	Capital	Total	Recurrent	Capital	Total
1997				1,895	160.9	42.2	203.1	95.7	8.3	104.0	78.0	9.2	87.2
1998				2,152	164.0	27.1	191.1	90.8	24.7	115.5	48.7	48.0	96.7
1999	1627.4	3674.4	5301.8	1,390	188.0	22.0	210.0	108.4	37.5	145.9	104.8	106.4	211.1
2000	1670.8	3457.3	5128.1	1,733	195.3	27.0	222.2	137.3	28.9	166.2	105.5	94.5	200.0
2001	1670.6	4574.7	6245.3	3,650	236.0	26.0	262.1	158.0	29.7	187.7	90.0	105.0	195.0
2002	1732.7	5911.1	7643.8	2,448	258.6	9.3	267.9	170.2	8.1	178.3	101.6	70.6	172.3
2003	1680.7	6391.4	8072.1	2,191	255.2	7.8	263.0	166.9	8.0	174.9	101.9	7.5	109.4
2004	1830.6	3367.9	5198.6	3,572	295.9	17.7	313.5	216.3	16.7	233.0	116.3	25.4	141.7
2005	1972.3	6627.0	8599.3	6,946	315.1	48.3	363.4	226.0	47.0	273.0	128.0	77.0	205.0
2006	2646.4	3540.1	6186.5	11,867	467.9	91.0	558.9	340.5	72.1	412.5	268.6	156.3	424.9
2007	2911.1	3950.7	6861.8	11,000	562.6	95.8	658.4	415.3	64.4	479.7	309.9	160.6	470.5
2008	3309.8	4580.3	7890.2	26,450	598.8	91.9	690.7	440.8	75.9	516.7	310.3	78.8	389.0
2009	3456.1	9828.4	13284.5	26,935	628.2	131.5	759.8	457.7	63.3	520.9	298.3	96.7	395.0
2010	3717.2	8048.0	11765.2	26,028	642.3	118.5	760.8	486.7	87.0	573.7	351.8	226.7	578.5
2011	3878.1	9974.5	13852.6	29,802	696.8	173.3	870.1	531.0	112.0	643.0	324.2	640.3	964.5
2012	3766.6	24962.5	28729.0	36,456	783.2	473.4	1256.6	606.2	185.2	791.4	409.9	727.3	1137.2
2013	3963.8	32235.0	36198.8	19,706	835.1	475.6	1310.7	642.9	312.5	955.4	478.2	710.0	1188.2
2014	4264.1	42284.6	46548.7	31,802	874.9	537.8	1412.7	673.0	351.7	1024.7	758.6	584.1	1342.7
2015	4981.4	44101.2	49082.6	49,571	1407.5	487.6	1895.1	1099.5	612.0	1711.5	1106.2	677.4	1783.6
2016	3088.4	6237.6	9326.0	27,771	1460.5	360.8	1821.3	1149.0	364.9	1513.9	1158.9	610.8	1769.7
2017	3158.1	10901.6	14059.7	30,361	1614.6	381.6	1996.2	1250.4	373.6	1624.0	1264.7	684.4	1946.1
2018	3210.1	11132.8	14342.9	26,948	1726.0	458.5	2184.5	1528.8	585.0	2113.8	1470.2	796.5	2266.7

Expenditure for Irrigation, fertilizer, Research and development, Extension and training, Seed programs

Year	Paddy (Rs.Mn)	Other Crops (Rs. Mn)	All Crops (Rs.Mn)
1997	412	178	590
1998	327	152	479
1999	312	151	463
2000	399	118	517
2001	402	334	736
2002	444	490	934
2003	713	511	1224
2004	904	441	1345
2005	1364	585	1949
2006	1217	727	1944
2007	1030	984	2014
2008	1604	1558	3162
2009	1846	1555	3401
2010	2541	1543	4084
2011	4418	2753	7171
2012	5527	4543	10070
2013	5427	4445	9872
2014	4762	3285	8047
2015	5202	6892	12094
2016	6384	7170	13554
2017	5561	6710	12271
2018	6879	10102	16981

Expenditure for Credits

Operations of the Crop Insurance Programme - Paddy Sector (Position as at 31 December 2018)													
Cultivated Season	Area Cultivated ('000 ha) (1)	Area Insured ('000 ha) (2)			Premia Collected (Rs.mn) (3)			Indemnities Paid (Rs. mn) (4)			Difference between Premia Collected and Indemnities Paid (Rs.mn) (5)=(3)-(4)		
		AAIB	CICL	Total	AAIB	CICL	Total	AAIB	CICL	Total	AAIB	CICL	Total
1997	730.0	21.0	0.6	21.6	12.9	0.5	13.4	7.3	0.1	7.4	5.6	0.4	5.9
1998	872.0	14.6	1.0	15.6	9.3	0.5	9.8	5.8	0.3	6.1	3.4	0.2	3.7
1999	879.0	13.2	1.5	14.7	8.3	1.3	9.6	5.8	0.7	6.5	2.5	0.6	3.1
2000	1361.0	11.4	4.2	15.7	7.1	5.9	13.0	4.0	3.3	7.2	3.1	2.6	5.7
2001	798.0	5.4	7.6	13.0	2.7	6.7	9.4	3.0	5.1	8.1	-0.3	1.6	1.3
2002	850.0	4.0	8.0	12.0	2.5	7.1	9.6	2.0	4.2	6.2	0.6	2.8	3.4
2003	1019.0	8.4	20.1	28.5	6.0	12.2	18.2	3.8	3.4	7.2	2.2	8.8	11.0
2004	800.0	6.0	37.9	43.9	5.1	21.4	26.5	8.6	22.0	30.6	-3.5	-0.7	-4.1
2005	938.0	9.4	18.7	28.1	7.7	12.8	20.6	3.8	5.8	9.6	3.9	7.0	10.9
2006	909.0	7.7	44.5	52.1	5.5	32.4	37.9	2.1	17.8	19.9	3.4	14.6	18.0
2007	813.0	7.3	31.4	38.7	6.0	23.8	29.7	1.0	21.6	22.7	4.9	2.1	7.1
2008	1052.0	14.0	15.6	29.6	12.8	11.7	24.5	10.4	11.4	21.8	2.4	0.2	2.6
2009	977.0	24.4	5.2	29.6	26.6	3.6	30.2	12.4	3.0	15.4	14.2	0.6	14.8
2010	1065.0	22.3	4.4	26.6	40.9	2.9	43.8	13.6	1.7	15.3	27.3	1.2	28.5
2011	1217.0	28.6	7.6	36.2	60.0	6.3	66.4	171.9	12.6	184.6	-111.9	-6.3	-118.2
2012	1169.0	40.7	8.8	49.4	94.3	6.5	100.8	72.8	5.6	78.3	21.5	1.0	22.5
2013	1228.0	25.2	5.8	30.9	74.1	3.7	77.8	131.5	4.7	136.2	-57.4	-1.0	-58.4
2014	968.0	19.5	6.2	25.7	57.4	4.4	61.8	52.6	2.6	55.2	4.8	1.8	6.7
2015	1202.0	22.5	7.7	30.2	75.5	6.3	81.8	146.5	8.2	154.7	-71.0	-1.9	-72.9
2016	1194.0	37.7	8.6	46.3	68.0	6.4	74.3	65.7	2.0	67.7	2.3	4.4	6.6
2017	809.0	22.7	7.5	30.2	7.2	6.1	13.4	5.6	3.2	8.8	1.7	2.9	4.6
2018	1027.0	1027.8	6.2	1034.1	43.9	5.2	49.1	1.9	3.2	5.1	42.0	2.0	44.0

Expenditure for insurance

Crop variety - Rathna									
District - Puttalam									
2005									
	Crop establishment					Crop maintenance Total labour cost Rs./Ha.			
Operation	Input quantity	Input cost Rs./Ha.	Power cost Rs./Ha.	Labour Mds/Ha.	Labour cost Rs./Ha.	1st year	2nd year	3rd year	4th year
Fencing				100	25000	25000			
Poles	140	35000				35000			
Barb wire (kg)	250	26500				26500			
Nails (kg)	10	1100				1100			
Land preparation (4w tractor)			8750			8750			
Preparation of pits									
Planting (No. of plants)	1125	16875		50	12500	29375			
Fertilizer application				28	7000	7000			
NPK (kg)**	1294	32315				32315	29603	29603	29603
Compost (kg)	4500	5625				5625	8875	8875	8875
Manual weeding				23	5750	5750	5750	5750	5750
Crop maintenance									
Chemical weed control									
Pest control		6200		6	1500	7700	7700	7700	7700
Irrigation		350000	10000	90	22500	382500	32500	32500	32500
Fixing support (wind break)**									
Harvesting							78000	78000	78000

Land rent	10000				10000	10000	10000	10000
Total labour (man day)			297			460	460	460
Total cost Rs.	483615	18750		74250	576615	172428	172428	172428
Yield Kg./ha.						38500	42778	37250
Producer price								
Gross income Rs./ha.						519750	577503	502875

Crop variety - Red Lady									
District - Puttalam									
2012									
	Crop establishment					Crop maintenance Total labour cost Rs./Ha.			
Operation	**Input quantity**	**Input cost Rs./Ha.**	**Power cost Rs./Ha.**	**Labour Mds/Ha.**	**Labour cost Rs./Ha.**	**1st year**	**2nd year**	**3rd year**	**4th year**
Fencing				100	80000	80000			
Poles	140	630000				63000			
Barb wire (kg)	250	48000				48000			
Nails (kg)	10	3250				3250			
Land preparation (4w tractor)			6000			6000			
Preparation of pits				15	12000	12000			
Planting (No. of plants)	1125	23625		10	8000	31625			
Fertilizer application									
NPK (kg)**	1575	37800		15	24000	61800	62070	62070	62070
Compost (kg)	22500	191250		13	10400	201650	201650	201650	201650
Manual weeding				23	18400	18400	18400	18400	18400
Crop maintenance									
Chemical weed control									
Pest control		9970		6	4800	14770	14770	14770	14770
Irrigation		250000	18000	90	72000	340000	90000	90000	90000
Fixing support (wind break)**		45000				45000			
Harvesting							249600	249600	249600
Land rent		50000				50000	50000	50000	50000
Total labour (man day)				272			459	459	459
Total cost Rs.		721895	24000		229600	975495	686490	686490	686490

Yield Kg./ha.	38500	42778	37250
Producer price			
Gross income Rs./ha.	1347500	1497230	1303750

Crop variety - Red Lady								
District - Puttalam								
2017								
	Crop establishment					Crop maintenance Total labour cost Rs./Ha.		
Operation	Input quantity	Input cost Rs./Ha.	Power cost Rs./Ha.	Labour Mds/Ha.	Labour cost Rs./Ha.	1st year	2nd year	3rd year
Fencing				100	110000	110000		
Poles	140	84000				84000		
Barb wire (kg)	250	51500				51500		
Nails (kg)	10	6000				6000		
Land preparation (4w tractor)			10000			10000		
Preparation of pits				21	23100	23100		
Planting (No. of plants)	1600	80000		14	15400	95400		
Fertilizer application								
NPK (kg)**	2616	130800		21	23100	153900	135900	135900
Compost (kg)	32000	320000		18	19800	339800	339800	339800
Manual weeding				20	22000	22000	22000	22000
Crop maintenance								
Chemical weed control								
Pest control		12240		9	9900	22140	22140	22140
Irrigation		565200		90	99000	784200	219000	219000
Fixing support (wind break)**		100000				100000		
Harvesting				93	102400	102400	170667	68267
Land rent		125000				125000	125000	125000
Total labour (man day)								
Total cost Rs.		1474740	130000		424700	2029440	1034506	932106

Yield Kg./ha.	76800	128000	51200
Producer price			
Gross income Rs./ha.	3456000	5760000	2748295

			Crop variety - Red Lady			
			District - Vavuniya			
			2019			
Operation	**Input quantity**	**Input cost Rs./Ha.**	**Power cost Rs./Ha.**	**Labour Mds/Ha.**	**Labour cost Rs./Ha.**	**Total Cost**
Crop Establishment						
Land preparation (4w tractor)			9225	53	65,835	75,061
Planting (No. of plants)	1381	71404		32	41,580	112,984
						188,044
Crop maintenance						
1st year						
Fertilizer application				18	23,633	23,633
NPK (kg)**	217	10520				10,520
Compost (kg)	5043	17009				17,009
Manual/ machinery weeding			18937	31	39,894	58,831
Pest control		19949	10522	30	39,096	69,566
Irrigation			16134	48	62,442	78,576
Harvesting				33	42,849	42,849
Land rent						15,000
						315,985
Yield Kg./ha.						21,234
Producer price						30
						637,007
2nd year						
Fertilizer application				15	19,412	19,412
NPK (kg)**	360	14805				14,805
Compost (kg)	5187	20419				20,419
Manual/ machinery weeding			16604	29	38,211	54,815
Pest control		27749	15690	40	51,699	95,138
Irrigation			16469	55	71,840	88,309
Harvesting				88	114,037	114,037
Land rent						15,000
Total Cost						421,934
Yield Kg./ha.						74,849
Producer price						30
						2,245,481
3rd year						

Fertilizer application				13	16,738	16,738
NPK (kg)**	438	21197				21,197
Compost (kg)	4940	32110				32,110
Manual/ machinery weeding			12624	25	32,609	45,234
Pest control		32639	13173	27	34,580	80,392
Irrigation			14714	37	48,272	62,986
Harvesting				58	74,852	74,852
Land rent						15,000
Total Cost						348,509
Yield Kg./ha.						46,021
Producer price						30
						1,380,642
Total Cost						1,274,472
Total Income						4,263,130
						2,988,658

			Crop variety – Taninung/Red Lady			
			District - Kurunegala			
			2019			
Operation	**Input quantity**	**Input cost Rs./Ha.**	**Power cost Rs./Ha.**	**Labour Mds/Ha.**	**Labour cost Rs./Ha.**	**Total Cost**
Crop Establishment						
Fencing		77585		38	56908	134493
Land preparation (4w tractor)			70416	39	54026	124443
Planting (No. of plants)	1424	62778		21	26744	89522
						213964
Crop maintenance						
1st year						
Fertilizer application				38	49428	49428
NPK (kg)**	1627	50222				50222
Compost (kg)	5686	31539				31539
Chemical Weeding		7267	8645	4	5211	21123
Manual/ machinery weeding			10616	42	55210	65826
Pest control		6349	4485	22	29134	39968
Irrigation			33068	57	73688	106756
Harvesting				43	55590	55590
Land rent						15000
						435453
Yield Kg./ha.						14857
Producer price						35
						519984
2nd year						
Fertilizer application				27	35748	35748
NPK (kg)**	1968	48963				48963
Manual/ machinery weeding			11347	45	58735	70082
Pest control		5451	5729	46	59225	70405
Irrigation			78085	86	112271	190355
Harvesting				102	132639	132639
Land rent						15000
Total Cost						563192
Yield Kg./ha.						34762
Producer price						40
						1390465

3rd year						
Fertilizer application				20	26602	26602
NPK (kg)**	1129	73710				73710
Manual/ machinery weeding			10685	42	55229	65914
Irrigation			85642	122	158409	244052
Harvesting				52	67217	67217
Land rent						15000
Total Cost						492495
Yield Kg./ha.						20012
Producer price						40
						800477.6
Total Cost						1705104
Total Income						2710926
						1,005,822

Crop enterprise budget										
District - Gampaha										
2000										
	Crop establishment					Crop maintenance Total labour cost Rs./Ha.				
Operation	**Input quantity/ha**	**Input cost Rs./Ha.**	**Power cost Rs./Ha.**	**Labour Mds/Ha.**	**Labour cost Rs./Ha.**	**1st year**	**2nd year**	**3rd year**	**4th year**	**5th year**
Fencing										
Poles										
Barb wire (kg)										
Nails (kg)										
Land preparation (4w tractor)			7600			7600				
Preparation of pits										
Planting (No. of plants)	1100 plants	22000		53	9275	13250				
Fertilizer application	1452[2]kg	12100		18	3150	15250	21476	21476	21476	15250
NPK (kg)**										
Dolomite (kg)**										
Kieserite (kg)**										
Compost (kg)	4.5[1] mt	4500		50	8750	13250	6425	6425	6425	6425
Crop maintenance				45	7875	7875	7875	7875	7875	7875
Chemical weed control		2800		2	350	3150	3150	3150	3150	3150
Pest control	11[3]kg	2145		3	525	2670	2670	2670	2670	2670
Irrigation										
Harvesting							2800	2800	2800	2275
Land rent		4000				4000	4000	4000	4000	4000
Total labour (man day)				171			95	95	95	92

Total cost Rs.	47545	7600		29925	85070	48396	48396	48396	41645
Yield Kg./ha.						24200	22000	19800	15400
Producer price	8 Rs./kg								
Gross income Rs./ha.						193600	176000	158400	123200

						Crop variety - Ambul				
						District - Rathnapura				
						2005				
	Crop establishment					**Crop maintenance Total labour cost Rs./Ha.**				
Operation	**Input quantity/ha**	**Input cost Rs./Ha.**	**Power cost Rs./Ha.**	**Labour Mds/Ha.**	**Labour cost Rs./Ha.**	**1st year**	**2nd year**	**3rd year**	**4th year**	**5th year**
Fencing				100	30000					
Poles	140	35000				35000				
Barb wire (kg)	250	26500				26500				
Nails (kg)	10	1100				1100				
Land preparation (4w tractor)			9000			9000				
Preparation of pits										
Planting (No. of plants)	1100	16500		70	21000	37500				
Fertilizer application				33	9900	9900				
NPK (kg)**	1485	36828				36828	40728	40728	40728	40728
Dolomite (kg)**										
Kieserite (kg)**										
Compost (kg)	4500	6750				6750	10050	10050	10050	10050
Crop maintenance				26	7800	7800	8100	8100	8100	8100
Chemical weed control		6000		7	2100	8100	5900	5900	5900	5900
Pest control							23500	23500	23500	23500
Irrigation		150000	10000	45	13500	173500	26400	26400	26400	26400
Harvesting							8400	8400	8400	8400
Land rent		8400				8400	193	214	195	165
Total labour (man day)				281						
Total cost Rs.		287078	19000		84300	390378	130878	137178	131478	122478

Yield Kg./ha.	25500	38250	28679	17000
Producer price				
Gross income Rs./ha.	255000	382500	286790	170000

Crop variety - Ambul										
District - Rathnapura										
2012										
	Crop establishment					Crop maintenance Total labour cost Rs./Ha.				
Operation	**Input quantity/ha**	**Input cost Rs./Ha.**	**Power cost Rs./Ha.**	**Labour Mds/Ha.**	**Labour cost Rs./Ha.**	**1st year**	**2nd year**	**3rd year**	**4th year**	**5th year**
Fencing				100	80000	80000				
Poles	140	63000				63000				
Barb wire (kg)	250	48000				48000				
Nails (kg)	10	3250				3250				
Land preparation (4w tractor)			15000			15000				
Preparation of pits				20	16000	16000				
Planting (No. of plants)	1100	55000		25	20000	75000				
Fertilizer application										
NPK (kg)**	1540	36960		13	10400	47360	47360	47360	47360	
Dolomite (kg)**	550	8250				8250	8250	8250	8250	
Kieserite (kg)**	330	26400				26400	26400	26400	26400	
Compost (kg)	11000	99000		20	16000	115000	115000	115000	115000	
Crop maintenance				26	20800	20800	20800	20800	20800	
Chemical weed control		11250		7	5600	16850	16850	16850	16850	
Pest control							14750	14750	14750	
Irrigation		300000	12000	45	36000	348000	48000	48000	48000	
Harvesting							70400	84000	72000	48000
Land rent		90000				90000	90000	90000	90000	90000
Total labour (man day)				256			204	221	206	60
Total cost Rs.		741110	27000		204800	972910	452530	466130	520130	138000

Yield Kg./ha.	25500	38250	28679	17000
Producer price	1275000	1912500	1433950	850000
Gross income Rs./ha.				

Crop variety - Kolikuttu										
District - Rathnapura										
2012										
	Crop establishment					Crop maintenance Total labour cost Rs./Ha.				
Operation	Input quantity/ha	Input cost Rs./Ha.	Power cost Rs./Ha.	Labour Mds/Ha.	Labour cost Rs./Ha.	1st year	2nd year	3rd year	4th year	5th year
Fencing				100	80000	80000				
Poles	140	63000				63000				
Barb wire (kg)	250	48000				48000				
Nails (kg)	10	3250				3250				
Land preparation (4w tractor)			15000			15000				
Preparation of pits				20	16000	16000				
Planting (No. of plants)	1600	80000		25	20000	100000				
Fertilizer application										
NPK (kg)**	2240	53760		13	10400	64160	56480	56480	56480	
Dolomite** (kg)	800	12000				12000	12000	12000	12000	
Kieserite** (kg)	480	38400				38400	38400	38400	38400	
Compost (kg)	16000	144000		20	16000	160000	160000	160000	160000	
Crop maintenance				26	20800	20800	20800	20800	20800	
Chemical weed control		11250		7	5600	16850	16850	16850	16850	
Pest control							14750	14750	14750	
Irrigation		300000	12000	45	36000	348000	48000	48000	48000	
Harvesting							70400	84000	72000	48000
Land rent		90000				90000	90000	90000	90000	90000
Total labour (man day)				256			204	221	206	60
Total cost Rs.		843660	27000		204800	1075460	527680	541280	529280	138000

Yield Kg./ha.	24000	30000	30000	20800
Producer price				
Gross income Rs./ha.	1800000	2250000	2250000	1560000

Crop variety - Seeni Kesel										
District - Rathnapura										
2012										
	Crop establishment					Crop maintenance Total labour cost Rs./Ha.				
Operation	Input quantity/ha	Input cost Rs./Ha.	Power cost Rs./Ha.	Labour Mds/Ha.	Labour cost Rs./Ha.	1st year	2nd year	3rd year	4th year	5th year
Fencing				100	80000	80000				
Poles	140	63000				63000				
Barb wire (kg)	250	48000				48000				
Nails (kg)	10	3250				3250				
Land preparation (4w tractor)			15000			15000				
Preparation of pits				20	16000	16000				
Planting (No. of plants)	1100	44000		25	20000	64000				
Fertilizer application										
NPK (kg)**	1540	36960		13	10400	47360	42080	42080	42080	
Dolomite (kg)**	550	8250				8250	8250	8250	8250	
Kieserite (kg)**	330	26400				26400	26400	26400	26400	
Compost (kg)	11000	99000		20	16000	115000	181000	181000	181000	
Crop maintenance				26	20800	20800	20800	20800	20800	
Chemical weed control		11250		7	5600	16850	16850	16850	16850	
Pest control							14750	14750	14750	
Irrigation		300000	12000	45	36000	348000	48000	18000	48000	
Harvesting							70400	84000	72000	48000
Land rent		90000				90000	90000	90000	90000	90000
Total labour (man day)				256			204	221	206	60
Total cost Rs.		730110	27000		204800	961910	518530	532130	520130	138000

Yield Kg./ha.	19800	25200	23800	19000
Producer price				
Gross income Rs./ha.	792000	1008000	952000	760000

Crop variety - Ambul										
District - Rathnapura										
2017										
	Crop establishment					**Crop maintenance Total labour cost Rs./Ha.**				
Operation	**Input quantity/ha**	**Input cost Rs./Ha.**	**Power cost Rs./Ha.**	**Labour Mds/Ha.**	**Labour cost Rs./Ha.**	**1st year**	**2nd year**	**3rd year**	**4th year**	**5th year**
Fencing				100	120000	120000				
Poles	140	84000				84000				
Barb wire (kg)	250	51500				51500				
Nails (kg)	10	6000				6000				
Land preparation (4w tractor)			22230			22230				
Preparation of pits				30	36000	36000				
Planting (No. of plants)	1100	71500		15	18000	89500				
Fertilizer application										
NPK (kg)**	1733	86625		13	15600	102225	89850	89850	89850	
Dolomite (kg)**										
Kieserite (kg)**										
Compost (kg)	11000	110000		20	24000	134000	128000	128000	128000	
Crop maintenance				26	31200	31200	31200	31200	31200	
Chemical weed control			14255	23	27600	41855	33484	26787	21430	
Pest control							20058	20058	20058	
Irrigation		366000	29925	45	54000	449925	83925	83925	83925	
Harvesting							105600	126000	108000	72000
Land rent		110000				110000	110000	110000	110000	110000
Total labour (man day)				272			210	224	206	60
Total cost Rs.		885625	66410		326400	1278435	602117	615820	592463	182000

Yield Kg./ha.	25500	38250	28679	17000
Producer price				
Gross income Rs./ha.	1351500	2027250	1519987	1172500

Crop variety - Kolikuttu										
District - Rathnapura										
2017										
	Crop establishment					Crop maintenance Total labour cost Rs./Ha.				
Operation	**Input quantity/ha**	**Input cost Rs./Ha.**	**Power cost Rs./Ha.**	**Labour Mds/Ha.**	**Labour cost Rs./Ha.**	**1st year**	**2nd year**	**3rd year**	**4th year**	**5th year**
Fencing				100	120000	120000				
Poles	140	84000				204000				
Barb wire (kg)	250	51500				51500				
Nails (kg)	10	6000				6000				
Land preparation (4w tractor)			22500			22500				
Preparation of pits				40	48000	48000				
Planting (No. of plants)	1600	200000		17	220400	220400				
Fertilizer application										
NPK (kg)**	2520	126000		14	16800	142800	124800	124800	124800	
Dolomite (kg)**										
Kieserite (kg)**										
Compost (kg)	16000	160000		20	24000	184000	178000	178000	178000	
Crop maintenance				26	31200	31200	31200	31200	31200	
Chemical weed control			14255	23	27600	41855	33484	26787	21430	
Pest control							18150	18150	18150	
Irrigation		366000	29925	45	54000	449925	83925	83925	83925	
Harvesting							105600	126000	108000	72000
Land rent		110000				110000	110000	110000	110000	110000
Total labour (man day)				285			211	225	207	60
Total cost Rs.		1103500	66680		342000	1632180	685159	698862	675505	182000

Yield Kg./ha.	24000	30000	30000	20800
Producer price				
Gross income Rs./ha.	2760000	3450000	3450000	2663500

Crop variety - Seeni kesel										
District - Rathnapura										
2017										
	Crop establishment					**Crop maintenance Total labour cost Rs./Ha.**				
Operation	**Input quantity/ha**	**Input cost Rs./Ha.**	**Power cost Rs./Ha.**	**Labour Mds/Ha.**	**Labour cost Rs./Ha.**	**1st year**	**2nd year**	**3rd year**	**4th year**	**5th year**
Fencing				100	120000	120000				
Poles	140	84000				84000				
Barb wire (kg)	250	51500				51500				
Nails (kg)	10	6000				6000				
Land preparation (4w tractor)			22230			22230				
Preparation of pits				30	36000	36000				
Planting (No. of plants)	1100	71500		15	18000	89500				
Fertilizer application										
NPK (kg)**	1733	86625		13	15600	102225	89850	89850	89850	
Dolomite (kg)**										
Kieserite (kg)**										
Compost (kg)	11000	110000		20	24000	134000	134000	134000	134000	
Crop maintenance				26	31200	31200	31200	31200	28600	
Chemical weed control			14255	23	27600	41855	41855	33484	26787	
Pest control							18150	18150	18150	
Irrigation		366000	29925	45	54000	449925	83925	83925	83925	
Harvesting							105600	126000	108000	72000
Land rent		110000				110000	110000	110000	110000	110000
Total labour (man day)				272			215	229	211	60
Total cost Rs.		885625	66410		326400	1278435	614580	626609	599312	182000

Yield Kg./ha.	19800	25200	23800	19000
Producer price				
Gross income Rs./ha.	950400	1209600	1142400	1183500

	Crop variety - Ambul					
	Region - Mahaweli (Embilipitiya/Ambalanthota/Thanamalwila/Sewanagala/Sooriyawewa)					
	2019					
	Crop establishment					
	Input quantity/ha	Input cost Rs./Ha.	Power cost Rs./Ha.	Labour Mds/Ha.	Labour cost Rs./Ha.	Total Cost Rs./Ha.
Crop establishment						
Land preparation (4w tractor) and preperation of pits			20289	29	43500	63789
Application of systemic insecticides		2364				2364
Planting (No. of plants)	1191			7	10500	10500
Crop maintenance						
Fertilizer application				23	34500	34500
NPK (kg)**	2439	68012				68012
NPK with micronutrients (kg)	175	18875				18875
Chemical weed control		15792	4528	5	7500	27820
Mechanical/manual weeding			5066	26	39000	44066
Irrigation				34	51000	51000
Maintenance				35	52500	52500
Harvesting				31	46500	46500
Land rent						134582
Total cost Rs.						**554508**
Yield Kg./ha.						18137
Producer price						23
Gross income Rs./ha.						417151
Crop maintenance						
Fertilizer application				28	42000	42000
NPK (kg)**	4212	101300				101300
NPK with micronutrients (kg)	213	19451				19451
Chemical weed control		11931	4168	4	6000	22099
Mechanical/manual weeding			5640	17	25500	31140
Irrigation				35	52500	52500

Maintenance				31	46500	46500
Harvesting				72	108000	108000
Land rent						134582
Total cost Rs.						**557572**
Yield Kg./ha.						43041
Producer price						23
Gross income Rs./ha.						989943
Crop maintenance						
Fertilizer application				28	42000	42000
NPK (kg)**	5140	101461				101461
NPK with micronutrients (kg)	99	16796				16796
Chemical weed control		10414	4117	3	4500	19031
Mechanical/manual weeding			2470	12	18000	20470
Irrigation				33	49500	49500
Maintenance				31	46500	46500
Harvesting				73	109500	109500
Land rent						134582
Total cost Rs.						**539840**
Yield Kg./ha.						43527
Producer price						24
Gross income Rs./ha.						1044648

	Crop variety - Kolikuttu					
	Region - Mahaweli (Embilipitiya/Ambalanthota/Thanamalwila/Sewanagala/Sooriyawewa)					
	2019					
	Crop establishment					
	Input quantity/ha	**Input cost Rs./Ha.**	**Power cost Rs./Ha.**	**Labour Mds/Ha.**	**Labour cost Rs./Ha.**	**Total Cost Rs./Ha.**
Crop establishment						
Land preparation (4w tractor) and preperation of pits			26953	30	45000	71953
Application of systemic insecticides		4775		2	3000	7775
Planting (No. of plants)	2543			13	19500	19500
Crop maintenance						
Fertilizer application				29	43500	43500
NPK (kg)**	3264	88009				88009
NPK with micronutrients (kg)	256	43533				43533
Chemical weed control		28373	4446	7	10500	43319
Mechanical/manual weeding			4273	21	31500	35773
Irrigation				48	72000	72000
Maintenance				49	73500	73500
Harvesting				43	64500	64500
Land rent						170623
Total cost Rs.						**733985**
Crop maintenance					0	0
Fertilizer application				5	7500	7500
NPK (kg)**	741	22971				22971
NPK with micronutrients (kg)						
Chemical weed control						
Mechanical/manual weeding			1606	5	7500	9106
Irrigation						
Maintenance				25	37500	37500
Harvesting				31	46500	46500
Land rent						170623
Total cost Rs.						**294200**

Yield Kg./ha.	21129
Producer price	92
Gross income Rs./ha.	1943868
Crop maintenance	
Fertilizer application	
NPK (kg)**	
NPK with micronutrients (kg)	
Chemical weed control	
Mechanical/manual weeding	
Irrigation	
Maintenance	
Harvesting	
Land rent	170623
Total cost Rs.	
Yield Kg./ha.	27055
Producer price	56
Gross income Rs./ha.	1515080

	Crop variety - Seeni					
	Region - Mahaweli (Embilipitiya/Ambalanthota/Thanamalwila/Sewanagala/Sooriyawewa)					
	2019					
	Crop establishment					
	Input quantity/ha	Input cost Rs./Ha.	Power cost Rs./Ha.	Labour Mds/Ha.	Labour cost Rs./Ha.	Total Cost Rs./Ha.
Crop establishment						
Land preparation (4w tractor) and preperation of pits			22700	25	37671	60372
Application of systemic insecticides		3499		3	4477	7976
Planting (No. of plants)	1156			8	12634	12634
Crop maintenance						
Fertilizer application				19	28521	28521
NPK (kg)**	1727	49914				49914
NPK with micronutrients (kg)	100	17049				17049
Chemical weed control		14634	3108	5	7778	25520
Mechanical/manual weeding			4107	22	32485	36592
Irrigation				36	54687	54687
Maintenance				41	62190	62190
Land rent						100337
Total cost Rs.						**455,792**
Crop maintenance						
Fertilizer application				23	34797	34797
NPK (kg)**	2543	68131				68131
NPK with micronutrients (kg)	165	27890				27890
Chemical weed control		10423	3293	4	5835	19552
Mechanical/manual weeding			3840	15	22902	26742
Irrigation				34	51144	51144
Maintenance				38	57741	57741
Harvesting				54	80824	80824
Land rent						100337
Total cost Rs.						**467,158**

Yield Kg./ha.						32143
Producer price						35
Gross income Rs./ha.						1125004
						669211
Crop maintenance						
Fertilizer application				25	36885	36885
NPK (kg)**	2485	61639				61639
NPK with micronutrients (kg)	68	11691				11691
Chemical weed control		10807	3293	3	5033	19133
Mechanical/manual weeding			36466	12	17674	54140
Irrigation				31	46765	46765
Maintenance				38	56366	56366
Harvesting				70	104947	104947
Land rent						100337
Total cost Rs.						**491,904**
Yield Kg./ha.						36476
Producer price						
Gross income Rs./ha.						

Crop variety - Pineapple										
District- Gampaha										
2000										
	Crop Establishment					Crop Maintenance Total CostRs/ha				
	Input		Power Cost	Labour						
Operation	Qty/ha	Cost Rs/ha	Rs/ha	Mds/ha	Cost Rs/ha	1st Year	2nd Year	3rd Year	4th Year	5th Year
Fencing										
Poles										
Barbed wire (Kg)										
Nails (Kg)										
Land Preparation(4WT)			8000			8000				
Preparation of ridges				30	5250	5250				
pre-treatment of planting material										
Planting (No. of suckers)	12500	37500		32	5600	43100				
Establishment cost						56350				
Fertilizer Application										
NPK (Kg)*										

Earthing up										
Compost (Kg)										
Kieserite (Kg)										
Pineapple Mix (Kg) (1st Year)	1235	12597		20	3500	16097				
Pineapple Mix (Kg) (2nd Year)	2470	25194		35	6125		31319			
Pineapple Mix (Kg)(3rd Year)	1235	12597		28	4900			17497		
Urea (Kg) (3rd Year)	610	3965						3965		
NPK *										
Lime (Kg)										
Manual Weeding/ Mulching				25	4375	4375	4375	4375	4375	4375
Chemical Weeding		6000		3	525	6525				
Pest Control		3920		5	875	4795	4795	4795	4795	4795
Hormone application										
Watching										
Harvesting							3500	4200	4200	5600
Land Rent(Rs/ha)		30000				3000	3000	3000	3000	3000
Total Labour (Mds)				178			115	112	84	92
Total Cost			8000		31150	91142	46989	37832	16370	17770

Yield (Kg/ha)- Total Fruit Production	12500	15000	15000	20000
Producer Price (Rs/Kg)	15	13	10	8
Gross Income (Fruits) (Rs/ha)	187500	195000	150000	16000
Gross Income(From Suckers) (Rs/ha)	31250	50000		
Total Gross Income Rs./ha	218750	245000	150000	16000

						Crop variety - Pineapple			
						District- Gampaha			
						2005			
	Crop Establishment					**Crop Maintenance Total CostRs/ha**			
	Input		**Power Cost**	**Labour**					
Operation	**Qty/ha**	**Cost Rs/ha**	**Rs/ha**	**Mds/ha**	**Cost Rs/ha**	**1st Year**	**2nd Year**	**3rd Year**	**4th Year**
Fencing				**100**	**30000**	**30000**			
Poles	**140**	**35000**				**35000**			
Barbed wire (Kg)	**250**	**26500**				**26500**			
Nails (Kg)	**10**	**1100**				**1100**			
Land Preparation(4WT)			8750			**8750**			
Preparation of ridges									
pre-treatment of planting material									
Planting (No. of suckers)	12500	51500		35	10500	**62000**			
Establishment cost									
Fertilizer Application				10	3000	3000			
NPK (Kg)*	1400	29932				29932	32392	32392	
Earthing up				13	3900	3900	3900	3900	
Compost (Kg)									
Kieserite (Kg)									
Pineapple Mix (Kg) (1st Year)									
Pineapple Mix (Kg) (2nd Year)									
Pineapple Mix (Kg)(3rd Year)									

Urea (Kg) (3rd Year)								
NPK *								
Lime (Kg)								
Manual Weeding/ Mulching			25	7500	7500	7500	7500	
Chemical Weeding	5250		5	1500	6750	6750	6750	
Pest Control	5000		5	1500	6500	6500	6500	
Hormone application	1750		5	1500	3250	3250	3250	
Watching			16	4800	4800	4800	4800	
Harvesting						6000	6000	6000
Land Rent(Rs/ha)	9000				9000	9000	9000	9000
Total Labour (Mds)			214			99	99	99
Total Cost	165032	8750		64200	237982	80092	80092	15000
Yield (Kg/ha)- Total Fruit Production						12500(Fruits/ha)	12500(Fruits/ha)	20000(Fruits/ha)
Producer Price (Rs/Kg)								
Gross Income (Fruits) (Rs/ha)						275000	250000	280000
Gross Income(From Suckers) (Rs/ha)						35000	35000	
Total Gross Income Rs./ha						310000	285000	280000

Crop variety - Pineapple									
District- Gampaha									
2012									
	Crop Establishment					Crop Maintenance Total CostRs/ha			
	Input		Power Cost	Labour					
Operation	Qty/ha	Cost Rs/ha	Rs/ha	Mds/ha	Cost Rs/ha	1st Year	2nd Year	3rd Year	4th Year
Fencing				**100**	**60000**	**60000**			
Poles	**140**	**63000**				**63000**			
Barbed wire (Kg)	**250**	**48000**				**48000**			
Nails (Kg)	**10**	**3250**				**3250**			
Land Preparation(4WT)			16250			16250			
Preparation of ridges									
pre-treatment of planting material									
Planting (No. of suckers)	12500	100000		35	21000	121000			
Establishment cost						**248500**			
Fertilizer Application									
NPK (Kg)*									
Earthing up									
Compost (Kg)	10000	37500		13	7500	45000			
Kieserite (Kg)									
Pineapple Mix (Kg) (1st Year)									
Pineapple Mix (Kg) (2nd Year)									
Pineapple Mix (Kg)(3rd Year)									
Urea (Kg) (3rd Year)									
NPK *	1688	51000		10	6000	57000	57000	57000	
Lime (Kg)	2000	10800		5	3000	13800			
Manual Weeding/ Mulching				25	15000	15000	15000	15000	

Chemical Weeding	4413		5	3000	7413	7413	7413	
Pest Control	3660		5	3000	6660	6660	6660	
Hormone application	1926		5	3000	4926			
Watching			16	9600	9600	9600	9600	
Harvesting						13200	13200	13200
Land Rent(Rs/ha)	15000				15000	15000	15000	15000
Total Labour (Mds)			232			96	96	20
Total Cost	338549	16250		138900	493699	131673	131673	28200
Yield (Kg/ha)- Total Fruit Production						12500	12500	20000
Producer Price (Rs/Kg)								
Gross Income (Fruits) (Rs/ha)						1062500	1062500	1700000
Gross Income(From Suckers) (Rs/ha)						96000	96000	
Total Gross Income Rs./ha						1158500	1158500	1700000

Crop variety - Pineapple									
District- Gampaha									
2017									
	Crop Establishment					Crop Maintenance Total CostRs/ha			
	Input		Power Cost	Labour					
Operation	Qty/ha	Cost Rs/ha	Rs/ha	Mds/ha	Cost Rs/ha	1st Year	2nd Year	3rd Year	4th Year
Fencing				**100**	**120000**	**120000**			
Poles	**140**	**84000**			**84000**	**84000**			
Barbed wire (Kg)	**250**	**51500**			**51500**	**51500**			
Nails (Kg)	**10**	**6000**			**6000**	**6000**			
Land Preparation(4WT)			32110			32110			
Preparation of ridges									
pre-treatment of planting material		7233		18	21600	28833			
Planting (No. of suckers)	16,500	247,500		46	55200	302700			
Establishment cost						**625143**			
Fertilizer Application									
NPK (Kg)*	1,980	99,000		13	15600				
Earthing up									
Compost (Kg)	10,000	100,000		13	15600	115,600			
Kieserite (Kg)	248	10,643				10643	14,190	14,190	
Pineapple Mix (Kg) (1st Year)									
Pineapple Mix (Kg) (2nd Year)									
Pineapple Mix (Kg)(3rd Year)									
Urea (Kg) (3rd Year)									
NPK *				13	15600	114600	114600	114600	
Lime (Kg)	2,000	16,000		5	6000	22000			
Manual Weeding/ Mulching				25	30000	30000	30000	30000	

Chemical Weeding	6,600	5	6000	12600	12600	12600	
Pest Control	5083	5	6000	11083	11083	11083	
Hormone application	2883	6	7200	10083	10083	11813	
Watching		16	19200	19200	19200	19200	
Harvesting					34800	34800	39600
Land Rent(Rs/ha)	25,000			25,000	25,000	25,000	25,000
Total Labour (Mds)		269			116	117	33
Total Cost	661,442		322800	1016352	291957	293687	64600
Yield (Kg/ha)- Total Fruit Production					16500	16500	26400
Producer Price (Rs/Kg)							
Gross Income (Fruits) (Rs/ha)					1485000	1485000	2376000
Gross Income(From Suckers) (Rs/ha)					237600	237600	
Total Gross Income Rs./ha					1722600	1722600	2376000

	2000	2005	2012	2017	2019	
Crop Establishment						
Machinery/ power cost	**8000**	**8750**	**16250**	**32110**	**38393**	
Land Preparation (4WT)						
Labour Cost	**10850**	**40500**	**84000**	**218400**	**70293**	
No.of Labourers	62	135	153	182	49	
Input Cost including imputed cost	**37500**	**114100**	**262550**	**512233**	**244096**	
Fencing related inputs		62600	114250	141500	50193	(33%)
Pre-treatment				7233	6997	
Lime/Dolomite			10800	16000	6434	(27%)
Compost			37500	100000		
Planting density (Number of Suckers per Ha)	12500	12500	12500	16500	14549	
Planting material Cost	37500	51500	100000	247500	232777	
Crop Establishment Cost	**56350**	**163350**	**362800**	**762743**	**352781**	
Total Fixed Cost	56350	163350	362800		352781	
Crop Maintenance						
1st Year (90 sample)						
Fertiliser (Kg)	1235	1400	1688	1980	2731	
Fertiliser Cost	12597	29932	51000	109643	110,784	
Agrochemicals Cost	9920	12000	9999	14566	19,194	
Weedicides	6000	5250	4413	6600	7,899	
Pesticides	3920	5000	3660	5083		
Hormone		1750	1926	2883		

Machinery/Power Cost					1,895
Labour Cost	9275	23700	36600	84000	108,974
Labour days	53	79	66	70	79
Harvesting Cost		6000	13200	34800	
Land rent	3000	9000	15000	25000	24886
Total Cost	34792	80632	125799	268009	265,734
YIELD (Kg/Ha)	12500	12500(Fruits/ha)	12500	16500	15157
2nd Year (79 sample)					
Fertiliser (Kg)	2470	1400	1688	1980	2313
Fertiliser Cost	25,194	29932	51000	109643	73,610
Agrochemicals Cost	3,920	12000	8073	14566	15,220
Weedicides				6600	6,705
Pesticides				5083	
Hormone				2883	
Machinery Cost					1,180
Labour Cost	11,375	23700	36600	104400	81,017
Labour days	65	79	66	87	58
Harvesting cost	3,500	6000	13200	34800	
Land rent	3,000	9000	15000	25000	24886
Total Cost	46,989	80632	123873	288409	195,914
YIELD	15000	12500(Fruits/ha)	12500	16500	11730
3rd Year (17 sample)					
Fertiliser (Kg)	1845	1400	1688	1980	1886
Fertiliser Cost	16562	29932	51000	99000	50,313
Agrochemicals Cost	3920	12000	8073	14566	15,600

Weedicides				6600	7,284
Pesticides				5083	
Hormone				2883	
Machinery Cost					2,676
Labour Cost	10150	23700	36600	104400	61,359
Labour days	58	79	66	87	43
Land rent	3000	6000	13200	34800	24886
Harvesting cost	4200	9000	15000	25000	
Total Cost	37,832	80632	123873	277766	154,835
YIELD	15000	20000(Fruits/ha)	20000	26400	12697

Crop variety - Passion fruit										
District - Gampaha										
2000										
	Crop Establishment					Crop Maintainence - Total Cost (Rs/ha)				
	Input		Power Cost	Labour						
Operation	Qty/ha	Cost Rs/ha	Rs/ha	Mds/ha	Cost Rs/ha	1st Year	2nd Year	3rd Year	4th Year	5th Year
Fencing										
Poles										
Barbed wire (Kg)										
Nails (Kg)										
Land Preparation(4WT)			7600			7600				
Planting (No. of plants)	1100 Plants	11000		19	3325	14325				
Fertilzer application				30	5250	5250	5250	5250	5250	875
Urea (Kg)	198	1386				1386	1386	1386	1386	
Rock Phosphate (Kg)	379	2735				2735	2735	2735	2735	
MOP (Kg)	182	2548				2548	2548	2548	2548	
Poultry (Load)	2	1482				1482	1482	1482	1482	1482

NPK (Kg)*										
Compost (Kg)										
Kieserite (Kg)										
Lime (Kg)/Dolamite										
Trelising & training				20	3500	3500				
Poles	1200	30000								
Barbed wire (Kg)	150	11250								
Pruning				20	3500	3500	3500	3500	3500	3500
Manual Weeding				175	30625	30625	17500	17500	17500	13125
Pollination										
Irrigation			2500	20	3500	6000	6000	6000	6000	6000
Harvesting				20	3500	3500	7778	9333	8556	7000
Land Rent		3000				3000	3000	3000	3000	3000
Total Labour (Mds)				304			214	223	219	160
Total Cost (Rs.)		63401	10100		53200	126701	51179	52734	51957	34982
Yield (Kg/ha)- Total Fruit Production						4000	10000	12000	11000	9000
Producer Price (Rs/Kg)		15								
Gross Income (Rs/ha)						60000	150000	180000	165000	135000

Crop variety - Passion fruit										
District - Kaluthara										
2005										
	Crop Establishment					Crop Maintainence - Total Cost (Rs/ha)				
	Input		Power Cost	Labour						
Operation	**Qty/ha**	**Cost Rs/ha**	**Rs/ha**	**Mds/ha**	**Cost Rs/ha**	**1st Year**	**2nd Year**	**3rd Year**	**4th Year**	**5th Year**
Fencing				100	30000	30000				
Poles	140	35000				35000				
Barbed wire (Kg)	250	26500				26500				
Nails (Kg)	10	1100				1100				
Land Preparation(4WT)			8750	19	5700	14450				
Planting (No. of plants)	1125	16875		62	18600	35475				
Fertilzer application				40	12000	12000				
Urea (Kg)										
Rock Phosphate (Kg)										
MOP (Kg)										
Poultry (Load)										
NPK (Kg)*	776	13234				13234	24738	33585	42026	33586
Compost (Kg)	7500	7500				7500	12000	12000	12000	
Kieserite (Kg)	68	3400				3400				
Lime (Kg)/Dolamite										
Trelising & training				35	10500	10500				
Poles	1125	28125				28125				
Barbed wire (Kg)	150	21000				21000				
Pruning							1750	1750	1750	
Manual Weeding				100	30000	30000	17500	17500	17500	14000
Pollination				30	9000	9000	17500	17500	14000	10500

Irrigation	125000	6000	20	6000	137000	12000	12000	16000	16000
Harvesting	9000		20	6000	6000	14000	14000	10500	7000
Land Rent					9000	9000	9000	9000	9000
Total Labour (Mds)			426			205	205	205	120
Total Cost (Rs.)	286734	14750		127800	429284	108488	117335	122776	90086
Yield (Kg/ha)- Total Fruit Production					7125	28000	20000	14000	5000
Producer Price (Rs/Kg)									
Gross Income (Rs/ha)					156750	616000	440000	308000	110000

Crop variety - Passion fruit										
District - Kaluthara										
2012										
	Crop Establishment					Crop Maintainence - Total Cost (Rs/ha)				
	Input		Power Cost	Labour						
Operation	Qty/ha	Cost Rs/ha	Rs/ha	Mds/ha	Cost Rs/ha	1st Year	2nd Year	3rd Year	4th Year	5th Year
Fencing				100	70000	70000				
Poles	140	63000				63000				
Barbed wire (Kg)	250	48000				48000				
Nails (Kg)	10	3250				3250				
Land Preparation(4WT)			20000	19	13300	33000				
Planting (No. of plants)	1125	33750		62	43400	77150				
Fertilzer application										
Urea (Kg)										
Rock Phosphate (Kg)										
MOP (Kg)										
Poultry (Load)										
NPK (Kg)*	866	24488		40	28000	52488	48250	57958	57958	
Compost (Kg)	5625	16875				16875	21094	21094	21094	
Kieserite (Kg)										
Lime (Kg)/Dolamite	563	2970				2970				
Trelising & training				35	24500	24500				
Poles	1125	56250				56250				
Barbed wire (Kg)	150	28800				28800				
Pruning							6300	6300	6300	
Manual Weeding				15	10500	10500	10500	10500	10500	
Pollination				30	21000	21000	21000	21000	21000	

Irrigation	200000	10000	20	14000	224000	24000	24000	24000	
Harvesting			20	14000	14000	28000	28000	21000	
Land Rent	15000				15000	15000	15000	15000	
Total Labour (Mds)			341			154	154	144	
Total Cost (Rs.)	492383	30000		238700	760783	174144	183852	176852	14000
Yield (Kg/ha)- Total Fruit Production					7125	28000	20000	14000	
Producer Price (Rs/Kg)									
Gross Income (Rs/ha)					285000	1120000	800000	560000	200000

					Crop variety - Passion fruit					
					District - Kaluthara					
					2017					
	Crop Establishment					Crop Maintainence - Total Cost (Rs/ha)				
	Input		Power Cost	Labour						
Operation	Qty/ha	Cost Rs/ha	Rs/ha	Mds/ha	Cost Rs/ha	1st Year	2nd Year	3rd Year	4th Year	5th Year
Fencing				100	120,000	120,000				
Poles	140	84,000				84,000				
Barbed wire (Kg)	250	51,500				51,500				
Nails (Kg)	10	6000				6,000				
Land Preparation(4WT)			30,000	19	22,800	52,800				
Planting (No. of plants)	1,125	84,375		62	74,400	158,775				
Fertilzer application										
Urea (Kg)										
Rock Phosphate (Kg)										
MOP (Kg)										
Poultry (Load)										
NPK (Kg)*	866	30,206		40	48,000	78,206	76,333	91,391	106,444	106,444
Compost (Kg)	11,250	112,500				112,500	119,700	119,700	119,700	119,700
Kieserite (Kg)	124	5,332				5,332	2,666	2,666	2,666	2,666
Lime (Kg)/Dolamite	563	4,504				4,504	4,504	4,504	4,504	4,504
Trelising & training				35	42,000	42,000				
Poles	1,125	163,125				163,125				
Barbed wire (Kg)	150	34,500				34,500				
Pruning							10,800	10,800	10,800	
Manual Weeding				15	18,000	18,000	18,000	18,000	18,000	18,000
Pollination				30	36,000	36,000	36,000	36,000	36,000	36,000

Irrigation	366,000	15,000	20	24,000	405,000	39,000	39,000	39,000	39,000
Harvesting			20	24,000	24,000	48,000	48,000	36,000	30,000
Land Rent	37,500				37,500	37,500	37,500	37,500	37,500
Total Labour (Mds)			341			154	154	144	130
Total Cost (Rs.)	979542	45000		409,200	1,433,742	392,503	407,561	410,614	393,814
Yield (Kg/ha)- Total Fruit Production					7,125	28,000	25,000	14,000	5,000
Producer Price (Rs/Kg)									
Gross Income (Rs/ha)					427,500	1,680,000	1,500,000	840,000	571,500

	Crop variety - Passion fruit					
	District - Kaluthara					
	2019					
	Input		**Power Cost**	**Labour**		**Total Cost**
Operation	**Qty/ha**	**Cost Rs/ha**	**Rs/ha**	**Mds/ha**	**Cost Rs/ha**	
Crop Establishment						
Land Preparation(4WT)				125	179801	179801
Planting (No. of plants)	1059	38984		61	66720	105704
Fertilzer application						
Dolamite (Kg)	434	12648		30	44346	56995
Compost (Kg)	1792	16239				16239
Trelising & training				63	94740	94740
Poles	1143	63002				63002
Barbed wire (Kg)	148	48840				48840
						565321
Crop Maintainence - Total Cost (Rs/ha)						
Year 1						
Fertilzer application						
NPK (Kg)*	708	24256		58	86759	111015
Pruning				50	74453	74453
Mechanical/manual weeding			15202	44	65375	80577
Pollination				89	132929	132929
Harvesting				116	173672	173672
						572646
Yield (Kg/ha)- Total Fruit Production						5880
						88.00
						517443
Crop Maintainence - Total Cost (Rs/ha)						
Year 2						
Fertilzer application						
NPK (Kg)*	1022	33347		25	36911	70258
Pruning				27	39900	39900
Mechanical/manual weeding			16898	40	60139	77037
Pollination				49	73126	73126
Harvesting				138	206336	206336
						466658
Yield (Kg/ha)- Total Fruit Production						8736
						90.23

						698919
Crop Maintainence - Total Cost (Rs/ha)						
Year 2						
Fertilzer application						
NPK (Kg)*	1152	40320		26	38948	79269
Pruning				27	39900	39900
Mechanical/manual weeding			18163	42	62311	80474
Pollination				48	72428	72428
Harvesting				136	203340	203340
						475411
Yield (Kg/ha)- Total Fruit Production						8852
						92.50
						818843
Total Labour (Mds)						
Total Cost (Rs.)						
Yield (Kg/ha)- Total Fruit Production						
Year 1						
Year 2						
Year 3						
Producer Price (Rs/Kg)						
Gross Income (Rs/ha)						

Annex 1 : Stakeholders of the Key Informant Survey (Recordings)

Director General /DOA

1. The role of department of agriculture in releasing technology that has been developed by institute other than department of agriculture to farmers
   Does DOA have the sole of authority? OR other institute also has the authority in releasing technology.
2. What system is the most effective in innovations of technology ?
   (a) Conducting own R&D by DOA (Direct government undertaking)
   (b) Directly funding others to conduct R&D (e.g., government funds research through the National Science Foundation grants, CARP), and
   (c) GOVERNMENT providing incentives for others to conduct more R&D - 'private' R&D by strengthening intellectual property rights
   OR any other?
3. How informed is the DOA on R&D of research community out side DOA?
4. Commercializing and up-scaling of new technology – Effectiveness of Existing mechanism????

Scientists DOA Institutes

- Rice Research and Development Institute
- Fruit Crops Research and Development Institute
- Field Crop Research and Development Institute
- PGRC
- Seeds and Planting Materials Development Institute
- SEPC
- Extension and Training Centre
- Seed certification and plant protection centre
- Crop Leaders

Officers of Other Institutes

- Mahaeweli Development
- Agrarian services centers
- NITF
- Agrarian Insurance Board
- NSF
- CARP

Private sector – Hayles, CIC, Fruits Associations

Farmer Organizations/ Retailers

Annex 2

Factors affecting Productivity of Pineapple

District :..............................

Divisional Secretariat : ....

Agrarian Service Center : ....

Grama Niladari Division : ....

Agro Ecological Zone : ....

Water Source/Irrigation Method : 1. **Minor** 2. **Rainfed** 3.**Drip** **4.Sprinkler**

Business Owner/ Farmers Name : ....

Is your business registered : ....

Address : ....

....

....

Investigators Name : ....

Date : ....

1. Household Information:

1.1 No. of member in the Household: ………………

1.2 Details of the Household

Serial Number 1		Relationship to the head of the household (කේතය-1) 2	Sex 1. Female 2. Male 3	Age (Years) 4	Level of Education (Code-2 5	Activity (Code-3 6	Main Occupation (Code-4) 7	Monthly Income in Rupees	Secondary Occupation (Code-5) 8	Monthly Income in Rupees
0	1									
0	2									
0	3									
0	4									
0	5									
0	6									
0	7									
0	8									
0	9									
1	0									
1	1									
1	2									

(Code -1)	(Code -2)	(Code -3)	(Code - 4/5)
Relationship to the Household head	**Level of Education**	**work**	**Main / Secondary occupation**
1 Head	1. 1-5 year	1. Employed	1. Farming
2Husband / Wife	2. 6-8 year	2. Unemployed (involuntary/seeking employment)	2. Self-Employment (Please specify ....)
3. Son / daughter	3Years 9-11 (up to GCE)	3. Unemployed (voluntary))	3. Agricultural hire d worker
4 Brother/a sister	4. Passed the GCE (O / L)	4. Students	4. Non-agricultural hired worker
5. Nephew/Neece	5. Passed the GCE (A / L)	5. Retired, old, frail, infant, etc.	5. Craftsman Jobs
6. Grandson / granddaughter	6. Undergraduate	6. Housewife	6. Private sector salaried jobs
7. Mother / father	7. Graduate	7. Other	7. Foreign Employment (Domestic Worker etc.)
8. Other	8. No -schooling / Unable to write		8.Government jobs
	9. No-schooling / Can write		9. Other
	10 Not eligible to go to school		

2. Details of Owned Land Cultivated

Extent in Acres		Ownership (Code-6)	Location 1.In the residential village 2.Outside	2018 Pineapple cultivated extent			2018 Other crops cultivated		
				Cultivated Extent Acres	Irrigation method ((Code 7)	*Pineapple Variety* ((Code 8)	Cultivated Extent Acres	Irrigation method (Code 7)	Cultivated Crop (Code 9)
1	**Homestead**								
2	**Highland**								
2.1	....								
2.2	....								
2.3	....								
3	**Lowland**								
3.1	....								
3.2	....								
3.3	....								
3.4	....								
4	**Chena Land**								
4.1	....								
4.2	....								
4.3	....								
4.4	....								

Code: 6 **Owner Ship**	**Code:** 7 **Water supply**	**Code** :8 ***Pineapple*** Varity	**Code**:9 **Cultivated crops**	
1.Own	1Lake	1.mauritius	1.	
2. Joint ownership	2.Canal/oya	2.kew	2.	
3. Taken up	3. Rain water	3.singapore spanish	3.	
4.lease	4. Agriculture Well	4.	4.	
5. Mortgaged	5. Drip water	5.	5.	
6. illegal	6. Sprinkler	6.	6.	
7. Government taxes	7.	7.	7.	
8. Plantation company taxes	8.	8	8.	

3. **Details of Pineapple extent cultivated on Lease/rent**

Land Plot	Cultivated Extent in Ac	1.Rent 2.Lease 3.Morgaged	How long have you been cultivating? (Years)	Rent/Lease/.Mortgaged Period (Years)	1. Under Crop 2. Mono Crop	Nature of Lease/Rent Rent amount

3.1 What are the problems / conditions associated with tenant, lease or mortgage pineapple cultivation?

1...

2...

3. ....

3.2 What are the land related problems to expand the pineapple cultivation?

1...

2. ....

4. Ownership of Machineries (Owned);

Tool	Purchased on Cash /lease	Year of Purchased	Value	Brand
4 Wheel Tractor				
2 Wheel Tractor				
Sprayer				
Water pump				
Lorry				
Weeder				
Other				

05. General Information on Pineapple Farming

5.1 Experiences in Farming (Years) ....

5.2 Experience in Pineapple farming (Years): …………..

5.3 Extent of Pineapple cultivation, Yield

Serial number	**Extent Cultivated**	**Type of Cultivation** **1. Mono Crop** **2.Mixed Crop** **3.Under crop** **(state under which crop)**)	**(Varity) Code: 10**	Type of Planting material **Code: 11**	**Yield in 2018 (No of fruits/kg)**)

Code: 10 **Varity:** 1.Mauritius 2.Kew 3.Singapore **S**panish

Code: 11 **Type of Planting material:** l Ground Suckers 2.stem Suckers 3.slips 4.crown 5.Tissue Culture

5.4 Pineapple cultivation compared to previous years:

1. Decreased 2. Increased 3 Unchanged

5.5 What were the reasons for the increase / decrease in the amount of land used for pineapple cultivation?

....

5.6 Are you satisfied with the yield? 1. Yes 2. No

5.6.1 If No, give reasons

....

5.7 Does the yield vary depending on the size of the land? 1. Yes 2. No

5.7.1 Give reasons. ....

5.8 Disposal of Harvest/ Marketing

Instances of marketing	Quantity kg	To whom the harvest was marketed (Code 12)	Place of Disposal/ marketing (Code13)	Price Rs/kg	Cost incurred Rs.	Transport cost Rs.
1						
2						

3						

Code:12 To whom the harvest was marketed		Code : 13 Place of Disposal	
1.Retailer	**6.Processor**	**1. Farm gate**	**5.Manin Market**
2.Wholesaler	**7.Exporter**	**2. House**	**6.Other(specify)**
3.Collector	**8.Village fair**	**3.Village fair**	
4.Contractor	**9.Other(specify)**	**4.Road side**	
5.Under forward agreement			

5.8.1 Are you satisfied with the price received? 1. Yes 2. No
5.8.2 If No, give reasons.

....

5.9 Supply of Pineapple for Export

5.9.1 Are you a supplier of pineapple for export 1. Yes 2. No

5.9.2 If yes, what are the institutes buy your products? ....

5.9.3 Are those institutes buying: 1) in stocks 2. Selected fruits/ nuts.

5.9.4 How do you manage your pineapple cultivation to get fruits to satisfy the export requirements?

1. Weight .... 2. Shape .... 3.Fruit and Crown ratio........... 4. Other

5.9.5 Are you satisfied with the export price? Yes 2. No

5.9.6 If "No" What problems do you have?

....

5.10 Do you grow organic pineapples? 1. Yes 2. No

5.10.1 If "Yes" cultivated 1. High demand 2. Better Price 3...............

5.10.2 You don't grow organic pineapple 1. Low Yield 2. No significant price difference

6. **Use of planting materials (plants)**

6.1 Quantity of pineapple planting (plant) used for 1 acre / the source of planting material :

Planting Variety **1.Mauritius 2.Kew 3.Singapore Spanish**	Type of Planting material **(Code:11)**	Plants per Acre		Cost of a plant (Rs)	How are you getting planting materials **(Code:12)**	How do you identify healthy planting materials for cultivation **(Code:13)**	Spacing between plants 1.Single row 2.Double row 3.Other	**Expected harvest (1 acre)**
		For Mono cultivation	Under-cultivated land					

Code: 11 Type of Planting material: 1. Ground Suckers 2.stem Suckers 3.slips 4.crown 5.Tissue Culture

Code: 12 How to get: 1. Own 2.DOA 3.Agrarian Services Dept. 4.Private Company 5.Friends 6.Neighbor 7. Farmer Organization 8.NGO 9.Other

Code: 13 Plants are identified; **1.** Presence of spine leaves 2.fruit yield 3.fruit weight 4.farmer preference 5.drought Resistance 5.cultivated extent 6.other

6.2 Does spacing between plants affect the yield? 1.yes 2.No

6.3 To the answer above Reasons

……………………………………………………………………………………

6.4 Does the spacing of plants differ in other ways (such as grafting plants ....)? 1.yes 2.no

6.5 If yes Explain ..

……….

6.6 Are you satisfied with the painting materials purchased ? 1.yes 2.no

6.**7** If not reasons

1.price is not affordable
2.quality is not acceptable
3.required quantities not available at required time
4.other (specify)

6.8 Planting and Harvesting period

	Type of planting material **Code: 10/11** **……………………..**	Type of planting material **Code: 10/11** **…………………..**	Type of planting material **Code: 10/11** **……………………..**
Time of planting material			
Harvesting time: Harvest 1			
Harvest 2			
Harvest 3			
Harvest 4			

6.9 Diseases and use of chemicals

	Infectious diseases	**Insect Damages**	**Fungal Damages**

Varity&Type of Planting material Code:10/11	**Disease**	use chemicals	**Disease**	use chemicals	**Disease**	use chemicals

Pre-treatment

6.10 Do you know about pre-treatment measures used before planting pineapple?1.Yes 2.No

6.11 How did you know about pre-treatment?
1.AI 2.kpns 3.other farmers 4.experience 5.others

6.12 What are the chemical used for pre-treatment?..

6.13 What problems do you have at the time of planting these pineapples?....................................

Moisture content in the soil

6.15 What are the measures you take to protect moisture content in the soils?

1. Mulch of Coir Dusk 2. Hay 3. Leaves 4.other

6.1**7** If yes, who advises you?
1.**AI** **2.kpns** **3.other farmers** **4.experence** **5.others**

6.1**8** How do you maintain cultivation during the drought season

1..Water Motor Application 2.Sp 3. Other

6.1**9 What problems do you have during the drought?**

....

7. Pineapple Cultivation - Labor use

7.1 Pineapple cultivation- Which labor do you use most? (Please specify the order)

The type of labor	**Sequence number**	**Reasons to use it**
1 Family labor		
2 Attam labor		
3 Hired labor		

7.2 Do you use Hired Women labor for pineapple cultivation? 1. Yes 2. No

7.2.1 If yes, please explain why it is used.

1. ....
2. ....

7.3 Is family women labor used for pineapple cultivation? 1. Yes 2. No

7.3.1 If so, how would it affect the family's daily routine?

1. ....
2. ....

7.4 What are the difficulties in obtaining labor for pineapple cultivation as a whole?

....

2. ....

Soil testing of lands

7.5 Is soil testing done on the soil before pineapple planting? 1. Yes 2. No

7.5.1 "Yes" Who was aware of this? 1.AI 2.kpns 3.other farmers 4.experence 5.others

7.5.2 Do you follow the instructions? 1. Yes 2. No

7.5.3 If yes, what were the results?

....

7.5.4 If "No", explain why you don't follow the instructions.

....

8. Cost of production of Pineapple

(Only obtain information on one pineapple plot that can provide relevant information)

8.1 Specify the serial number of the selected land for production cost.
(As per Question 2)

	2018
Serial Number of the Land	

8.3 8.2 Source of water for the land: ....

8.4 You Cultivation: 1.Normal 2.Organic Pineapple

8.4 The crops grown in the last 5 years in the above plots 1. .... 2 .... 3. ....

8.5 Other costs for farm power and machinery (Only for the above plots)

Equipment used		Machine		Using the driving force of the machine				Other labor				
								Male		Female		Contract (Rs.)
Machine (2w,4w)	Used Time	1.Own 2.Hired	**If Hired Price**	Family labor day	Hired labor day	Rent cost (Rs.)	Rent food cost	**F**	**H**	**F**	**H**	
	Land preparation -1											

	Land preparation -2											
	Laying the beds											

8.5.1 To protect the cultivation (Only for the above plots)

Fencing	Quantity	unit price (Rs.)	Total amount (Rs.)	The Transport Cost (Rs.)	The use of labor				
					Male		Female		Contract (Rs.)
					F	H	F	H	
Posts									
Barbed Wire Kg.									
Nails (kg)									
Other									

8.6 Planting Material Type / Price / Planting Costs (Only for the above plots)

Varity 1.Mauritius 2.Kew 3.Singapore Spanish	Type of Planting material (Code: 10)	Cost of planting material (Rs.)	Who's buying? (Code: 14)	Total amount (Rs.)	The Transport Cost (Rs.)	Using labor for planting					Expected yield Acre	Spacing between plants 1.Single row 2.Double row
						Male		Female		Contract (රු.)		
						F	H	F	H			

Code: 10 Type of Planting material:

1. Ground Suckers 2.stem Suckers 3.slips 4.crown 5.Tissue Culture 6.seedling

Code: 14 Buy:

1. Own 2.DOA 3.Agrarian Services Dept. 4.Private Company 5.Friends 6.Nneighbor 7.Farmer Organization 8.NGO 9.Other

8.7 To select that pineapple variety What are the reasons?

1. Being a recommended pineapple variety 2. Easy availability
3. Resistance to pests and diseases 4. Increasing market demand
5.Customer Interest 6. Other.....

8.8 What is your opinion on the quality of the planting material used?

1Poorly 2. Moderate 3. Good

8.9 Pre-treatment of Planting material (Only for the above plots)

The amount of planting material used for **Pre-treatment** (Plants)	The amount of Planting (Plants)	Used Safe chemical type	Safe chemical **cost (Rs.)**	Safe chemical Transport Cost (Rs.)	For planting material safety the use of labor					
					Male		**Female**		Hired Cost (Rs.)	Hired food cost (Rs.)
					F	**H**	**F**	**H**		

8.10 Safe chemicals were used for **<u>pre-treatment</u>** with "no" procedures and costs which?
8.11 Procedures: ………
8.12 Cost (Rs) : ……………………….

9. Use of fertilizer

9.1 Application of fertilizer and cost incurred - **(Only for the above plots)**

Type of Fertilizer	Year1		Year2		Year3		Year4		Year5	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Dolomite (Kg)										
Compost (Kg)										
Kieserite (Kg)										
N (Kg)										
P (Kg)										
K (Kg)										
NPK (Kg)										
TRANSPORT COST										

9.2 Fertilizer application for Labor (Labor Days) - (Only for the above plots)

Fertilizer	Year1				Year2				Year3				Year4				Year5		
	Male		Female		Male		Female		Male		Female		Male		Female		Male		Fema
	F	H	F	H	F	H	F	H	F	H	F	H	F	H	F	H	F	H	F
Dolomite (Kg)																			
Compost (Kg)																			

Kieserite (Kg)																			
N (Kg)																			
P (Kg)																			
K (Kg)																			
NPK (Kg)																			

9.3 From whom did fertilizer be purchased?1.CIC 2.Hayles 3.Baur 4. ASC Center 5. Other

9.4 Who got the knowledge on fertilizer application? 1.AI 2.kpns 3.other farmers 4.experence 5.others

9.5 Fertilizer application 1. Recommended quantities 2. At his own discretion

9.6 Because of the application

Fertilizer application	**The next harvest** **1. Low 2.Fantastic 3.No change**	**The reasons**
1. Recommended quantities		
2. At his own discretion		

10. Use of Hormone

Hormone Type and Cost - **(Only for the above plots)**

Type of *Hormone*	Year1		Year2		Year3		Year4		Year5	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value

10.1 Hormone sprayers and applied labor (Labor Days) **(Only for the above plots)**

Type of Sprayers 1.Hand 2.Motor	**Year**	For the machine			Manpower for the machine			**Other labor**				
		1.Own 2.Hired	**If own Oil / maintenance cost**	If the rent Price	Family Labor DAY	Hired Labor DAY	Hired Food Cost **(Rs))**	Male		Female		Contract
								F	H	F	H	

	1											
	2											
	3											
	4											
	5											

10.2 *Time of application of Hormone* 1. *Days of planting*.......... 2. .... 3. ....

10.3 *Where did you get the idea of using Hormone?*

1.AI 2.kpns 3.other farmers 4.experence 5.others

10.4 Hormone application 1. Recommended quantities 2. At his own discretion

10.5 Because of the application

Fertilizer application	**The next harvest** **1. Low 2.Fantastic 3.No change**	**The reasons**
1. Recommended quantities		
2. At his own discretion		

11. Pest and Disease Control

Pest and Disease Type and Cost - (Only for the above plots)

Type of **Pest and Disease**	Year1		Year2		Year3		Year4		Year5	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value

11.1 Pest and Disease sprayers and applied labor (Labor Days) **(Only for the above plots)**

Type of Oil sprayers	Year		For the machine		Manpower for the machine			**Other labor**		
		1.Own	If own	If the Hired	Family	Hired	Hired	Male	Female	Contract

1.Hand 2Motor		2.Hired	Oil / maintenance cost	Price (Rs)	Labor DAY	Labor DAY	Food Cost **(Rs)**	F	H	F	H	Rs.
	1											
	2											
	3											
	4											
	5											

11.2 *Pest and Disease* - ***From whom did you learn the application?***

1.AI 2.kpns 3.other farmers 4.experence 5.others

11.3 *Pest and Disease* application 1. Recommended quantities 2. At his own discretion

11.4 Because of the application

Pest and Disease application	**The next harvest 1. Low 2.Fantastic 3.No change**	**The reasons**
1. Recommended quantities		
2. At his own discretion		

12.Chemical Weeding භාවිතය

Chemical **Type and Cost -** **(Only for the above plots))**

Type of Chemical	Year1		Year2		Year3		Year4		Year5	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value

12.1 ***Chemical Weeding*** **- Sprayers and applied labor** (Labor Days) **(Only for the above plots)**

Type of Oil	Year		For the machine	Manpower for the machine	**Other labor**

sprayers 1.Hand 2.Motor		1.Own 2.Hired	If own Oil / maintenance cost	If the Hired Price (Rs)	Family Labor DAY	Hired Labor DAY	Hired Food Cost **(Rs)**	Male		Female		Contract Rs.
								F	H	F	H	
	1											
	2											
	3											
	4											
	5											

12.2 ***Chemical Weeding -*** From whom did you learn the application?

1.AI 2.kpns 3.other farmers 4.experence 5.others

12.3 Chemical Weeding application 1. As per the above instructions 2. At his own discretion

12.4 Because of the application

Chemical Weed application	**The next harvest 1. Low 2.Fantastic 3.No change**	**The reasons**
1. Recommended quantities		
2. At his own discretion		

13. Mechinary Weeding

***13.1 Mechinary Weeding* - Sprayers and applied labor - (Labor Days) (Only for the above plots)**

Type of Oil sprayers 1.hand 2.motor	Year		For the machine		Manpower for the machine			**Other labor**				
		1.Own 2.Hired	If own Oil / maintenance cost	If the Hired Price (Rs)	Family Labor DAY	Hired Labor DAY	Hired Food Cost **(Rs)**	Male		Female		Contract Rs.
								F	H	F	H	
	1											
	2											
	3											
	4											
	5											

13.2 Mechinary Weeding - *From whom did you learn the application?*

1.AI 2.kpns 3.other farmers 4.experence 5.others

13.3 Machinery weeding *application* 1. As per the above instructions 2. . At his own discretion

13.4 Problems with Machinery Weeding for pineapple cultivation as a whole?

………

13.5 Are we using polythene to cover the soil for weed control? 1. Yes 2. No

14. Water supply - ***For water motors***

14.1 Please refer to source of water:: ....

14.2 Water, Machinery & Labor - **(Labor Days) (Only for the above plots)**

Type of Water Motor 1.Fuel 2.Current	Year	For the machine			Manpower for the machine			**Other labor**				
		1.Own 2.Hired	තමාගේ නම් තෙල්/විදුලි නඩත්තු වියදම	If the Hired Price (Rs)	Family Labor DAY	Hired Labor DAY	Hired Food Cost **(Rs)**	Male		Female		Contract Rs.
								F	H	F	H	
	1											
	2											
	3											
	4											
	5											

14.3 *How often do you water before harvesting?................*
14.4 *Do You Need More Water? 1. Yes 2. No*
14.5 Leave a comment: ………………………………………………………………………………………

15. ***Details of Harvesting*** *(Only for the above plots)*

	Year1	**Year** 2	**Year3**	**Year**4	**Year5**	**total**
Frequency of lotus						
Quantity of harvested **(Kg)**						
Less than 1 Kg						
More than 1 Kg						
Amount of waste (Kg)						
balance						
Average Kg per Nut						

15.1 Labor exerted

Harvesting Season	**Year1**				**Year2**				**Year3**				**Year4**				**Year5**		
	Male		Female		Male		Female		Male		Female		Male		Female		Male		Fema
	F	H	F	H	F	H	F	H	F	H	F	H	F	H	F	H	F	H	F
1																			
2																			
3																			
4																			
5																			

15.2 *(Harvesting)* If Contract given in details:

..

..

....

15.3 What problems do you have during this pineapple harvest season?

....

16. Harvest of the above plots

			1	2	3	4	5
16.1	Pineapple harvested area (acre)						
16.2	**If there is a decline in pineapple harvest, what are the reasons?**						
	1.	Climate factors					
	2.	Pests and diseases					
	3.	Damage to animals					
	4.	Other (mention)..................					
	1	Yield **(Kg)**					
	2	Harvest available **(Kg)**					
16.3	If the yield is less than the yield, what are the reasons?						
	1	Decreased inputs					
	2	Lack of labor					
	3	Lack of water					
	4	Degradation of seed quality					
	5	Insects and diseases					
	6	Other (specify)					

17. Total cost of transporting the farm from home to house **(Only for the above plots)**

Use vehicles		For the vehicle			Loading / Loading Human labor				Contract Rs.
vehicles	**year**	1.Own 2.Hired	Own The cost	Hired The cost	Male		Female		
					M	F	M	F	
	1								
	2								
	3								
	4								
	5								

18. Total cost of moving from farm to market place **(Only for the above plots)**

Use vehicles		For the vehicle			Loading / Loading Human labor				Contract Rs.
vehicles	**year**	1.Own 2.Hired	Own The cost	Hired The cost	Male		Female		
					M	F	M	F	
	1								
	2								
	3								
	4								
	5								

19 Harvest Sale (for above plots only)

	Year1	Year2	Year3	Year4	Year 5	total
1. Quantity of harvested (Kg)						
2. **Did you sell the stock at once ?** 1.**Yes** 2.**No**						
3. If yes, then the price given is Rs.						
4 If "No" Did you sell it? 1.**Yes 2.No**						
5. If yes, then the price given is Rs. **Grade** 1. **Grade** 2. **Grade** 3.	....	....	....	....	....	....
6. **Selling from time to time?** 1.**Yes 2.No**						
7.If sold periodically Price:						

19.1 Other labor (only for the above plots)

	Year1				Year2				Year3				Year4				Year5		
	Male		Female		Male		Female		Male		Female		Male		Female		Male		Fema
	F	**H**	**F**	**H**	**F**	**H**	**F**	**H**	**F**	**H**	**F**	**H**	**F**	**H**	**F**	**H**	**F**	**H**	**F**
Weeding																			
Looking after																			
Adding Soil																			
Harvesting process																			
Other																			
Other																			

19.2 Daily Salary - (Per Day) - Yala 2018

	Hired labor (With meals)	**Hired labor (With meals)**
	Daily wage (Rs.)	**Daily wage (Rs.)**

Cultivation practice		M	F	M	F
1	Clearing the land				
2	Weed control				
3	Preparation of nursery				
4	Land preparation -1				
5	Land preparation -2				
6	Land preparation -3				
7	Crop Protection -Planting of poles				
8	Laying the beds				
9	Planting of seeds				
10	Fertilizer application				
11	*Hormone application*				
12	Application of pest				
13	Weed control				
14	Water supply				
15	Looking after				
16	Harvesting				
17	Harvest transport				
18	Harvesting process				
19	Harvest transport				
20	Other				

(Provide the following information based on all land production).

20.Management of Manufacturing

	Year 1	Year 2	Year 3	Year 4	Year 5	total
1. Obtained from this land Harvest (Kg)						
2. From other lands (Kg)						
3. Total pineapple harvest (Kg)						
4. **Amount of waste (Kg))**						
5. The amount sold (Kg)						
6. Average price (Rs./Kg)						
7.At the sale price during the year Range (Rs./Kg)						

21Training / Awareness

21.1 **Have you participated in any kind of training / awareness program on pineapple cultivation?**

1. Yes 2. No

21.2 If yes, state the details

Name of the program / course	the year	Organized organization / officer	Assessment of the program		
			The nature of the program (Code 10)	Did the knowledge used? 1. Yes 2. No	If yes, give reasons

Code 10: Nature of the Program: 1. Something 2. Knowing 3. Nothing

22. Where do you get technical advice for pineapple cultivation?

1. DOA 2. Private sector (cic / baurs / heylease /other)
3. NGO 4.Other (specify…)

23. What type of advice /services have you received?

	Type of services	1.Yes 2.No	Officer
1	Farm Planning and development		
2	Financial management		
3	Farm record keeping		
4	Weed management		
5	Pest and disease control		
6	Pest and disease indexing		
7	Fertilizer recommendation		
8	Soil fertility tests		

9	Irrigation advice		
10	Processing and grading Advice		
11	Post-harvest management		
12	Forward sales agreements		
13	Market information and marketing		
14	Nursery management		
15	Credit facilities arrangement		
16	Other (specify.)		

24. Do you satisfied with overall extension service received by you?

Category	*1.Yes 2.No*
1.Production technologies	
2.Management and marketing	
3.processing and value adding	
4.Record keeping and accounts maintaining	

25. What are the constraints do you face in pineapple cultivation?

	problems	Yes	No	If yes reason	suggestion
1	Financial (credit facilities)				
2	land				
3	machinery				
4	Hired labor				
5	Chemical fertilizer				
6	compose				
7	Irrigation water				
8	price				
9	middleman				
10	Extension service				
11	Pest and disease				
12	other inputs (eg.hormone)				
13	Other (specify)				

26. Have you obtained training on pineapple cultivation? 1. Yes 2.No

If yes what type of training have you received?

	Area of training	Received service 1.yes 2.no	Weather adopted 1. Yes 2. no	If not why?
1	Financial management			
2	Farm planning and development			
3	Crop management			
4	Soil fertility management			
5	Nursery management			
6	Agro processing and value adding			
7	Marketing			
8	Pest and disease management			
9	Quality improvement and hygienic production			
10	Organic farming			
11	Farm record keeping and accounts maintaining			
12	other			

27. Home Loans & Payments: (Loans & Others)

27.1 Have you obtained any loans or loans for farming in the last 5 years? 1.Yes 2.No

(Including mortgage loans).

27.2 Loans

The way of borrowing (Code1)	The reason for the loan (Code 2)	Loan Amount	Pineapple cultivation Size	Annual interest	Payment period	Approved hold (Code 3)	Amount to be paid now	Reasons for non-payment (Code 4)

Code 1
1 State Banks

Code 2
1. For pineapple cultivation

Code 3
1 no guarantee

Code 4
1 the pay day is still ahead

2 Private banks	2 For paddy cultivation	2 Real estate	2. Pineapple Crop destruction
3. Sanasa	3. For animal husbandry	3 Vehicles	3. Debt cutting from the government
4 Samurdhi Bank	4Consumption	4 jewelery	4. Cultivation of disease
5 Agrarian Bank	5. Function	5. Machinery	5. . Other........
6. The village merchant	6. For Business	6 Personal guarantee	
7. The merchant outside the village	7. Loans Escape	7 House Items	
8 People who give money interest	8. Housing Development	8. Payment Method	
9. Neighbors / relatives	9.Other........	9. . Other........	
10. Other........			

28. Have you participate any post harvest practices/processing before selling pineapple? 1.Yes 2.No (if no go to ques. No. 32)

29. If yes type of processing adopted?

Value adding /processing	1.yes 2.No
Grading	
Cleaning	
Packaging	
Dehydration	
Others(specify)	

30. Have you find any price difference after adding value for pineapple?
1. Yes 2.No

31. If yes what benefit have you derived from value addition?

Benefit	Response
Farm gate price increased by <10%	
Farm gate price increased by 10% -15%	
Farm gate price increased by 15% -20%	
Farm gate price increased by 20%-25%	
Farm gate price increased by >25%	

32. Have you faced any difficulties in marketing of pineapple? 1. Yes 2.No

33. If yes what type of problems are you facing in marketing of pineapple?
1. Developed market Centre not available for pineapple
2. Middle man not paid reasonable price for pineapple
3. Quantity not enough to bring to nearest market as transport cots is high.

4. Transport facilities not adequately developed or difficult to find.
5. Price are fluctuating not stable price for pineapple
6. Price paid for pineapple are not enough to cover the cost of production
7. Existing marketing channels are inadequate
8. Any other

34. What are your suggestions to overcome above problems?

………………………………………………………………………………………………………..

………………………………………………………………………………………………………..

35. Have you encountered pre and post-harvest losses before selling?

1. Yes 2. No

36. What is the % loss out of total production?

% of loss	**Pineapple** (code 11)
1.damages occurred when harvesting	
2.handling at farm (collecting and transporting to store)	
3.at store before transporting to market (decayed at store)	
4.damaged made by birds animals after harvested	
5.transport to market	
6.other …	

Code: 11
1. <5 % 2. 6%-10% 3. 11%-15% 4. 6%-20% 5. >25%

37. Do you need storage facilities to store your products before selling? 1. Yes 2.No
38. What type of assistance do you need to find storage facilities?
…………………………………………………………………………………………………
…………………………………………………………………………………………………
………………

39. Do you willing to undertake processing? 1. Yes 2.No (If No go to ques. No. 42)

40. If yes what type of processing do you wish to start?

Type of processing	**pineapple**
Dehydration for local market	
Dehydration for export market	
Chips production	
Other (specify)	

41. If you are willing to undertaken processing what constrains do you face in Starting?
1. Startup capital 2 .working capital 3. Technology
4. Procurement of machinery 5. Skilled labor 6. Other

42. Do you cultivate pineapple as out grower affiliated with any?
Company/producer/exporter? 1. Yes 2.No (if No go to ques. No. 46)

43. If yes please give information
1. Name of contractor/company/exporter: ………………….
2. Date started: ………………
3. Type of contractual arrangement (legal agreement/mutual agreement/ Mutual understanding)
4. Valid period: …………….

44. Type of assistance obtained under out grower arrangements

1. Financial assistance provided to purchase inputs (annul/seasons)
2 Supplied inputs (planting/material/fertilizer/agro chemicals/hormones Etc.) On Agreement to supply the produce to company Contractors/exporter and pay Selling Price after deducting from cost incurred for inputs materials)
3. Farm advisory provided on free of charge
4. Agreed to pay prevailing market price of produce
5. Provide credit facilities to cultivate pineapple

45. How do you assess the out grower farming arrangement?

1. Farmers know the price they would received for the products in advance
2. Farmers get financial assistance to purchase raw materials
3. Farmers get interest free credit facilities for cultivation
4. Farmers get technical assistance on time
5. assured market for farm products
6. Always liable to sell products to the contractor even though purchasing prices are High in Open market at harvesting time
7. Other (specify)

46. **Did you get any project for pineapple cultivation?**

46.1 If yes, indicate the project details

Project	**Material aid**	**Financial aid**	Training / awareness programs 1.Yes 2.No	If yes Specify
1.Moderniation project				

46.2 Are you involved in the Good Agricultural Cultivation (GAP) Project? 1. Yes 2. No

46.3 If yes, is GAP certified? 1. Yes 2. No

46.4 **What are the steps to follow in GAP?**

……………………………………………………………………………………………………

……………………………………………………………………………………………………..

47. Average cost

(Answer by monthly or annual how to spend)

	Type of expenditure	Monthly Expenditure (Rs)	Annual Expenditure (Rs)
1	For food		
2	For clothing		
3	Drugs		
4	Travel expenses		
5	Education		
6	Events/ festivals		
7	Housing		
8	Furniture Purchases		
9	Debt settlement		
10	social services		
11	Other..................		
12			
13			
14			
15			

48. Household Income (In the past year - Rs.)

	Source of income	Last month	Last 6 months	In the year 2018
1	**Proceeds from the sale of pineapples**			
2.	**By selling pineapple plants**			
2	By selling other agro-crops			
3	By selling permanent crops			
4	Income from paddy cultivation			
5	Animal Husbandry (Milk, Dung, Fertilizer, Sale of Animals)			
6	Agricultural hire work			

7	Non-agricultural rent			
8	Trading			
9	Pensions			
10	Private sector jobs			
11	Government jobs			
12	of Foreign Employment			
13	Samurdhi Donations			
14	Ping stairs			
15	Other..................			
16				

49. **Your views on the issues that should be prioritized for increasing the productivity of**

Pineapple

1...

2...

3...

4...

5...

end 26