RE-ENGINEERING THE SEED SECTOR

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FOREWORD

Seed, that's where it all begins. And this is a fact that is too often forgotten. Seeds, by nature, tiny and therefore missed in the all too typical quick sweep across agrarian territories dominated by hardware that punctuates every step of the process from farm to fork, are nevertheless territories of contestation. They are infused with ideology and coated with political economy. That, however, is not the thrust of this study. It needs to be mentioned though not least of all because of the overarching ways in which seed politics colour the agrarian landscape and indeed impact issues such as food security and sovereignty.

This study focuses on the issue of quality in improving farm productivity and thereby resolving food insecurities. In other words, even if we set aside the politics of seeds, there are factors which compromise efficiency. Put another way, there are untapped potentials. The research team set out to identify inhibiting factors and based on evidence gathered and analyzed have developed recommendations which policy makers can consider when making decisions that impact the sector or elements thereof.

The study has revealed, for example, that there has been a significant growth in production across many crops over the past two decades, with chilli being the exception. Interestingly, the research team has noted a growth in both quantity and costs of seed imports. It is significant and worrying on several counts that the formal seed sector accounts for just 10-12 percent of the total requirement of the country. A generous interpretation would be that this is indicative of the potential for significant improvement.

The team has identified the ills and also suggested remedies which include improved cooperation between private and public sectors, the creation of an enabling business environment, legislative enactments, regulatory mechanisms, enforcement strategies, and stringent certification processes, among other things. The delineation of vulnerabilities and pathways to mitigate the same are also important contributions to the literature on this subject.

It is, then, an important academic intervention whose full fruition would require close reading of the text and pragmatic policy interventions.

Malinda Seneviratne
Director/Chief Executive Officer

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EXECUTIVE SUMMARY

Seed is a crucial input in any form of crop production and quality seed has significant potential in increasing farm productivity and ensuring food security. Inadequate supply of good quality seeds is considered as one of the major factors contributing to the slow growth rate in the agricultural sector. Hence, this study explored the seed sector in Sri Lanka to diagnose underlying system challenges by identifying where performance is lacking as well as untapped potentials in order to better inform management and investment decisions. Primary data was collected through interviews with stakeholders of the seed sector and secondary data was collected from the Sri Lanka Custom, Department of Agriculture, and its affiliated institutions. The compound growth rate analysis was used to examine growth trends and descriptive analysis was used to identify potentials and barriers in the seed sector.

According to the growth analysis from 2000 to 2020, rice, maize, potato, chilli, and most of the vegetables showed significant increment in annual production while in the case of rice and maize there had been a significant growth in cultivated extents. Seed production of maize and potato showed a significant growth rate over this period. However, the annual growth rate of seed production and requirements of chilli have significantly declined. Though the vegetable seed sector has a positive growth in seed production, the annual cost and quantity of imported seeds showed an increasing trend. The formal seed sector supplies only 10-12 percent of the total seed requirement and the majority of rice farmers (90 percent) still rely on farmer-saved seeds while depending on imported seeds for other crops. This highlights the huge untapped potential for seed production in the country. The implication is that local seed production and distribution programme should expand and be strengthened to increase the availability of local seeds.

The importation of crops that can be produced locally must be limited (for example, chilli) to promote local seed production. It was observed that the interaction between private and public sectors is still at a very low level and therefore an enabling business environment to support seed industry development is a key area in need of strategic government involvement. This includes the legislation and enforcement of policies and regulations that encourage private investment in seed production and marketing, tax incentives for land used for seed production, preferential access to improved germplasm from the public research system, subsidized credit, credit guarantees, tariff exemptions on equipment imports and other benefits that lower the seed production and distribution costs.

There is a dearth of better quality and more accessible data, information and analysis for major crops. This inhibits informed decision-making. Even the extension service was found to be less capable of providing technical assistance and building capacities of farmers. Therefore, a proper information system must be developed and the latest information should disseminate through Agrarian Services Centers. Front line demonstrations need to be conducted with utmost care in order to increase the adoption and diffusion of new seed varieties.

The lengthy certification process, lack of staff and inadequate budget to carry out operations in seed certification are identified as key constraints. In addition, the capacity to monitor seed quality once it reaches the market and is purchased by farmers seems to be limited. There is no proper compensation system for farmers who are victims of substandard seeds. Therefore, the need for a regulatory agency which is worked as an independent body and authorized to consider farmer appeals, make compensations for victims and take legal action against the trade of substandard seeds is evinced.

The existing provisions under the Seed Act No. 22 of 2003 are not sufficient to address emerging issues in modern agriculture and ensure the rights of farmers. Hence, it is essential to monitor the Seed Act No. 22 of 2003 and its impact in the first instance. The Act requires revisiting in view of improvement through amendment. Sri Lanka is also lagging far behind the other countries in formulating and implementing property rights pertaining to the agricultural sector, especially on new plant varieties and farmers' traditional knowledge. Hence, agricultural sector in Sri Lanka is vulnerable to outside exploitation because of its inability to provide necessary protection for new plant varieties and farmers' traditional knowledge. Therefore, it is a need to protect the gene pool of traditional crop varieties through farmer communities, strengthen the existing conservation system further and to promote sustainable utilization of traditional germplasm.

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ABBREVIATIONS

ASCs	Agrarian Services Centers
CAGR	Compound Annual Growth Rate
CDVI	Cuddy Della Valle Index
DOA	Department of Agriculture
IPRs	Intellectual Property Rights
ISTA	International Seed Testing Association
MOA	Ministry of Agriculture
NSP	National Seed Policy
OFCs	Other Field Crops
PPPs	Public-Private Partnerships
R&D	Research and Development
SCPPC	Seed Certification and Plant Protection Centre
SLCARP	Sri Lanka Council for Agriculture Research Policy
SPMDC	Seed and Planting Material Development Centre
SRR	Seed Replacement Ratio
TRIPS	Trade-Related Aspects of Intellectual Property Rights

CHAPTER ONE

Introduction

1.1 Seed as a Key Input

Seed is one of the most critical inputs in agricultural production, and quality seed has significant potential in increasing on-farm productivity and food security (Wekundah, 2012). Increasing the availability and quality of seeds can increase the yields of crops by significant amounts, and thus, is one of the most economical and efficient inputs to agricultural development (FAO, 2006). The efficiency of all other agro-inputs depends on seed quality, and the direct contribution of quality seed to total production is estimated as 15-20 percent, depending upon the crop. Production can be further raised to 45 percent with efficient management of other inputs (Singh *et al*., 2019).

Crop improvement is synonymous with, and dependent on, seed improvement. The ways in which plant-breeding and seed-production activities are organized, and their performance over the years and coming decades, will be pivotal in influencing the future of agriculture. Hence, the success of any crop-improvement programme depends on the availability and effective use of improved and quality seeds. However, the quality of seeds, especially genetic integrity, gets degraded after some generations of farmer seed production. Therefore, establishing a sustainable system for supplying good quality seeds is regarded as essential.

1.2 Seed Sector in Sri Lanka

An organized seed sector was started by the Department of Agriculture (DOA) in late 1950 and remained the sole supplier of seeds up to 1980. However, the production of enough seeds to meet the national requirement has been one of the most difficult tasks entrusted to a single agency like the DOA. With the liberalization of seed importation in 1984, the private sector started to import seeds. Subsequently, in 1990, the private sector got into local seed production and supply. However, the DOA is still a major player in agricultural research, and the provision of breeder seeds and support services, including quality assurance.

The main institutions responsible for seed production and distribution are the Ministry of Agriculture (MOA) and DOA. The Seed and Planting Material Development Centre (SPMDC) is responsible for seed production, marketing and distribution, while the Seed Certification and Plant Protection Centre (SCPPC) is responsible for seed certification. In addition, the private sector is engaged in seed importation, commercial seed production, seed distribution and sales. However, the role played by the DOA is more service-oriented, and this does not help to ensure its commercial activities run smoothly (Udakumbura *et al*., 2002).

Government policy promotes the use of certified seeds produced by the formal sector. Such efforts have seen self-sufficiency in seed-paddy production. However,

the seed supply of most other crops remains heavily import-dependent. Even in seed-paddy production also, the formal sector covers only 12-15 percent of the total annual requirement, and at least 20-25 percent of the annual seed paddy requirement has to supply certified or assured seeds in order to obtain a significant increase in rice productivity (Senevirathna *et al*., 2008). The private sector does not engage in supplying Other Field Crops (OFCs) seeds, apart from certain cash crops such as chilli, big onion and maize. Meanwhile, the majority of the potato seeds and most of the upcountry vegetable seeds are imported. Seeds of low-country vegetables are produced within the country, while some hybrid varieties and open-pollinated varieties are imported (Wijesinghe and Wijesinghe 2018).

1.3 Seed Policy Reform in Sri Lanka

A National Seed Policy (NSP) was approved to establish a viable seed industry in Sri Lanka. The main purpose of setting up the NSP was to provide guidelines to encourage private-sector participation in producing quality seeds to fulfill the country's requirements. However, this was not entirely successful, and problems with regard to seed quality emerged. Therefore, the government enacted the Seed Act No 22 of 2003 to regulate the quality of seed and planting materials, and to safeguard farmers as well as seed handlers from malpractices that would harm the seed industry. Although passed in 2003, the Act came into practice only in 2008. The National Seed Council was established under this Act.

The global seed industry has grown steadily over the last four decades in terms of global trade. The Asia-Pacific region has been witnessing increased adoption of hybrids, and an increasing seed replacement rate in key crops such as rice, maize and vegetables (Singh *et. al*., 2019). However, some farmer aspirations, as well as objectives of the seed policy, such as easy access to seeds of good quality, are yet to be fulfilled in Sri Lanka (Hirimuthugodage, 2014). This emphasizes the need for policy reforms in the field of seeds and planting materials.

1.4 Problem Statement

Seed has a critical role in agriculture development in terms of both production and productivity enhancement. Massive efforts and investments have been made to introduce varieties based on technical characteristics such as high yields, resistance or tolerance to biotic and abiotic stresses, palatability, nutrition, etc. Therefore, it is essential to maintain sustainable seed systems, which supply an adequate quantity and quality of a diverse variety of seeds to meet the needs of farmers.

The national policy on agriculture has strongly recognized the need for developing the seed sector in order to accelerate the development of the agriculture sector to achieve the national goals of food security and the improvement of the livelihood of farmers (Weerasekara *et al*., 2006). The agricultural policy framework of a "People-Centric Economy'' with the 'Vistas of Prosperity and Splender-2020", also identifies the importance of a revolution in the use of seed and planting-material production. The recent Covid 19 pandemic and import-restriction policies have also reiterated

the importance of maintaining a sustainable seed system. However, only 20-25 percent of the seed and planting materials used in Sri Lanka come from registered producers, and the rest is supplied through informal sources (Hirimuthugodage, 2014). An inadequate supply of good quality seeds and planting materials is considered as one of the major factors contributing to the slow growth rate in the agricultural sector (Chandrasiri and Bamunuarachchi, 2015; SLCARP, 2017), and attention needs to be paid to research and extension services to supply better quality seeds to farmers (Hathurusinghe *et al*., 2012).

Seed importation increased with regard to particular crops, especially hybrids while local seed production declined. The annual vegetable-seed import costs are on the increase in Sri Lanka (Wijesinghe and Wijesinghe, 2018) and were around 1.064 billion rupees (International Seed Federation, 2017). Seed importation negatively affects the foreign exchange reserves of the country and poses substantial risks due to the high dependence on imports to sustain the country's food and nutrition security. The continuous imports of foreign-planting materials in significant amounts could result in the depletion of the local genetic resource base of the country. Farmers have to keep buying hybrid seeds every season making them dependent on seed companies. Further, growing concentration and oligopolization of the seed markets have been highlighted with respect to the effects of increasing prices, reduction in the variability of varieties, slowing rates of innovations and sustainability challenges with regard to access and the decline of agricultural biodiversity (Bonny, 2013).

In line with current agricultural commitments, more efforts must be given to seed production for Sri Lanka to become self-sufficient. However, key questions emerge concerning the capacity of the Sri Lankan seed supply system to support the introduction and/or expansion of supplies of local varieties with assured quality, and if this does not meet national requirements, what needs to be done to address these issues. Therefore, a preliminary examination of the seed sector in Sri Lanka is essential for policy implications, and possible improvements.

In this perspective, a general assessment of the seed sector to test robustness in practice, and to fill in the details about what is happening, are essential for performance improvements. This suggests a need for new data and analysis to improve our understanding of how seed systems function. Hence, this study will explore the context of Sri Lanka's seed-sector development employing key food crops.

This study explores the seed sector in Sri Lanka, illustrating rice, maize, potato, big onion, chili and several vegetable crops, by highlighting seed-sector growth trends, its potentials and barriers. Findings in this study will diagnose underlying system challenges by identifying where performance is lacking, and untapped potentials, which will be of value in management and investment decisions in the seed industry in the future. It will provide insights on seed-market dynamics, and assist

stakeholders and policy makers, particularly in designing strategies and policies for seed-sector development.

1.5 Objectives

1.5.1 General Objective

To examine seed-sector capacities, disparities and trends to design strategies and policies for seed-sector development in Sri Lanka.

1.5.2 Specific Objectives

1. To examine growth trends in the seed sector
2. To identify potentials, barriers and strategies in seed-sector development in Sri Lanka

CHAPTER TWO

Review of Literature

Seed is both basic and one of the most critical inputs for sustainable agriculture. They are inevitably crucial for successful crop production, profitability and farm productivity (Tripp 2001; Edward 2016; Kuruppu *et al*., 2020). A seed system refers to the economic and social mechanism by which farmers' demands for seeds, and the various traits seeds provide are met by various possible sources of supply (Lipper *et al*., 2010). There is no single set of rules or regulations that leads directly to the development of such a system. Rather, decisions on how to build that system must balance a complex set of social and economic trade-offs (Spielman and Kennedy, 2016).

2.1 Growth Trends in the Seed Sector

The growth of any variable indicates its past performance. Therefore, an analysis of growth is usually used in economic studies to determine the trend of a particular variable over a period of time. It is imperative to compute a growth rate for the formulation of plans, policy decisions and strategies to boost production performance. A Compound Annual Growth Rate (CAGR) is estimated to measure growth performance, as it indicates the performance of the variable under consideration. Hence, it can be used to make interpretations and to evolve policy decisions (Acharya *et al*., 2012; Timsina *et al*., 2015; Joshi *et. al*., 2021).

The global seed market is estimated to grow at a CAGR of 9.9 percent in the forecasted period 2017-2022 and is estimated to reach a market value of 80.88 million U.S. dollars by 2022. The vegetable-seeds market is projected to register a CAGR of 9.44 percent, during the forecast period of 2019-2024 (Mordor intelligence, 2020).

Previous literature has been reviewed, and a study by Joshi *et al*., (2021) computed the CAGR and Cuddy Della Valle Index (CDVI) to analyze the growth rate and instability of major cereals in Nepal from 1995 to 2014. The time-series data of 29 years, from 1990/91 to 2018/19, was analyzed by dividing the total period into three sub-periods of three decades. Further, the study by Gairhe *et al*., (2018), aimed at analyzing the dynamics of major-cereals productivity in Nepal from 1995 to 2014. The percentage change, CAGR, the annual rate of change, coefficient of variation and instability index were calculated to analyze the results. The results showed that the area, production and productivity of major cereals had an increasing trend over the study period.

Deb and Pramanik (2015) analyzed the performance of groundnut production in Bangladesh in the 1990s and 2000s, both at the district and national levels. Production performance was measured in terms of growth and variability. The study concludes that groundnut breeders should focus more on yield increase rather than

on reduction in variability in yield. The study of Das and Mishra (2020), estimated the CAGR of tea in the state of Assam and Sonitpur district of Assam. The study was based on secondary data, which related to area, production and productivity of green tea leaves for the period of 2003-04 to 2017-18.

The study by Meena and Nandal (2016) analyzed the trend in production and productivity of principal crops in Haryana state, India. The trends of growth rate in production and productivity for all nine major crops were estimated by using CAGR. The results showed that the productivity trend remained positive for all principal crops except gram, during the pre-reform period. Though the productivity trend has remained positive for all the principal crops during the post-reform period also, yet the growth of yield/productivity of many crops, i.e. rice, wheat, pulses and oilseeds, has stagnated during the post-reform period. Correspondingly, Acharya *et al*., (2012) estimated the growth in the area, production and productivity of different crops in Karnataka using the compound growth function. Growth rates showed a significant positive growth in area under pulses, vegetables and spices and fruits and nuts, while cereals showed significant negative growth.

According to Manjunatha *et al*. (2013), the growth was more spectacular in the last decade (2001 to 2010) when seed production tripled with a robust CAGR of 15 percent. The rapid growth of innovations (improved varieties, hybrids and proprietary technologies) and seed markets (especially for Bt cotton, single-cross maize hybrids, hybrid rice, vegetables and few self-pollinated crops), strengthening of Intellectual Property Rights (IPRs), and liberalized seed policies were identified as the growth drivers of this period. Further, they emphasized that technological breakthroughs to mitigate biotic and abiotic stresses, a favorable regulatory environment for Genetically Modified Crops, government policies to promote investment in seed research and infrastructure, and providing access to international markets would be the growth drivers of the future. The study by Parthiban *et al*. (2019) also highlighted the determinants of the growth of vegetable-seed industries in India. It was found that policy factors, geographical factors, market factors and farmer-oriented factors were the major determinants influencing the growth of a hybrid vegetable-seed industry in India. However, studies focused on seed-sector growth and its dynamics are lacking in the Sri Lankan context.

2.2 Potentials and Barriers in the Seed Sector

The COVID-19 pandemic seriously affected production, certification, distribution, and the cost of seeds in the initial months of the pandemic. Facing this adversity played a fundamental role in developing resilient agricultural sectors and food systems in the least-developed countries (Mordor Intelligence, 2020).

Despite significant and demonstrated benefits to society, actual public sector spending on agricultural research is decreasing, particularly in developed countries (OECD, 2019; Heisey and Fuglie, 2018; Clancy *et al*., 2016). Therefore, the public-sector seed industry has to be revitalized to address challenges of competitiveness in

research and development (R&D), development and protection of new varieties, and efficient technology transfer systems (Manjunatha *et al*., 2013; OECD, 2019).

Stagnation in the capacity and contribution of public research to cultivar improvement (Beintema *et al.,* 2012; Flaherty *et al.,* 2013) and Agricultural Public-Private Partnerships (PPPs) have played a pivotal role in the economics of developing countries. Areal and Riesgo (2014) found that PPPs mainly focus on strategic crops for the European market and on strategic traits (e.g., climate-change adaptation, food security and biofuels). They may also pay limited attention to minor crops. Phillips *et al*., (2013) found that PPPs in plant breeding often required extended public-sector funding in Canada, as it takes about 15 years to generate an independent cash flow. The study of Kuruppu *et al*., (2020) determined the prospects in initiating PPPs to improve quality seed-potato production in Sri Lanka. They clearly envisage that a certain lag has existed in quality seed-potato production in Sri Lanka over the years, and forming viable and realistic PPPs are the sustainable solution to escape this situation.

Tripp and Pal (2001) studied the information flow between seed firms and farmers in the pearl-millet market of eastern Rajasthan. Branding is a convenient shortcut for communicating product quality, and it is also an entry barrier to small and new firms that cannot afford to advertise or do not have past reputations to build on. Tripp and Pal found that such information is not used by farmers. Thus, in the absence of farmer education, quality regulation fails to protect farmers, and neither does it reduce barriers to entry that are created by branding. However, information asymmetry between seed retailers and farmers lead to fake seed companies, and dealers exploiting farmers (Spielman *et al*., 2016).

There is an extensive literature predicting that the entry and growth of private R&D investment in developing-country agriculture would hinge significantly on intellectual property rights, particularly in cases involving advanced biotechnology tools and products (Byerlee and Fischer, 2002; Pingali and Traxler, 2002). Therefore, IPRs support the ongoing trends towards the commercialization of the breeding and seed sectors. This trend disregards or even threatens the interests of resource-poor farmers. However, there are also predictions that IPRs, by providing private firms with temporary monopolies, may limit smallholder-farmer access to new technologies in developing countries, and raise difficult economic and social costs (Goeschl and Swanson, 2000; Srinivasan and Thirtle, 2000).

According to Fernandez-Cornejo (2004), in the United States, small seed businesses gave way to larger enterprises by integrating plant breeding, production, conditioning, and marketing functions. The industry was further shaped by widespread mergers and acquisitions, rapid growth in private research and development (R&D), shifting roles of public and private R&D, and agricultural biotechnology. Koundinya and Kumar, (2014) emphasized that government policies of India since independence liberalized and encouraged the seed trade in India. The vegetable-seed industry has had a positive influence on the Indian economy in terms

of income and employment generation, and in earning foreign exchange on the international market. However, there are few constraints like high cost of seed production, technical problems and stringent laws, which set brakes on the vegetable-seed industry in India.

The adoption of technology is a complex process shaped by diverse technical, socioeconomic, cultural and institutional factors. As farmers around the world transition from local varieties to bred varieties with improved productivity and resilience, varietal diversity for certain crops will decrease. This in turn could impact the gene pool available for future breeding (Access to Seeds Index, 2019). Although there is limited evidence that the genetic diversity of cultivated plants has consistently decreased, genetic uniformity in the field may increase as farmers cultivate the same varieties over large areas (Bonnin *et al*., 2014), and with insufficient investment in the conservation of in-situ and ex-situ plant-genetic resources (Koo *et al*., 2004; Smale, 2006).

Chandrasiri and Bamunuarachchi (2015) explored different socioeconomic and institutional factors influencing the adoption of some crop varieties in Sri Lanka. The study found that the selection of crop varieties are mainly based on crop yield and farm incomes. The study by Wijesinghe and Wijesinghe (2018) identified the decisive factors in selecting vegetable seeds, either local or imported, and the cost-effectiveness of vegetable cultivation with respect to variety type. They found that yield, land size, source of access to seeds, seed cost, seed quality, distance and resistance to pest and diseases significantly influence decisions on variety selection. A high yield from the imported varieties is considered the most important factor when seeds are selected by farmers.

Varied and often opposing philosophies shape seed-sector development (McGuire and Sperling, 2016). One way to shift this discourse is to focus attention on data and analysis that expand understanding of how seed systems function. However, the limited number of research articles raise questions about support strategies for achieving seed-system gains at scale, on a sustained basis, and those that serve smallholder farmers.

CHAPTER THREE

Methodology

3.1 Data Collection

This study collected primary and secondary data. Primary data was collected through key informant interviews by employing stakeholders in the seed sector. A series of stakeholder discussions were conducted employing breeders, seed producers, heads of seed companies, leaders of seed associations, agriculture instructors, agriculture production and research assistants, and leaders of farmer organizations, to collect information on the current status and major issues in the national seed sector.

Secondary data was collected from Sri Lanka Customs, the Department of Agriculture and its affiliated institutions, and private seed companies. In addition, secondary information was gathered through research reports, journals and newspaper articles.

3.2 Key Informant Interviews

Key informant interviews were conducted employing officers in the SPMDC, SCPPC, National Plant Quarantine Service, research institutions and government farms. In addition, personnel from private seed companies, professionals from seed associations, leaders of seed-producing organizations and cooperatives, and farmer leaders in farmer organizations, were interviewed.

3.3 Data Analysis

Objective 1: To Examine Growth Trends in the Seed Sector

Analytical Method: Compound Growth Rate Analysis

Compound Annual Growth Rates were estimated by using log-linear functions, which is an appropriate functional form described by Gujarati, 2009. The function has been applied in many other studies for the computation of CAGR (Deb and Pramanik 2015; Rimal and Gurung 2016; Gairhe *et. al*., 2018).

The growth in cultivation extent, crop production, seed production, seed requirements and seed imports for particular crops, were estimated using the compound growth function in the form:

$$\mathbf{Y_t = a\, b^t\, u_t} \qquad (1)$$

Where:

$\mathbf{Y_t}$ = Dependent variable for which growth rate will estimated in period t
a = Intercept
b = Regression coefficient = (1+g), where g is the compound growth rate

t = Years which takes values, 1, 2 …n
$\mathbf{u_t}$ = error term

The equation was transformed into a log linear form, and was estimated using the Ordinary Least Squire technique. The compound growth rate (g) in percentage was computed using the relationship:

g = {Antilog of (ln b) -1}*100 (2)

The significance of the coefficient was estimated and tested for its significance with "t" statistics.

Objective 2: To Identify Potentials and Barriers in the Seed Sector Development in Sri Lanka

Analytical Method: Descriptive Analysis

Descriptive methods were used to identify potentials and barriers in the seed sector. Existing gaps in policy reforms and regulations were also identified to develop strategies for strengthening seed sector performance.

CHAPTER FOUR

Growth Trends in the Seed Sector

4.1 Growth Trends

The secondary data on cultivation extents, crop production, seed production and seed imports, were used to analyze the growth trends. The growth in the area, production, seed supply and the seed requirement for different crops, were estimated using the compound growth function. The analysis covered the period from 2000 to 2019. The seed requirement was calculated using seed rate and average cultivated extents.

Table 4.1: Growth Rate of Extent and Production of Crops

Crop	Extent			Production		
	Mean (Ha)	CV (%)	CGR (%)	Mean (MT)	CV (%)	CGR (%)
Maize	47619.13	37.31	6.54**	135519.00	67.89	15.18**
Potato	5066.53	15.29	0.17	76068.15	19.38	1.78*
Big Onion	4047.80	41.80	-1.61	57194.75	42.46	1.12
Chilli	5066.53	15.29	0.17	56476.85	19.02	1.80**
Paddy	993813.43	15.12	1.47**	3577473.32	20.36	2.12**

Source: Author's Calculation

*Note: * denotes significance at 5 percent, ** denotes significance at 1 percent*

The average area under maize during the study period was 47,619.13 ha (Table 4.1). The fluctuation of extent as well as production under maize appeared to be high as the coefficient of variation was 37.31 and 67. 89 percent respectively. On average, 135,519.00 MT of maize were produced within the country with an annual growth rate of 15.18 percent. Local maize seed production has shown 10.63 percent annual growth (Table 4.2). Meanwhile, an average 6,336.55 MT of maize seeds are imported for cultivation, with a growth rate of 0.17 percent per annum. Moreover, the maize seed requirement also significantly increased by 5.75 percent.

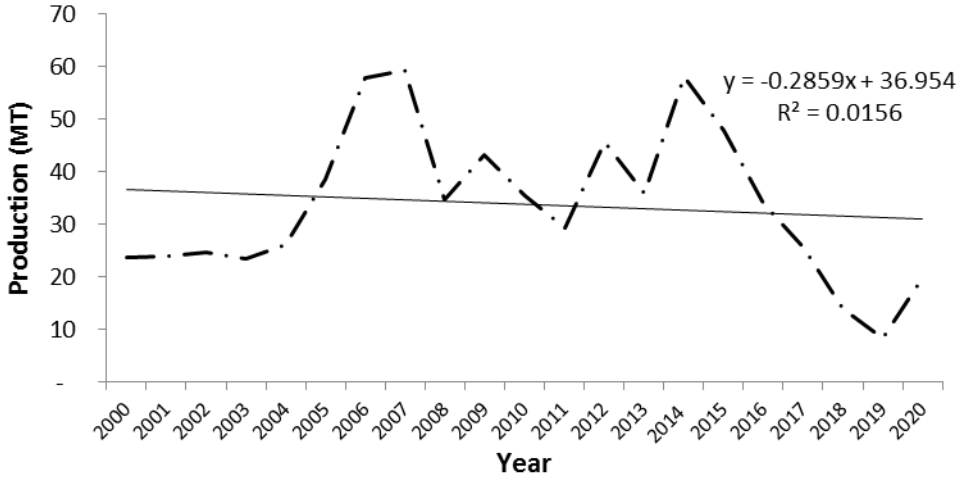
Table 4.2: Growth Trends of Production and Requirements Seeds

Crop	Seed Production			Seed Requirement		
	Mean (MT)	CV (%)	CGR (%)	Mean (MT)	CV (%)	CGR (%)
Maize	1839.31	57.64	10.63**	409513.99	45.32	5.75**
Potato	189.88	22.50	12.14**	4834.78	21.20	-0.10
Big Onion	34.51	41.17	-1.38	34.41	41.80	-1.61
Chilli	21.94	14.40	-1.82**	14.63	14.40	-1.82**
Paddy	-	-	-	99381.34	15.12	1.47**

Source: Author's Calculation

*Note: * denotes significance at 5 percent, ** denotes significance at 1 percent*

Sri Lanka shows an annual increment of 1.47 percent growth in the extent of paddy. The average annual production of rice in the country is around 3,577,473.32 MT. National rice production is growing at around 2.12 percent per annum considering the data of 2000-2019, and its fluctuation is also not all that conspicuous.

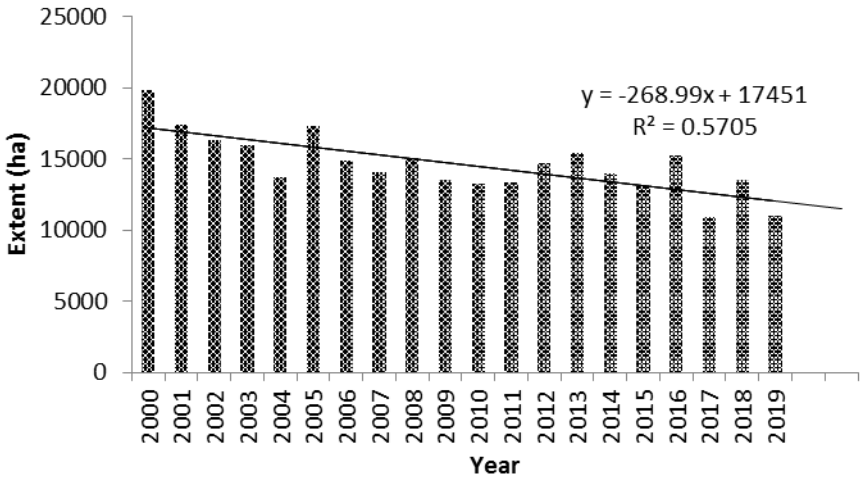


Source: Department of Agriculture, 2000-2020

Figure 4.1: Seed Production of Big Onion

The major big-onion producing districts are Anuradhapura, Polonnaruwa, Matale and the Mahaweli System 'H'. In addition, Mannar, Vavuniya, Mullaitivu and Kurunegala Districts also cultivate big onion. The area under big onion shows a declining growth rate of -1.61 percent per annum. Despite the decrease in area, the production of big onion has shown an increasing growth trend in the country. It showed a production growth rate of 1.12 percent per annum. This may be due to increases in productivity of big onion. Importation of big onion seeds gradually increases from 2000-2019, while local big onion seed production has declined at the rate of -1.38 percent per annum. However, unavailability of good quality seeds of recommended varieties in adequate quantities is considered as the main constraint for increasing production of

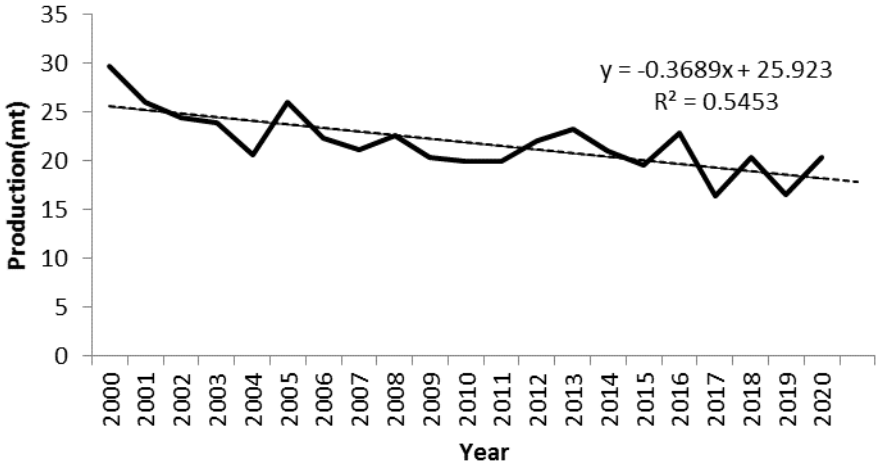
big onion in Sri Lanka. Furthermore, the quality of the imported big onion true seeds is not up to standard. Poor germination and bulbing, high thick neck percentage and low yield are characteristic to such seeds.



Source: Department of Agriculture

Figure 4.2: Cultivation Extent of Chilli

At present, the major chilli growing districts are Anuradhapura, Moneragala, Ampara, Putthalama, Vavuniya, Kurunegala, Hambantota and Mahaweli System H. According to growth analysis, the area under chilli has witnessed a marginal annual increment of 0.17 percent per annum. At present, the country is producing an average 56,476.85 MT of chilli, and growth in chilli production is around two percent per annum, with a fluctuation of 19 percent. However, both local chilli seed production, and seed requirements, show a declining rate of 1.82 percent per annum.



Source: Department of Agriculture, 2000-2020

Figure 4.3: Seed Production of Chilli

Potato is the most popular crop among upcountry farmers due to its high net return. At present, potato is extensively cultivated in the Nuwara Eliya and Badulla Districts, in paddy fields and on high land, during both the *Yala* and *Maha* seasons. The growth in area under potato has recorded a mild annual increment of 0.17 percent, while its production has shown a 1.78 percent annual growth. On average, 2,696.35 MT of potato seeds are annually imported to the country. However, importation of potato seeds gradually decreased from 2000-2020, at a declining rate of 6.23 percent. At the same time, local seed production of potato recorded a 12.14 percent annual growth, while having 22.5 percent annual fluctuations.

About 90 percent of the seed requirement of up-country vegetables are imported. Bean, tomato and radish seeds are the main up-country vegetable seeds produced locally. Other than the frequent release of new improved varieties, varieties are being multiplied locally by the Department of Agriculture. Around 33 percent of the national seed requirement of low country vegetable are imported annually.

Table 4.3: Growth Rate of Extent and Production of Vegetables

Crop	Extent			Production		
	Mean (ha)	CV (%)	CGR (%)	Mean (MT)	CV (%)	CGR (%)
Beans	7541.86	9.46	0.67	52848.8	38.90	4.27**
Okra	7266.67	9.28	0.60	54071	24.09	3.15**
Brinjal	10593.30	7.95	0.43	103848.9	21.96	2.98**
Carrot	3053.34	14.74	1.70**	46079.3	40.69	4.80**
Leeks	1824.96	15.83	1.15	32168.25	35.55	2.10**
Pumpkin	7810.93	14.23	0.71	91108.75	24.11	2.18**

Source: Author's Calculation

*Note: * denotes significance at 5 percent, ** denotes significance at 1 percent*

Upcountry vegetables constitute such crops as cabbage, carrot, beetroot, cauliflower, knol khol, beet, bean, tomato and capsicum which are grown on a commercial scale with high input use. The other group constitutes low-country vegetables, which include brinjal, bitter gourd, red onion, pumpkin, luffa, cucumber and snake gourd, which are cultivated less intensively under low inputs. Most frequently used upcountry and low country vegetables are used in this calculation.

Compared to year 2000, the average percentage of the extent under carrot, leeks, tomato, beet root, okra, wine beans, bush beans, bitter gourd, cabbage, capsicum, cucumber, khol khol, radish, red pumpkin and ash pumpkin, has been increased although several fluctuations could be observed from year 2000 to 2020. However, the cultivation extent of carrot shows a significant growth of 1.7 percent. Most of

the vegetables shows the significant increment in their annual production (Table 4.3).

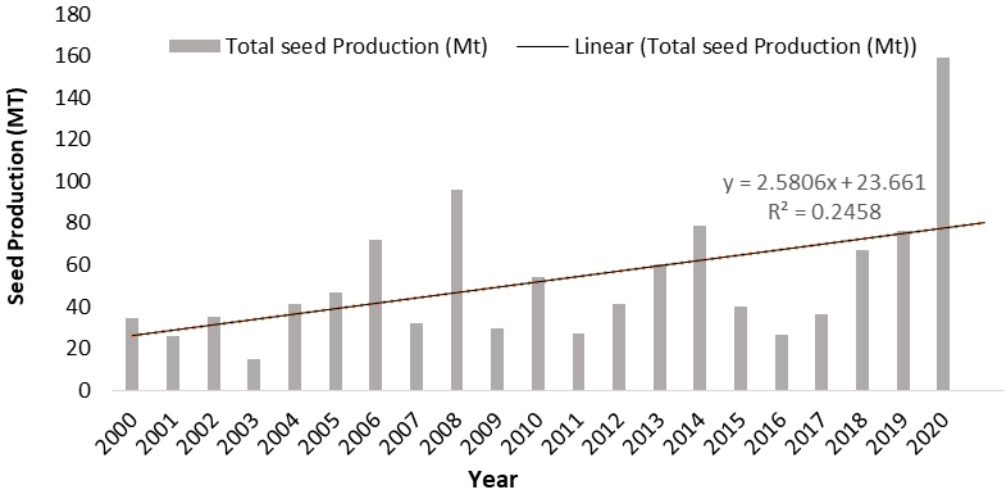
Table 4.4: Growth Rates of Production and Imports of Vegetable Seeds

Crop	Seed Production			Seed Imports		
	Mean (MT)	CGR (%)	CV (%)	Mean (MT)	CGR (%)	CV (%)
Beans	963.31	0.76	9.70	166.93	-5.90	83.73
Carrot	-	-	-	42.19	-3.84	32.53
Leeks	-	-	-	11.85	2.99	41.14
Okra	35.17	1.59**	23.54	9.40	40.43**	65.88
Brinjal	4.27	1.35*	14.33	11.85	3.06	40.38
Pumpkin	7.86	0.75	13.59	0.49	0.50	24.52

Source: Author's Calculation

*Note: * denotes significance at 5 percent, ** denotes significance at 1 percent*

Okra and brinjals showed a marginal increment in local seed production. However, imports of okra seeds have also increased significantly over time. Bean-seed production shows a marginal increment, while bean seed imports have been declining over time.



Source: Department of Agriculture

Figure 4.4: Total Vegetable Seed Production

According to growth analysis, total vegetable-seed production shows a 3.53 percent annual increment, while having 38 percent of fluctuations. It indicates that the vegetable seed sector has had a positive growth in seed production, which need to be accelerated and developed in order to fulfil the vegetable seed requirement of the country.

CHAPTER FIVE

Potentials, Barriers and Strategies to the Way Forward

Sustainable seed systems provide the ability of supplying an adequate quantity and quality of a diverse varieties of seeds to meet the needs of farmers. In order to achieve this goal, seed systems rely on the interconnected performance of such key functions as seed production and distribution, R&D, rules and regulations, and supportive services to farmers. This chapter discussed the potentials, barriers and strategies related to such key functions.

5.1 Seed Supply

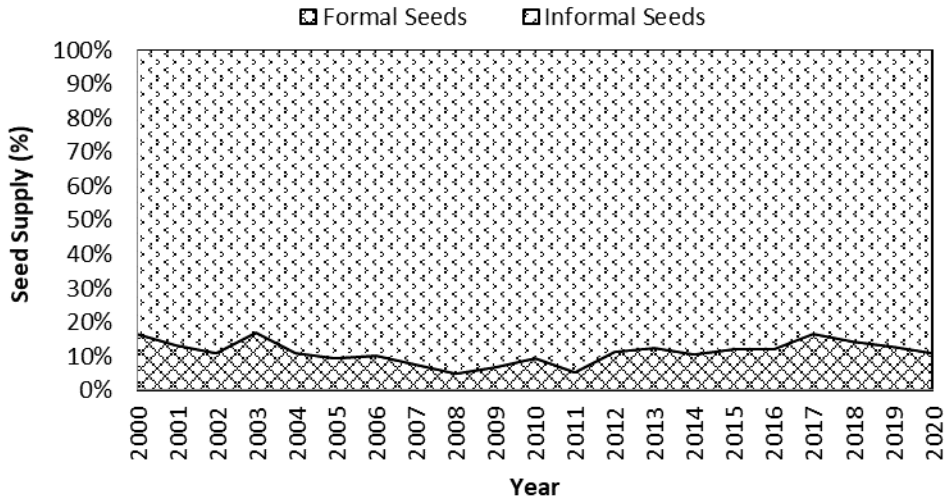
5.1.1 Seed Sources

The national seed system is composed of formal and informal sectors, which collectively provide the seed requirement of the country. The formal sector is based on a regulated process, with stakeholders, whose roles and responsibilities are well defined, supplying the market with certified seeds of verified varieties for production.

The informal sector is unstructured and unregulated. Activities conducted within this sector are neither monitored nor supervised by any public or private institution. Activities tend to be integrated, and constitute such channels as self-saved seeds, seed exchanges among farmers, and/or seed market.

Both public and private sectors are involving in supplying formal seeds. Research stations under the DOA provide breeder seeds and foundation seeds. Government seed farms, contract growers, and private growers are multiplying the given foundation seeds into registered seeds, and finally, registered seeds into certified seeds. At the end these certified seeds are utilized by farmers.

It may be observed that the formal sector covers nearly 10-12 percent of total seed production considering data from the past two decades. According to Figure 5.1, the formal seed supply of the paddy, OFC and vegetable sectors shows better performance in 2000, 2003, 2017 and 2018, while from 2007 to 2009 and 2011, it shows the lowest formal seed supply in the country. These statistics suggest that the majority of rice farmers still rely on farmer-saved seeds and import seeds for other crop production. Therefore, this highlights the huge untapped potential for the seed business in the country. There is much to be done to better integrate informal and formal seed systems, thereby ensuring that farmers benefit from improved cultivars emerging from breeding programme.



Source: Department of Agriculture, 2000-2020

Figure 5.1: Total Seed Supply of Paddy, OFCs and Vegetables by Seed Source

Generally, the Seed Replacement Ratio (SRR) is 25 percent for paddy and OFCs. It is 50 percent for vegetables. This means that quality new seeds should be used at least once in four seasons for paddy and OFCs. For vegetables, quality new seeds should be applied at least once in two seasons. However, the local or informal seed sector remains the prevailing sources of seed for considered crops. Therefore, it is of paramount importance to make strategies to increase the availability of quality seeds to boost agricultural productivity, farmer income, and finally, national food production. In addition, it will maintain healthy crop establishment, and justify government investment in crop improvement programmes.

5.1.2 Seed Requirement

Seed use depends on several factors, including the acreage under cultivation, the seeding rate per cultivated acre, cropping practices, and variations in geographic location and agro-climatic conditions.

Table 5.1: Seed Requirement of Paddy, Maize, Potato, Big onion and Chilli

Year	Seed Requirements (MT)				
	Paddy	Maize	Potato	Big onion	Chilli
2000	88914.45	343.75	7284.00	19.57	19.83
2001	80839.79	308.54	8492.00	19.71	17.35
2002	86335.61	280.96	13210.00	20.34	16.29
2003	99509.62	324.71	12626.00	19.39	15.92
2004	78842.95	281.05	10990.00	21.53	13.75
2005	94908.32	340.81	11202.00	31.86	17.31
2006	92205.63	384.02	10588.00	47.70	14.89
2007	82708.83	410.21	10672.00	48.92	14.08
2008	106636.80	622.99	9738.00	28.64	15.06
2009	98997.70	610.28	8277.05	35.56	13.55
2010	107880.91	691.42	7687.17	29.11	13.26
2011	123858.62	606.54	8957.52	24.16	13.31
2012	108016.30	714.34	9295.92	37.71	14.73
2013	124283.42	808.46	10287.45	29.56	15.45
2014	97725.96	806.63	10729.50	47.79	13.98
2015	126920.48	839.66	10991.46	39.32	13.03
2016	115581.78	811.55	11506.74	27.88	15.27
2017	80173.33	630.53	8914.48	21.18	10.94
2018	105417.41	850.74	10348.26	10.14	13.55
2019	113111.80	761.39	10863.68	6.64	10.98
2020	122380.14	938.99	7130.20	16.13	13.58

Source: Authors' Calculation

According to Table 5.1, the annual seed requirement of the country has been calculated, and slight variations may be observed over the years. However, these variations are in line with the extent of cultivation. For example, the cultivation extent of maize drastically declined in 2017 when compared to 2016 and 2018. In line with this, the seed requirement also declined.

Table 5.2: Seed Requirements of Selected Vegetables

Year	Seed Requirements (MT)										
	Beans	Carrot	Cabbage	Beet Root	Leeks	Capsicum	Brinjal	Tomato	Okkra	Pumpkin	Cucumber
2000	341.15	9.25	0.96	10.90	5.93	2.77	3.66	1.45	32.99	6.81	2.50
2001	317.65	10.22	0.98	11.28	6.24	2.71	3.29	1.33	30.18	6.43	2.36
2002	327.80	10.17	0.91	10.82	5.98	2.64	3.47	1.35	34.74	6.62	2.64
2003	314.55	9.94	0.93	10.32	5.76	2.82	3.72	1.48	30.85	7.23	3.15
2004	373.45	11.52	0.97	11.19	6.83	2.90	3.26	1.50	26.53	6.54	2.67
2005	385.75	12.37	1.02	12.68	6.61	3.11	3.43	1.55	30.35	8.20	3.15
2006	390.45	11.86	1.02	13.88	6.41	3.00	3.56	1.66	29.91	7.19	2.85
2007	385.80	12.99	1.10	17.20	7.16	3.19	3.56	1.67	29.59	7.94	2.92
2008	443.20	15.74	1.28	16.73	8.53	1.64	4.10	2.16	34.49	7.87	3.33
2009	395.50	11.58	1.00	16.16	6.30	3.29	3.77	1.78	32.54	9.20	3.09
2010	385.76	11.17	0.92	16.34	6.16	3.11	3.85	1.82	33.32	8.69	3.30
2011	390.49	12.57	1.04	16.03	7.36	3.39	3.96	1.90	33.30	9.36	3.25
2012	379.60	11.41	1.02	15.83	8.11	3.18	4.12	1.98	34.68	9.10	3.07
2013	395.25	11.53	1.05	15.69	4.84	3.84	4.31	1.81	37.63	9.47	3.58
2014	398.64	11.37	1.07	15.49	5.07	4.05	4.07	1.84	38.59	9.36	3.39
2015	413.94	13.88	1.10	15.50	7.57	3.69	3.79	1.64	33.29	7.75	3.87
2016	426.42	15.23	1.11	13.23	8.24	3.47	3.60	1.55	31.83	6.98	2.99
2017	386.17	14.75	1.06	12.97	8.30	3.21	3.38	1.33	30.72	6.16	2.45
2018	367.22	12.50	1.05	13.41	7.60	3.68	3.79	1.68	37.65	8.47	3.23
2019	323.07	14.21	1.04	10.83	7.88	3.09	3.46	1.47	30.83	6.86	2.56
2020	391.48	15.69	1.14	13.15	8.70	3.70	3.89	1.64	36.40	7.74	2.69

Source: Authors' Calculation

The total amount of the certified or labelled seed sold may be quite a small proportion of the total seed requirement. However, the estimation of seed requirement is the first step in seed-demand forecasting, and this is obvious as it is a prerequisite for making decisions in regard to various aspects of seed supply management. Inefficient estimation procedures have led to a shortage of some varieties of seeds, and surpluses of some varieties. Most of the low-country vegetable seeds (i.e., tomato, capsicum, brinjal, okra, long beans, gourds, and pumpkin) lose their viability during prolonged storage due to loss of moisture. Therefore, too many carryovers and stock write-offs will prove to be expensive, while a lack of seed means a loss of revenue.

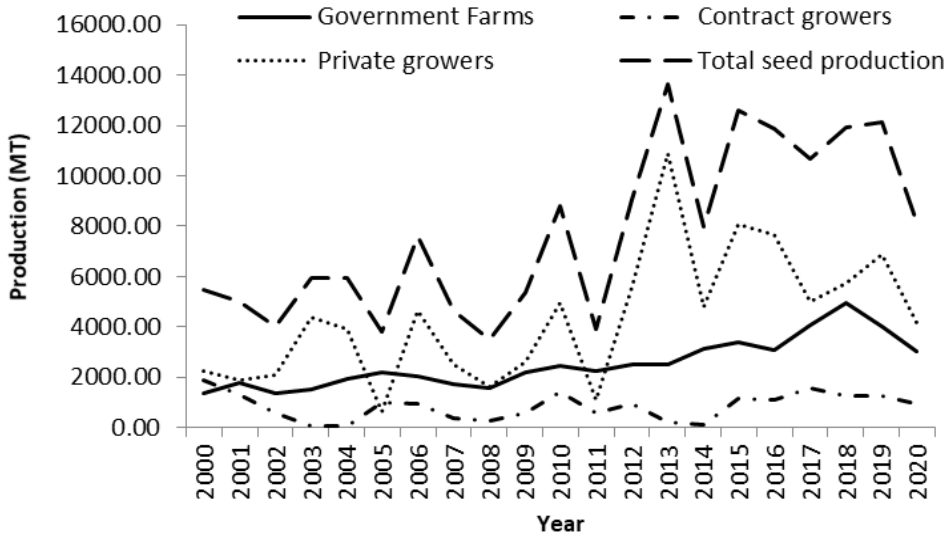
Therefore, overproduction or underproduction of seeds can cause serious financial consequences. This emphasizes the need for better quality and more accessible data, information and analysis. To enable this, the collection of spatially-disaggregated, variety-specific data for major crops is needed. Further, information management systems and portals are compulsory to make this information available to seed-industry actors, researchers and academics to make informed decisions.

5.1.3 Local Seed Production

The goal of a national seed programme should be to make quality seeds available on time, in adequate quantities, at affordable prices.

5.1.3.1 Seed Paddy Production

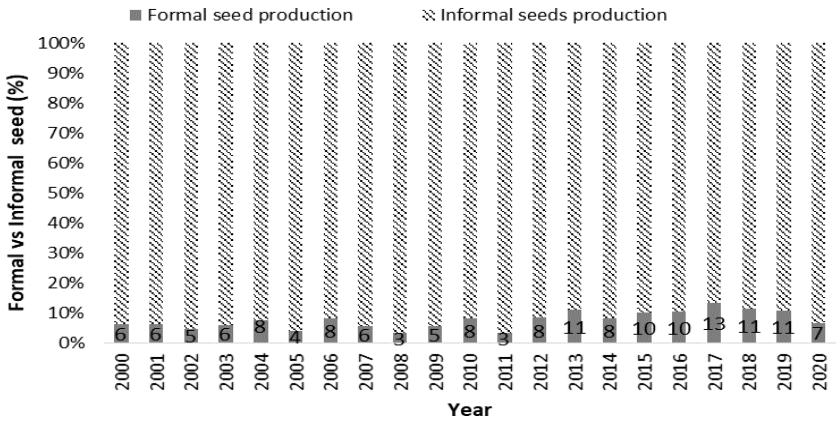
Government seed farms, contract growers and private growers have engaged in seed paddy supply in Sri Lanka. The involvement of private growers in seed paddy production has significantly increased over the past two decades. According to Figure 5.2, around 80 percent (2013) of the total of formal seed production comes from private growers. Seed paddy programmes with contract growers have shown some decreasing trends over time. However, seed paddy production on government farms increased from 2009-2020.



Source: Department of Agriculture, 2000-2020

Figure 5.2: Seed Paddy Production from 2000 to 2020

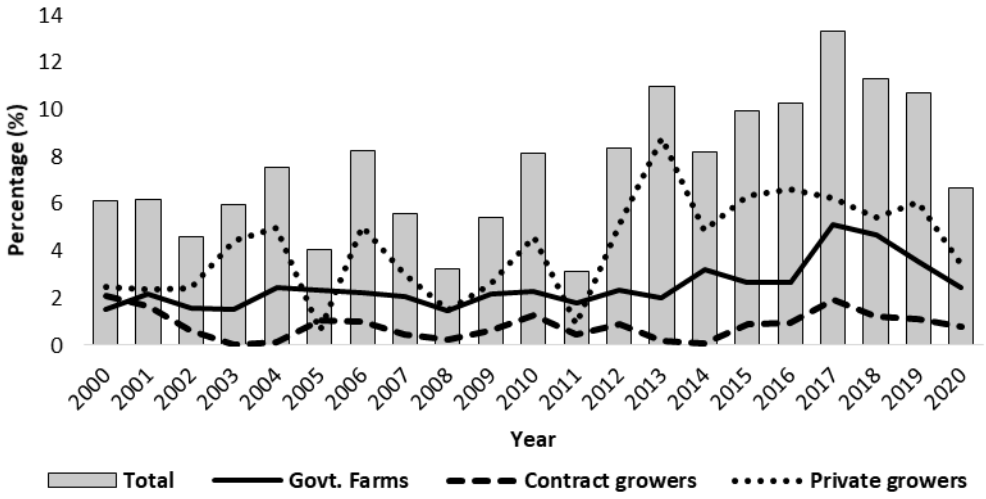
Formal seed paddy production slightly increased in the 2016-2019 period. However, it showed a decline in production in 2020, which may have been due to the prevailing CoVID-19 pandemic.



Source: Department of Agriculture, 2000-2020

Figure 5.3: Formal vs Informal Seed Paddy Production

A point which needs to be highlighted is that, nearly 90 percent of Sri Lankan farmers use rice seeds, which are produced by themselves from their previous crop, or borrow/share from neighboring farmers, which are considered informal sources. Therefore, farmer training and demonstrations of quality seed production would lead to enhancing the quality of seeds produced on farmlands.



Source: Department of Agriculture, 2000-2020

Figure 5.4: Formal Seed Paddy Production

Formal seed-paddy production peaked (13 percent) in 2017. While a dramatic decline in 2020 of all corresponding parties are shown in Figure 5.4. According to the Senevirathna *et al*. (2008), at least 20-25 percent of the annual seed-paddy requirement should be supplied as certified or assured seeds in order to obtain a significant increase in rice productivity. However, the formal sector covers only 10-13 percent of the total annual requirement, and measures are needed to escalate formal seed-paddy production.

5.1.3.2 Seed Production of Other Field Crops

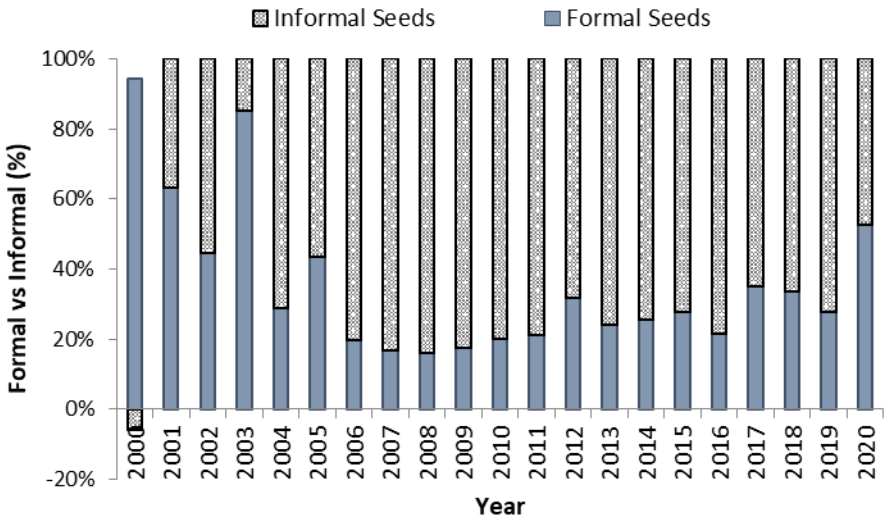
The government farms, contract growers and private growers engaged in the seed production of OFCs.

Table 5.3: Seed Production of OFCs

Year	OFC Seed Production (MT)			
	Government Farms	Contract Growers	Private Growers	Total
2000	46.26	104.43	0.00	150.69
2001	28.26	72.08	1.25	101.59
2002	17.27	24.61	0.00	41.88
2003	17.37	58.11	8.88	84.36
2004	23.38	44.14	0.34	67.86
2005	231.68	82.52	1.55	315.75
2006	24.75	75.18	0.00	99.93
2007	21.48	70.65	0.87	93.00
2008	66.91	73.65	0.00	140.56
2009	26.04	98.80	1.50	126.34
2010	17.24	227.42	5.61	250.27
2011	24.11	151.29	19.34	194.75
2012	31.24	275.12	3.70	310.06
2013	22.95	310.23	11.50	344.68
2014	65.79	576.11	11.17	653.08
2015	44.27	364.87	21.98	431.11
2016	75.84	459.47	5.62	540.93
2017	255.15	881.67	163.87	1300.69
2018	898.46	863.92	8.45	1770.83
2019	160.25	916.09	1.59	1077.93
2020	453.86	1011.67	424.59	1890.12

Source: Department of Agriculture, 2000-2020

Seed production of OFCs by government farms, contract growers and private growers increased during the period 2017-2020. Therefore, the total production of formal seed production for OFCs has increased over time. The private-sector contribution to OFC seed-production was at a very low volume during the period 2000-2013. However, the private-sector contribution is sharply increased in the year 2020. According to Table 5.5, seed production from contract growers is gradually increased, 2000-2010.

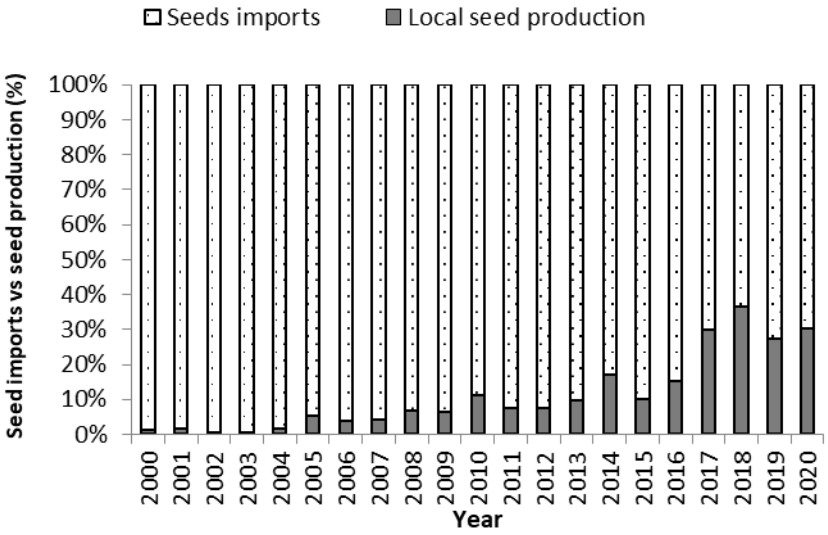


Source: Department of Agriculture, 2000-2020

Figure 5.5: Formal vs informal Seed Production of OFCs

According to Figure 5.5, the informal sector still provides the majority of the farmers' seed requirement for OFC seeds in the country. Most private companies are engaged in imports of OFC seeds, rather than in local production. The locally produced true seeds of big onion, which are labeled as "Dambullu Red" and "Galewela light red" have higher germination rates compared to imported seeds (6 kg/ha of local seed compared to 6.5-11 kg/ha of imported seed (Lesly et al., 2002). However, due to the inadequacy of domestic seed and relatively high prices of domestically produced true seed, more than 70 percent of farmers still use imported true seeds despite their poor quality.

Department of Agriculture has recommended 10 open pollinated chilli varieties up to now namely MI-1, MI-2, KA-2, Arunalu, MI- Hot, MI Green, Galkiriyagama Selection, MI waraniya 1, MICH 3, MIPC 1. The potential yield of these varieties is 10-15 t/ha as green chilli, but the national average yields is around 5.13 t/ha. Such low yields are mainly due to high incidences of pest and diseases, moisture stress, use of inferior quality seeds, poor crop management and high input costs. However, first local chilli hybrid, MICH HY 1 developed by the DOA released in year 2015 with the yield potential of 32t/ha as green chilli. This hybrid variety is highly suitable for green chilli with the potential yield of 32 t/ha of green chilli.



Source: Department of Agriculture, 2000-2020

Figure 5.6: Seed Imports vs Local Seed Production of OFCs

There was no major importations of OFC seeds during the period 2000-2005. However, local seed production for OFCs declined severely in that period. There was also a gradual increment in local seed production for OFCs in the period of 2016-2020, peaking in 2018.

5.1.3.3 Vegetables Seed Production

The government farms, contract growers and private sector engaged in local vegetable seed production.

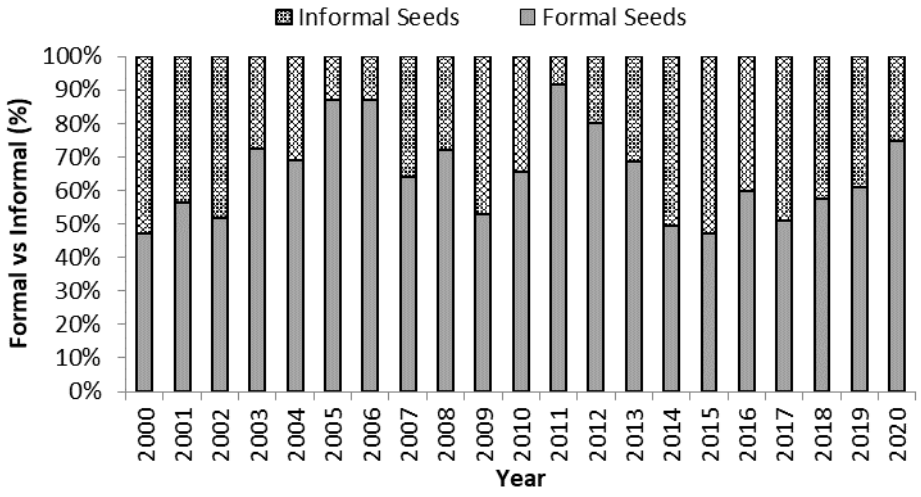
Table 5.4: Local Vegetable Seed Production

Year	Local Seed Production (MT)			
	Govt. Farms	Contract Growers	Private Growers	Total Seed Production (MT)
2000	8.67	3.25	22.30	34.22
2001	8.03	8.28	9.30	25.61
2002	13.31	2.31	19.18	34.80
2003	3.11	0.29	11.55	14.95
2004	9.12	18.87	13.49	41.47
2005	6.80	22.77	17.19	46.76
2006	0.53	42.17	29.16	71.86
2007	1.94	4.42	25.74	32.10
2008	89.68	2.30	3.78	95.76
2009	5.70	12.03	11.65	29.38
2010	9.31	20.33	24.62	54.25
2011	5.32	6.42	15.23	26.96

2012	7.73	25.87	7.31	40.91
2013	5.70	30.46	24.08	60.24
2014	9.48	53.49	15.66	78.62
2015	7.62	15.42	16.87	39.91
2016	6.51	11.09	8.74	26.34
2017	22.22	9.98	4.25	36.45
2018	38.01	24.24	5.04	67.29
2019	11.80	48.89	15.56	76.24
2020	11.21	142.36	5.31	158.89

Source: Department of Agriculture, 2000-2020

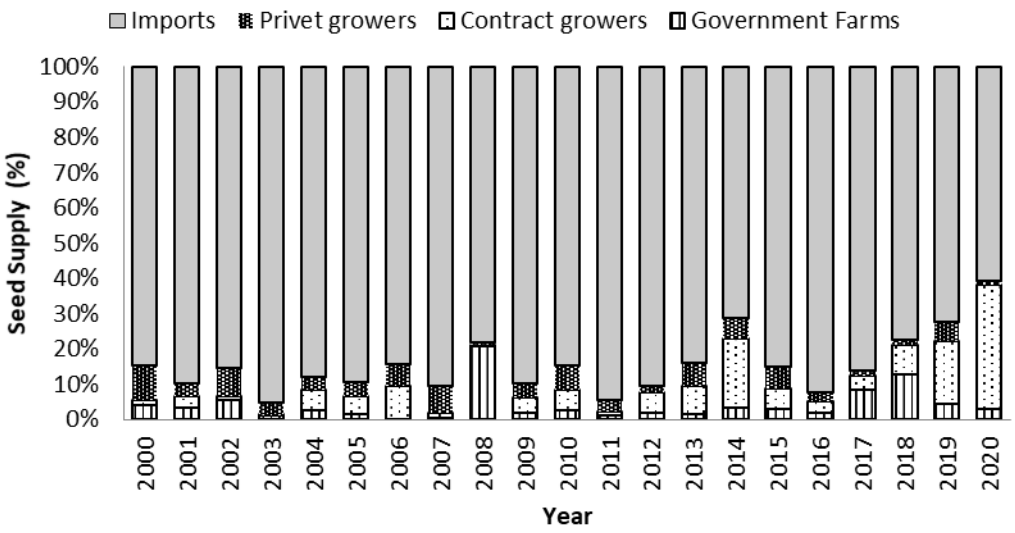
According to Table 5.4, there were slight variations from 2000-2020 in the country's vegetable seed production. The vegetable seed production of government farms has slightly increased since 2017. The government should encourage private-sector and contract-grower participation to increase local vegetable-seed production.



Source: Department of Agriculture, 2000-2020

Figure 5.7: Formal vs informal Seed Production of Vegetables

Figure 5.7 clearly shows that the majority of the vegetable seeds came from the formal sector, though there were slight variations over the years. Figure 5.8 shows the vegetable-seed supply from different parties. The majority of the seeds came from foreign markets as seed imports. However, there was an increment in vegetable-seed production among contract growers, from 2018-2020. There was also a gradual decline in the private-growers' contribution. There is a keen preference in the private sector for seed imports rather than local seed production.



Source: Department of Agriculture, 2000-2020

Figure 5.8: Vegetable Seed Supply

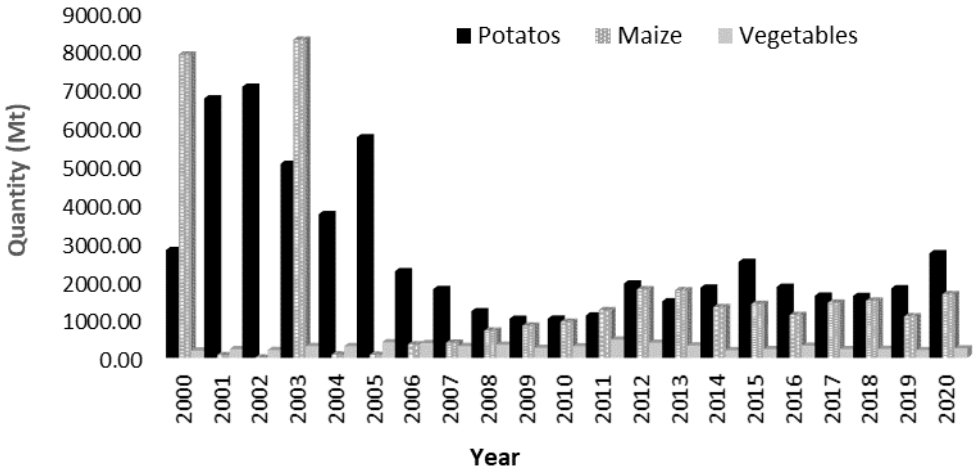
Lack of favorable climatic conditions (i.e., long-day conditions or low temperatures) is the major limiting factor for bolting and the subsequent seed set in carrot, beet, lettuce, leeks, cabbage, and a few other up-country vegetable species. However, there is no shortage of any imported seed varieties, especially vegetable seeds. However, the availability of low-demand seed varieties is poor in some seasons, mainly because most private-sector seed producers have little interest in producing low-demand seed varieties. Therefore, a majority of farmers obtain their seed requirement from the informal sector. This shortage of low-demand seed varieties may be overcome by implementing proper self-seed production programmemes. Paddy and big onion has such self-seed production programmes under the DOA, and they must be further expanded through proper training and extension.

Further seed production is normally confined to certain agro-climatic zones. High production costs are mainly due to labor shortage and high wages. Since fresh market vegetables are more profitable sometimes than seed production (i.e., hot pepper/chili), this has resulted in the reluctance of contract growers to engage in seed production.

5.1.4 Seed Imports

Countries that are heavily dependent on importation are susceptible to shocks in the market. Seed importation increased with respect to particular crops, especially hybrids, while local seed production declined. Seed importation negatively affected the foreign exchange reserves of the country, and has substantial risks due to high foreign dependence. Moreover, continuous imports of foreign planting material in a significant manner could result in the depletion of the local genetic resource base of the country.

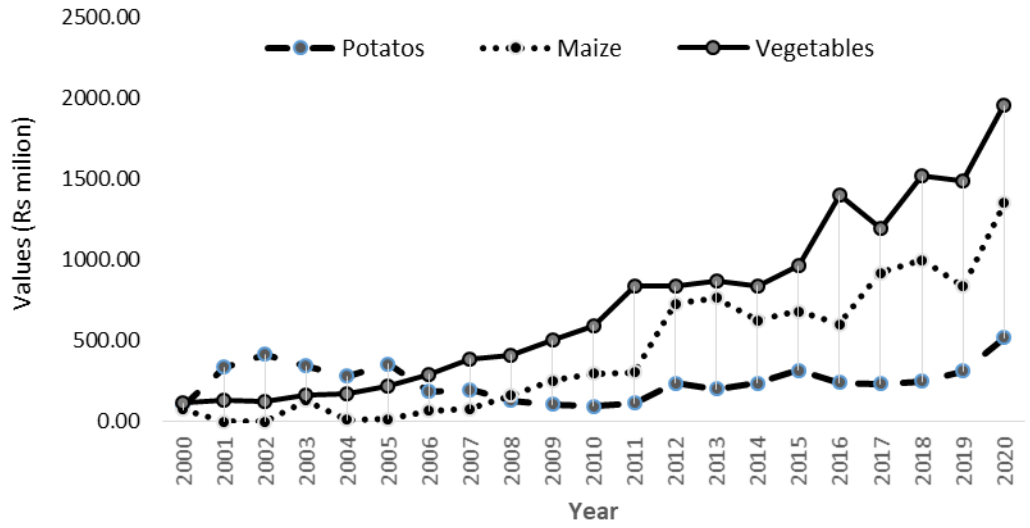
The import permit system prevents the importation of illegal and low-quality seeds. Because seed importers must provide an ISTA (International Seed Testing Association) certificate, and phytosanitory certificate from the Plant Quarantine Service, when they import seed consignments. An examination of consumer protection mechanisms related to imported seeds should be implemented, and attention should also be given to any unsanctioned 'imports', such as seeds coming from fisher folk, which results in the availability of poor quality seeds in the market (such as low-quality Dilhi hot-chilli and big onions from India).



Source: Sri Lanka Customs, 2000-2020

Figure 5.9: Quantity of Seed Imports

According to Figure 5.9, the importation of potato and maize seeds has declined over the years. However, importation of vegetable seeds are being increased. Around 90 percent of current local vegetable farming in Sri Lanka is based on imported hybrid seeds. Most of the seeds of upcountry vegetables including cabbage, carrot, leeks, beetroot, beans, tomato, capsicum and cauliflower as well as such low-country vegetables as pumpkin, cucumber, okra, brinjal, leafy vegetables, and long beans, etc., are imported. Since no quality second-generation seeds are being produced from the current seeds cultivated, farmers have to depend on imported seeds each and every time they cultivate.

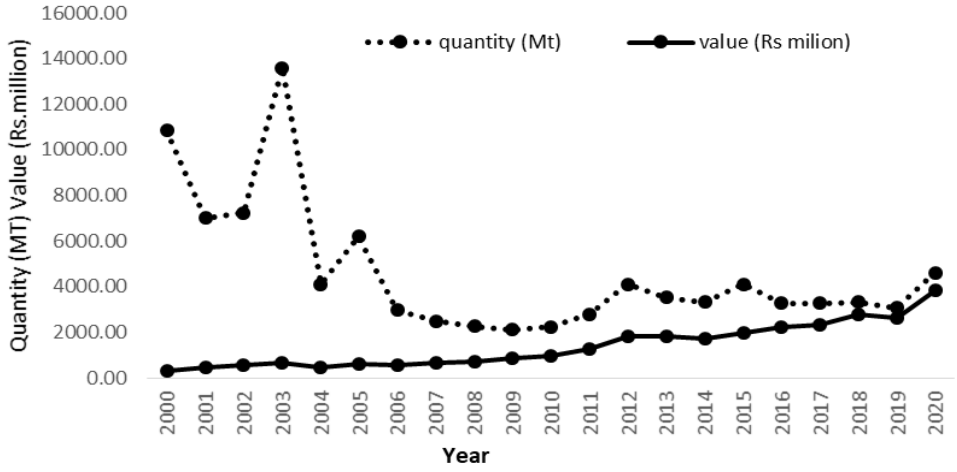


Source: Department of Agriculture, 2000-2020

Figure 5.10: Cost of Seed Imports

Seed importation costs have been increasing over the years, and devaluing the exchange rate has been one reason for the increased average domestic prices of seeds. Nearly two billion rupees are spent annually for importing vegetable seeds. Hence, local seed production and distribution programmemes should be expanded and strengthened to increase the availability of local seeds. The importation of crops that can be produced locally must be limited (i.e. chilli) to promote local production. Private-sector investments and involvement in this regard are very important. At the same time, farmers should be encouraged to adopt local or traditional varieties and existing traditional seed systems should be strengthened, especially among small scale farmers.

However, according to Wijesinghe and Wijesinghe (2018), although the government has spent a large amount of money annually on the promotion of the local seed industry, there is a 70 percent probability that local vegetable farmers will choose imported hybrid varieties. Since, seed prices have been increasing seasonally, based on variety and location, government intervention is mandatory to control the price of imported seeds.



Source: Sri Lanka Customs, 2000-2020

Figure 5.11: Quantity and Value of Seed Imports

According to Figure 5.11, both the quantity and value of seed imports have been increasing. Though there are slight variations in the quantity of imports, the value of seed import is continuously increasing.

5.1.5 Partnership Strategies

Public-sector seed supply has been insufficient to fulfill the country seed requirement, and the government should encourage private-sector involvement in seed industry. Therefore, an improvement in the seed system by providing a better atmosphere for small and medium-sized as well as large commercial seed entrepreneurs to attract more investment is essential. In this sense, the promotion of collaboration between the private and government sector to produce high quality seeds is of the utmost importance.

Though interaction between the private sector and public sector is not new, it is at a very low level. The development of a strong seed sector in the country requires collaborative efforts between the public and private sectors, through relevant and productive Public-Private Partnerships (PPP). However, many crops lack private-sector investment in the breeding and development of improved varieties, and the DOA has the monopoly power to produce breeder seeds identified at the research level.

Hence, special attention should be given to breeding and variety development through PPPs. Most PPPs are available for the seed multiplication process, as the private sector has no interest in investing in the early stages of seed production. Therefore, establishing a mechanism through PPPs to ensure the availability of good quality seeds on a timely basis is needed. For this, providing incentives to private inventors and innovators is a clear and longstanding priority.

An enabling business environment to support seed industry development is also a key area in need of strategic government involvement. This includes legislation and

the enforcement of policies and regulations that encourage private investment in seed production and marketing, tax incentives for land to be used for seed production, preferential access to improved germplasm from the public research system, subsidized credit, credit guarantees, tariff exemptions on equipment imports, and other benefits that lower seed production and distribution costs. Companies may also look to regulations designed to encourage investments in the safe and effective application of advanced biotechnology. As a whole, policy reforms should be favourable to the private sector, and they should facilitate private enterprises rather than control them.

5.1.6 Seed Certification and Quality Assurance

Assuring the quality of seed and planting materials is of the utmost importance to maintain an efficient seed-certification system. However, an allocation of an adequate budget is not enough, and all the types of contradictions inherent to the seed quality control process should be identified, to generate breakthrough solutions to eliminate such contradictions. Seed quality control and certification addresses the fact that it is often difficult for farmers to assess the identity or quality of the seeds they buy. Thus, it is necessary to assess and provide better quality seeds to the market and improve farmer confidence.

The lengthy process in seed certification is highlighted as a key constraint, and the allocation of an adequate budget to carry out the operations of the seed certification process is needed. Hence, the shifting from quality control systems that rely on monitoring at all key points of the seed production process to a more straightforward system of point-of-sale inspection system will add significant efficiency to quality assurance. The seed certification programme of the DOA has followed the ISTA protocols since its inception a few decades ago. However, newly introduced techniques for assuring varietal purity (i.e., molecular assessments), and seed health (i.e., conducive environmental incubation and identification, liquid plating assay, enzyme-linked immune sorbent assay, and polymerase chain reaction (PCR) technology) at the global level (Marcos, 2015) have not been practically applied so far in Sri Lanka.

Seed certification is voluntary, and is not compulsory. Under the current system, there is no compensation system for farmers who are victims of substandard seeds. Farmers who buy seeds from unregistered dealers face such issues as lower yields and lower productivity, and sometimes even such unexpected outcomes as the crop turning out to be of a totally different variety to what was planted. Farmers themselves have to bear the costs of this fallout.

Under the Plant Protection Act (No. 35 of 1999), it is mandatory to standardize imported seeds before release to the local market. But there are no mechanisms or there seems to be limited capacity to monitor seed quality once it reaches the market and is purchased by farmers. Though legal action could be taken against those who supply low-quality seeds under the Consumer Protection Act, it is not very

effective. Therefore, proper regulatory mechanisms should be implemented to control seed quality. One way to control this is for the regulatory agency to conduct frequent point-of-sale inspections. This agency has been authorized to consider farmer appeals, pay compensation to victims, and take legal action against the trade in substandard seeds. In addition, "truthful labeling" systems are predicated on the ability of a consumer to seek redress for low quality seeds.

5.1.7 Conservation of Seeds

Traditionally, farmers have collected and stored seeds on their lands using traditional, simple, but effective techniques and tools. However, in the last three or four decades, as agriculture has become commercialized, these techniques and tools have been abandoned in many farming communities. Farmers have generally increased their use of imported seeds and improved varieties. This has led to a loss of crop diversity in many regions of the country.

The establishment of community-level seed banks will protect the gene pool of crop varieties, especially for traditional crop varieties, and further strengthen the existing conservation system. The establishment of community seed banks help farmers to acquire varieties that are adapted to local conditions. These varieties may not be accessible through formal seed systems, and also may be costly or suffer from erratic supply. Community seed banks may provide a basic ground for conservation, and the sustainable utilization of traditional germplasm. The challenges associated with the development of a community seed bank are the low level of technical and financial support, difficulties in finding competent resource persons, and the absence of successful community seed bank models in the country.

5.2 Governance and Strategy

5.2.1 Seed Act / Seed Policy / Policy Reforms / Market Regulations

Seed policies and regulations govern the production and distribution of certified seeds. The reasoning behind such regulations is to take action to protect and support the main consumers and producers, including agro-dealers, seed companies, and farmers. They need to address the problems of farmers by suitable amendments related to compensation mechanisms, regulation of seed sale prices, and incentivizing the informal seed sector. Meanwhile, the domestic policy and institutional environment has a strong impact on the ability of domestic and regional seed trade to meet the needs of farmers for improved seeds.

The Seed Act No 22 of 2003 was enacted to regulate the quality of seed and planting materials, and to safeguard farmers as well as seed handlers from malpractices that would harm the seed industry. However, this Seed Act's existing provisions, which are over two-decades old, are not sufficient to address emerging issues in modern agriculture, and to ensure the rights of farmers. Hence, it needs amendments, which are in line with current legal requirements and the competitiveness of the seed industry. To strengthen the National Seed Council, provisions for protecting

traditional agricultural crop varieties and plant genetic resources are other key requirements.

The merits and demerits of the current act should be identified to tackle those loopholes under any new law. The current seed act does not have provisions to compensate farmers who are victims of substandard seeds, as Sri Lanka continues to depend on imported seed varieties, especially for hybrid vegetables. Hence, the risk of farmers falling into this trap is high, and a robust compensation system for farmers is needed. There is much written on the disincentives posed by regulatory procedures involving multiple agencies, which lead to significant delays, costs, and risks. Stringent regulations, strict test standards, cumbersome procedures and slow processing tend to limit the number of improved cultivars that can be registered and put into production.

The price of seeds supplied by the formal sector is more expensive than the informal sector, as the quality assurance process by the former is costly. However, compared to imported "low-country vegetable" seeds, locally produced seeds within the formal sector have a lower share. The majority of the vegetables and OFC seeds are imported and sold by the private sector. The price of seeds is being increased, and farmers have to depend on seed companies with every season especially for hybrid seeds. Despite seed availability, farmers face problems with substandard seeds in the market, and different prices for the same seed variety from different commercial brands. There is no proper price-control mechanism, and seed price changes seasonally. Therefore, the government should intervene to establish price controls, especially for imported seed varieties.

5.2.2 Intellectual Property Rights (IPRs)

Although Sri Lanka passed its Intellectual Property Rights Act in 2003 to comply with the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement, it has not allowed the patenting of plants. Due to the inability to secure necessary protection, the Sri Lankan agricultural sector has had to face several difficulties in international trade, and it has also lost a number of opportunities to use its own plant varieties for the benefit of future generations.

The IPRs have been better formulated and better applied in developed countries than in developing countries. Sri Lanka has also been lagging far behind the other countries in formulating and implementing property rights pertaining to the agricultural sector, especially with new plant varieties and traditional rural knowledge. Therefore, the agricultural sector in Sri Lanka is vulnerable to outside exploitation because of its inability to provide necessary protection to new plant varieties and traditional farmer knowledge. Hence, having sufficient rules and regulations to protect new plant varieties and traditional farmer knowledge is a strongly felt need at present.

5.3 Private Sector in Seed Industry

Attracting private sector participation in the seed industry is important to improve farmer access to quality seeds, and is an important step in addressing food-security concerns in the country. Private-sector participation in the seed sector is confined mainly to the marketing of publicly developed improved varieties or the marketing of imported seeds. Private companies sell high-value hybrids and their share in value is greater than their share by volume. They rely on the National Agriculture Research Stations to obtain breeder seeds for seed multiplication and distribution. Additionally, only a very few companies have their own seed-testing facilities. While the majority of the small and medium-size companies focus on the marketing of imported seeds of high-yielding varieties.

However, relying only on import seeds will not be a viable strategy for the private sector to increase their market share in the long run. Investment in R&D aimed at developing new crop varieties, which can withstand biotic and abiotic stresses, is critical to increase their competitiveness and market share.

The public sector had a monopoly in the seed sector up to 1980s, and this was 'liberalized' after 1984. However, policies to attract private-sector R&D investments are lacking, and most private companies engage in the marketing of import seeds. Correspondingly, India also focused on opening up the seed sector to private companies, and regulating it for quality-control purposes since 1980s. However, policy reforms have incentivized the private sector to invest in R&D on new crop varieties. Those private-sector investments that leveraged the results of public-sector R&D investments contributed to increases in crop productivity in crop segments such as maize and pearl millet in India.

5.4 Research and Development

Research and development is a key segment of the seed industry, and directly impacts the availability of foundation seeds as well as the quality of the improved varieties that can be released. Apart from this, reports on the potential expansion of the local seed industry are confined to a few studies (Dissanayake and Weerasena, 2000).

Public sector expertise had mainly focused on rice-variety development. More than 88 rice varieties have been developed, and more than 28 varieties are used for breeder-seed production. However, breeding programmes are not geared to accommodate the changing needs of the OFC sector, and of the quality traits demanded by end users. Therefore, it is compulsory to promote farmer-participatory plant-breeding programmes to incorporate end-user utility demand into breeding programmes. However, breeding programmes are cost and time intensive, typically taking up to ten or more years to develop a new variety. Therefore, a proper breeding plan with long-term breeding priorities should be identified in accordance with a consistent crop-improvement policy.

There is a high demand for hybrid and new improved varieties. However, our research and development sector has such limitations as getting enough funds, expertise, infrastructure etc. Hence, private-sector investments that leveraged the results of public-sector R&D investments have contributed to increases in crop productivity. This can be done by exchanging germplasm and other inputs between the public and private sectors as per previous agreements.

5.5 Institutional Support and Services to Farmers

5.5.1 Extension Services

Extension services promoting the use of quality seed and of new varieties as well as providing vital marketing information back to operators in the seed value-chain is important. However, there is no proper extension service in the country, and it is mostly handled by retail-shop dealers. There is no proper information flow between farmer and researcher. Hence, an extension service should be capable enough to provide technical assistance and capacity building to farmers. A proper information system has to be developed to disseminate latest information through Agrarian Services Centers (ASCs), and frontline demonstrations need to be conducted with the utmost care in order to increase the adoption and diffusion of new seed varieties.

In general, the formal seed-production sector is incapable of achieving the country's total seed requirement. Therefore, informal seed production systems should be improved through seed extension with the main involvement of Agrarian Services Centers. The training of farmers in various aspects of seed production, and motivating them to take up seed production would ensure the availability of quality seeds to farmers and fetch foreign exchange for the nation.

Holding annual seed fairs / seed exhibitions will be a good mechanism for enabling the seed trade, creating market linkages, promoting new crop varieties, creating awareness, exchanging knowledge and experiences among farmers, researchers and extensionists, etc. Both public and private parties could join this venture, and it would facilitate the building of demand-driven seed-supply mechanisms.

5.5.2 Marketing and Distribution

The performance of the public-sector marketing channel is not satisfactory due to a poor organizational structure. The public sector does not actively participate in seed marketing and distribution. Agrarian Services Centers, particularly, do not store enough quantities of seeds due to the risk of losses. Therefore, it is difficult to sell adequate quantities of seeds through ASCs. However, farmers used to buy seeds from ASCs due to the reliability of DOA seeds. Therefore, the marketing structure to distribute seeds through ASCs must be recognized. Further, outlets for seed sales could be increased.

The private sector has a strong, dynamic and competitive marketing channel, which results in the high availability of seed varieties under different brand names. Private-

sector seed producers are profit-oriented and they produce or market only high-demand crop varieties. Therefore, there are seed shortages in some crop varieties. Nonetheless, there is no shortage of most imported seed varieties especially for upcountry vegetables.

Seed treatments such as priming, pelleting, or film-coating with additives, play an important role during germination and seedling emergence. Though seed-treatment techniques are quite common in foreign-seed markets (Taylor *et al*. 1998; Cantliffe 2003), their use in the local vegetable-seed industry is scarce. Most of the imported seeds are treated with crop protectants and specially developed coatings, which reduce seed losses. However, the majority of seeds available in local markets are from the informal sector, and hence the application of such advanced techniques is not feasible.

It is not enough to improve the local seed production system, there has to be a proper marketing system to distribute seeds and other planting materials. Further, there has been a lack of seed stocks during emergencies. Therefore, buffer-seed stocks should maintained.

The following flow chart illustrates the existing seed system in the country, and the modifications suggested are based on the preliminary work done, using existing literature. The suggested modifications are illustrated in Figure 5.12, in yellow color boxes.

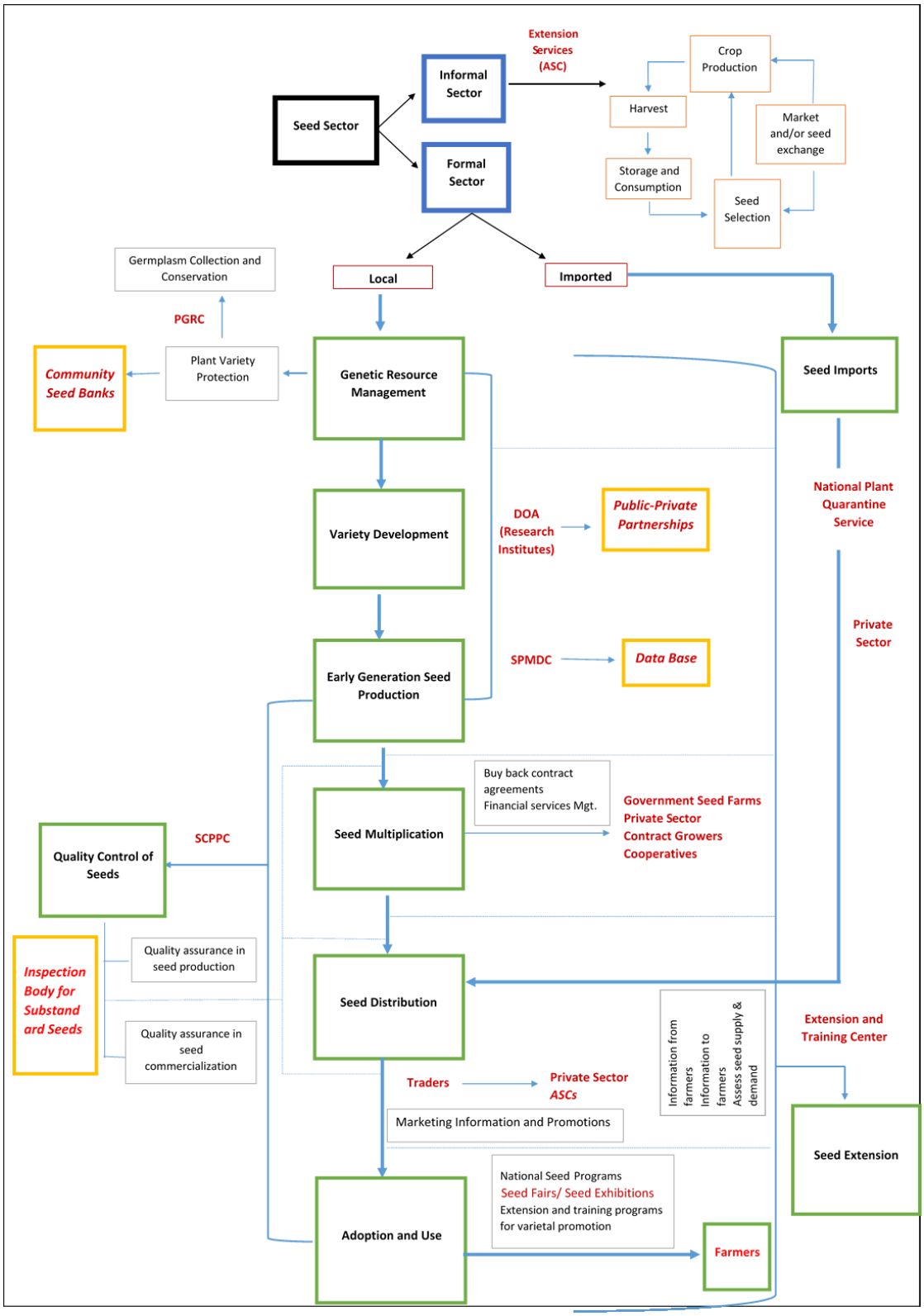


Figure 5.12: Seed System Structure with Suggested Improvements

CHAPTER SIX

Conclusions and Recommendations

6.1 Major Findings and Conclusions

- According to the growth analysis from 2000 to 2020, rice, maize, potato, chilli, and most vegetables showed a significant increment in their annual production. Rice and maize witnessed significant growth in cultivation extents.
- Seed production of maize and potato showed significant growth over the years 2000-2020, while annual growth of chilli-seed production, and seed requirements, significantly declined.
- The formal sector covers nearly 10-12 percent of the total seed supply. The majority of rice farmers (90 percent) still rely on farmer-saved seeds, and imported seeds for other crops. Therefore, this highlights the huge untapped potential for a seed business in the country.
- Overproduction or underproduction of seeds can cause serious financial consequences. There is a dearth of better quality and more accessible data, information and analysis for major crops to make informed decision-making.
- The interaction between the private sector and the public sector is still at a very low level. Although there are PPPs for the seed multiplication process, the private sector is not interested in investing in the early stages of seed production. Therefore, many crops lack private-sector investments in the breeding and development of improved varieties.
- A lengthy certification process, lack of staff and inadequate budgeting to carry out operations, in seed certification have been identified as key constraints. There are no mechanisms, or there seem to be a limited capacity, to monitor seed quality once it reaches the market and is purchased by farmers.
- There is a need to protect the gene pool in traditional crop varieties through farmer communities, to strengthen the existing conservation system further, and the sustainable utilization of traditional germplasm.
- The existing provisions under the Seed Act No. 22 of 2003 – almost two decades old – are not sufficient to address emerging issues in modern agriculture, and to ensure the rights of farmers. Hence, it is essential to monitor its impact, and to make amendments in line with current legal requirements.
- The agricultural sector in Sri Lanka is vulnerable to outside exploitation, due to of its inability to provide necessary protection for new plant varieties and traditional farmer knowledge, through the Intellectual Property Rights Act of 2003 to comply with TRIPS.

- Extension services have been found to be less capable of providing technical assistance and capacity building for farmers. A proper information system must be developed to disseminate the latest information through ASCs, and frontline demonstrations need to be conducted with utmost care in order to increase the adoption and diffusion of new seed varieties.
- There is no proper compensation system for farmers who are victims of substandard seeds. Therefore, the need for a regulatory agency, which is authorized to consider farmer appeals, make compensations to victims, and take legal action against the trading of substandard seeds is evident.
- The annual cost and quantity of imported seeds has been increased over the years. It adversely affects the country's foreign exchange reserves, and carries a significant risk due to high foreign dependence.
- Seed importation into the country and their distribution to farmers is mainly handled by the private sector. Public-sector marketing channels in the seed-sector have made a comparatively smaller contribution than the private sector.

6.2 Recommendations

- The existing provisions of the Seed Act No. 22 of 2003 are insufficient to address current issues in the seed sector. Therefore, the act should be amended to suit current legal requirements, and new trends in scientific and agricultural development.
- This requires a collaborative effort between the public and private sectors through relevant and productive public-private partnerships. The government should encourage private investment in breeding, and variety development through PPPs.
- Formal-sector seed production has been incapable in providing the country's total seed requirement. Therefore, informal seed production systems should be improved through seed extension, with the main involvement of Agrarian Services Centers.
- Local seed production and distribution programme should expand and strength to increase availability of local seeds. The importation of crops (chilli, etc.), that can be produced locally, must be limited, to promote local seed production.

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ANNEX

Annex 1: List of Key Informants

Name	Designation	Institute
Mr. J.R.Sudasinghe	Director (Extension & Training)	Extension and Training Center- Peradeniya
Ms.Theja Nanaykkara	Assistant Director of Agriculture (Research)	Horticultural Crop Research and Development Institute- Gannoruwa
Ms. K.N.C. Gunewardena	Director, Principal Agriculture Scientist	Field Crops Research and Development Institute- Mahailluppallama
Ms. M.J.M.P. Kumararathna	Assistant Director of Agriculture (Research)	Field Crops Research and Development Institute- Mahailluppallama
Mr. R.A.C.J. Perera	Assistant Director of Agriculture (Research)	Field Crops Research and Development Institute- Mahailluppallama
Ms. G.G.D.Lalani	Deputy Director	National Plant Quarantine Service- Katunayake
Mr. M.F.M.Rizwan	Assistant Director of Agriculture (Development)	National Plant Quarantine Service- Katunayake
Ms. K.P.A.D.Pathirana	Assistant Director of Agriculture (Development)	National Plant Quarantine Service- Katunayake
Dr. D.G.C.Jeewani	Additional Director Plant Genetic Resources Centre	Plant Genetic Resource Center- Gannoruwa
Ms. U.D.D. Damayanthi	Additional Director (PMEU)	Progress Monitoring & Evaluation Unit- Peradeniya
Dr. U.A.Kapila Siri Udawela	Assistant Director of Agriculture(Research)	Rice Research and Development Institute- Bathalagoda
Dr. W.M.U.K. Rathnayaka	Principal Agricultural Scientist	Rice Research and Development Institute- Bathalagoda
Ms. S.S.Paththinige	Assistant Director of Agriculture(Research)	Rice Research and Development Institute- Bathalagoda
Dr. M.G.D.L.Priyantha	Additional Director/Principal Scientist	Seed Certification Service- Gannoruwa
Mr. R.N. Premakumara	Deputy Director of Agriculture (Development)	Seed Certification Service- Gannoruwa
Ms. R.A.I.S.Ariyarathna	Deputy Director of Agriculture (Development)	Seed Certification Service- Gannoruwa
Mr. A.T. Sooriyaarachchi	Director	Socio-Economics and Planning Center- Peradeniya
Mr. Basnayake	Statistician	Socio-Economics and Planning Center- Peradeniya
Mr. K.D. Pushpananda	Director	Seed and Planting Material Development Center- Peradeniya
Mr. M.S.Thilakasiri	Deputy Director of Agriculture (Seed Paddy)	Seed and Planting Material Development Center- Peradeniya
Ms. E.M.G.K. Edirisooriya	Deputy Director of Agriculture (OFC)	Seed and Planting Material Development Center- Peradeniya
Mrs. Ramani R. Senarath	Additional Director of Agriculture (Vegetable Seed & Planting Material)	Seed and Planting Material Development Center- Peradeniya
Mr. Aruna Kariyawasam	Agriculture Instructor	Seed and Planting Material Development Center- Peradeniya