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SUBMITTED ARTICLES

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and Adoption in Sri Lanka*

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-S. Pandey, R.D.D.P. Rajapaksa and T.H.C.S. Perera

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to the Economic Development of Sri Lanka*

- P. Chathura Jayampathi De Silva

*Growth and Instability Analysis for Selected Other Field
Crops (OFC) in Sri Lanka*

- Subashini Perera



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RICE RESEARCH INVESTMENTS, VARIETAL RELEASE AND ADOPTION IN SRI LANKA

B.R. Walisinghe¹, Ma.Lourdes Velasco², D.M.N. Dissanayake³, S. Pandey⁴
R.D.D.P. Rajapaksa⁵ and T.H.C.S. Perera⁶ 2013

Abstract

Sri Lanka has shown a significant achievement in rice production leading to the realization of self-sufficiency. The outstanding performance of the rice sector is mainly attributed to technological advancement and implementation of favorable policies by the government. Development of improved rice varieties is the major component of this technological change. These improved varieties are now widely adopted by farmers throughout the country. To sustain the productivity growth, it is important that the rice breeding program of Sri Lanka continues to improve rice varieties that are best adapt to field conditions. Analyses of the varietal release patterns and cultivar-specific estimates of area under improved varieties are needed to help design future breeding priorities. The study provides such an analysis using data generated from different approaches including a survey of rice scientists and the expert panel elicitation of cultivar-specific adoption rates. The brief review of trend, government policies and research direction illustrates the growing interest on rice cultivation in varying agro-climatic zones. At present, rice breeders mainly concentrate on varietal development for problem areas which have potential improvement. The results of expert panel estimation of varietal spread in Sri Lanka were comparable with available secondary information. The expert panel exercise is a cost-effective and a rapid approach in

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estimating varietal spread which can avoid problems with present lag in data collection process. With a system of collecting varietal adoption data already in place, expert panel elicitation method is useful in verifying accuracy of estimates derived from national surveys. Moreover, timely availability of varietal adoption information is useful in reviewing investment on research and development and setting rice breeding priorities.

Keywords: *Expert panel elicitation, rice research investment, varietal adoption patterns*

Introduction

Rice is the staple crop in Sri Lanka occupying 47% of the agricultural area and contributing 11% to agricultural gross domestic product (Central Bank, 2012). Rice occupies nearly 12% of arable land in Sri Lanka and around 1.5 million farm families are involved in rice production. The country achieved self-sufficiency in rice in 2010 owing to the adoption of improved technologies and strong government support.

Rice production increased from 1.92 million tons in 1979 to 4.28 million tons in 2010. The increase in production is partly due to the expansion in rice area from 0.78 million hectares in 1979 to 1.05 million hectares in 2010. This expansion in area was achieved through the cultivation of paddy lands in conflict-affected areas after the cessation of the civil war. The re-cultivation of abandoned paddy lands during the civil war was the result of government encouragement and escalation of rice prices. Increase in rice yield was the main contributory factor in increased production as the yield almost doubled from 2.75t/ha in 1979 to 4.54t/ha in 2010. This improvement in productivity is a result of the remarkable contribution of rice research and improvements in irrigation infrastructure.

The Rice Research and Development Institute (RRDI) in Sri Lanka is the sole agency responsible for the generation of rice production and protection technologies. These technologies helped improve productivity and profitability of rice production in the country. Since its inception in 1952, RRDI continues to develop high-yielding rice varieties (HYV) with multiple resistance to major biotic stresses and tolerance to abiotic stresses. By 2010, RRDI has released 69 rice varieties adaptable to diverse agro-ecological conditions (see Appendix for a complete list of varietal releases). Although there has been almost full adoption

of HYVs, 58% of the total rice area is grown with only 4 dominant varieties (Jayawardena *et al*, 2010). Three of these varieties were released before 1993. Hence, there is a need to know what is happening to varietal change as a result of rice genetic improvement. Information on cultivar-specific adoption helps in deciding on relative resource allocation and specific lines of research. However, a large amount of resources and time is required to conduct surveys to collect such information.

This study aims to develop alternative methods of obtaining “quick and clean” estimates of varietal adoption levels that can be used to regularly monitor varietal adoption. The study also aims to assess rice varietal release pattern and extent of investment in rice genetic improvement. The general approach adopted follows the research design developed in the project “Tracking of Improved Varieties in South Asia (TRIVSA)” which is a collaborative study between the International Rice Research Institute and the Department of Agriculture of Sri Lanka. The expert panel elicitation method was tested in the study as an alternative to the conventional method of using household survey to obtain estimates of varietal adoption. Results of the expert panel elicitation method was compared with estimates derived from varietal adoption data collected by the Department of Agriculture and the Department of Census and Statistics in order to identify strengths and weaknesses of the method.

The report is organized as follows. The first section briefly discusses the rice production systems and trends in Sri Lanka from 1979 to 2010. The second section discusses the organization of and investments in rice research. Results of the expert panel elicitation method are discussed in the succeeding section and finally, conclusions are presented in the final section.

Rice Production Systems

In Sri Lanka, rice is grown in two seasons; *Maha*, the wet season crop, and *Yala*, the dry season crop. *Yala* is grown in April to September while *Maha* is grown in October to February. *Maha* is the main rice-growing season as nearly 61% of the annual production and annual rice area is from *Maha* season as recorded in 2010.

Agricultural land in Sri Lanka is divided into three climatic zones based on rainfall; dry, wet and intermediate. Most of the southeast, east and northern parts of the country comprise the dry zone and receive rainfall of 1200-1900

mm/year. Much of the rain falls in October to January and little precipitation is received for the rest of the year. Also falling under the dry zone is the arid northwest and southeast coasts which receive the least amount of rain (600-1200 mm/year) normally, concentrated within the short period of the monsoon. The central hilly areas and southwestern part of Sri Lanka known as the wet zone receives ample rainfall of over 2500 mm/year without pronounced dry periods. The intermediate zone is the area between the wet and dry zones receiving an average rainfall of 1750-2500 mm/year. Rice is cultivated in all 3 zones with the dry zone covering 60% of total rice area, the intermediate zone and the wet zone cover 22%, and 18%, respectively, (Table 1).

There are two types of irrigation schemes in Sri Lanka, major and minor. Major irrigation system is defined as one that has a command area of more than 80 ha. Small tanks or minor irrigation systems are those having an irrigated command area of 80 ha or less (Sivayoganathan and Mowjood, 2003). Major and minor irrigation schemes provide assured irrigation to 53% and 23% of total rice area, respectively, while rice production in the remaining 24% of the area relies on rainfall.

Table 1: Rice Area by Agro-ecology and Source of Water in Sri Lanka, 2010

	Sown Area ('000 ha)	% Share in Area
Agro-ecology		
Dry Zone	639	60
Intermediate Zone	237	22
Wet Zone	189	18
All	1065	100
Source of irrigation		
Major	562	53
Minor	247	23
Rainfed	257	24
All	1065	100

Source: Department of Census and Statistics, Sri Lanka.

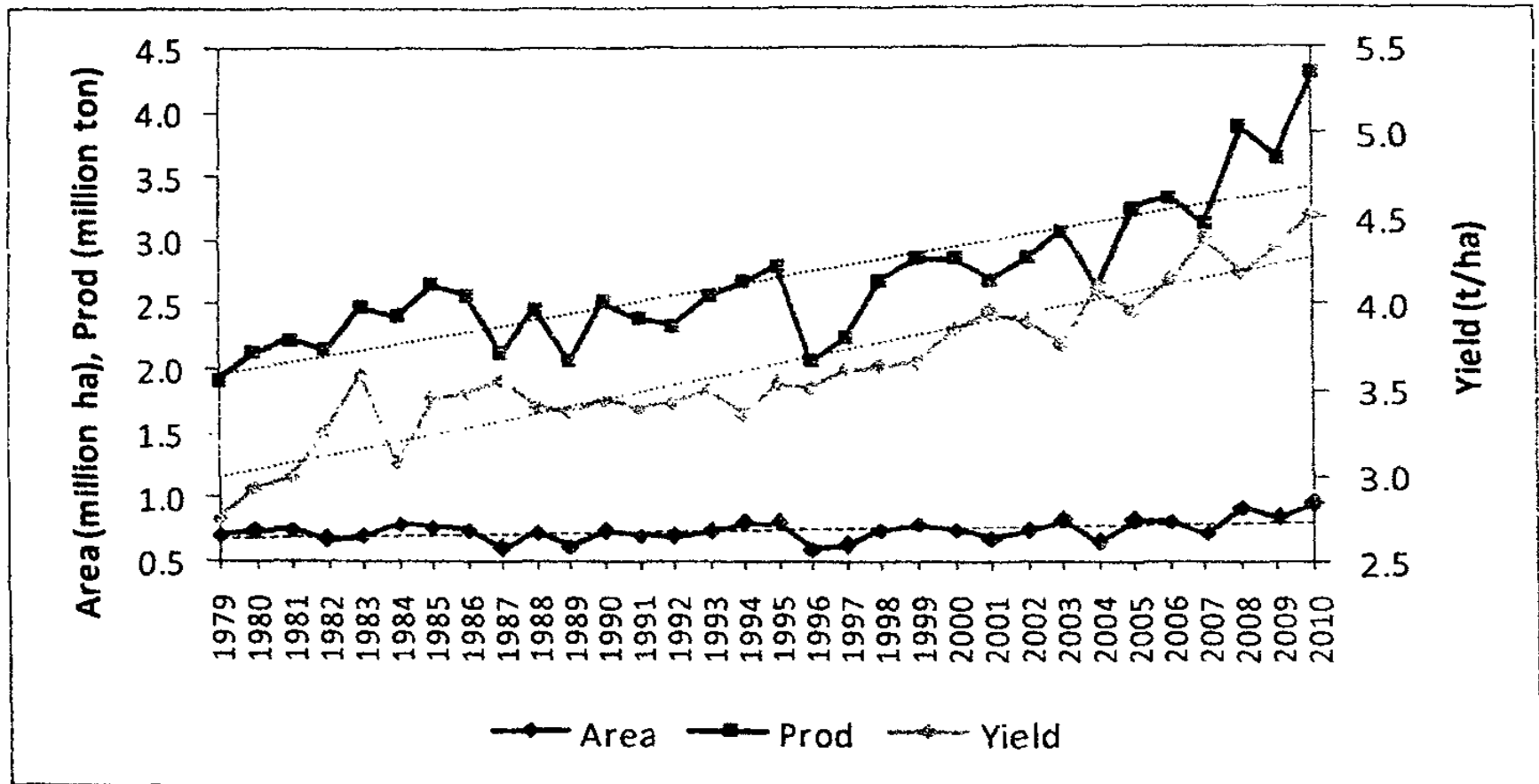
Rice-growing areas in Sri Lanka can be categorized as favourable and unfavourable based on water availability. Irrigated areas (major and minor) can be considered as favourable environments since it has assured water supply throughout the growing period. These favourable areas determine the national

rice production and research and investment on rice were generally concentrated in these areas. These favourable areas are also the major rice-growing areas contributing 76% to national rice production in 2010 (Department of Census and Statistics). Unfavourable areas, on the other hand, are areas with poor drainage and areas exposed to salinity and iron toxicity. Karunagoda *et al* (2010) reported that in their study which was conducted in favorable areas in districts of Polonnaruwa, Ampara, Anuradhapura, Hambantota and Kurunagala, rice is cultivated for commercial purposes as marketable surplus was about 65-75% of the rice harvest. On the other hand, areas cultivated under rainfed conditions were generally considered unfavourable areas. These unfavourable areas are important in terms of household food security as farmers in these areas produce rice for their own consumption. In addition, the wet zone serves as a buffer zone whenever calamities cause crop damage in major growing areas.

Trends in Rice Production, Area and Yield

Rice production as presented in Figure 1 shows an upward trend in the period 1979-2010 despite fluctuations. Fluctuations in production are due to changes in government policies and climatic conditions. The abolishment of the Paddy Marketing Board and reduction of the government support through liberalization of rice market under private sector led to a decline in production while policies such as technological advancement and escalation of world market price of cereals led to the increase in production. The annual growth rate of production 1.66% is mainly due to growth in rice yield (Table 2). Growth in production was the highest in the *yala* season. As the yield has almost the same growth rate in each season, expansion in area during the *yala* season made a significant contribution to the growth in production during that season. A closer look at the growth in area by source of irrigation in the *yala* season shows that expansion in rice area during the season is due to expansion in area irrigated through the major irrigation scheme (Table 3). Irrigation by the major irrigation scheme was also implemented in re-cultivated areas following the civil war and in rainfed rice cultivating areas, as a decline in rainfed rice cultivating area during the *yala* season is observed (Figure 2). This is further supported by the high negative annual growth rate of -1.98% in the rainfed area during the period (Table 3).

Figure 1: Trends in Rice Area, Production and Yield in Sri Lanka, 1979-2010



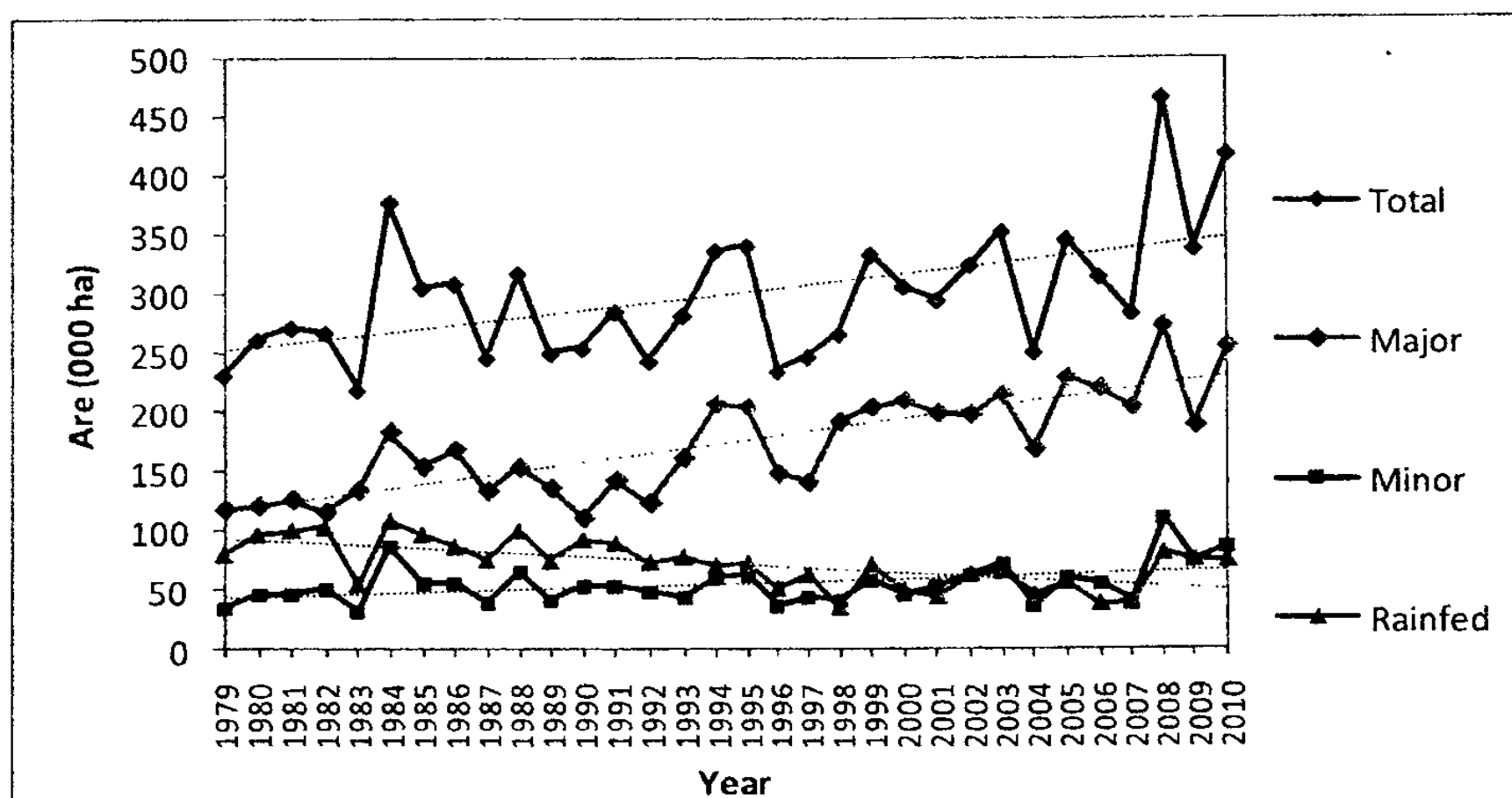
Source: Department of Census and Statistics, Sri Lanka

Table 2: Annual Growth Rates (%/year) of Rice Area, Production and Yield, 1979-2010

Season	Area	Prod	Yield
Maha	0.26	1.35	1.09
Yala	1.01	2.27	1.26
Annual	0.52	1.66	1.14

Source: Authors' estimation

Figure 2: Trends in Rice Area by Source of Water During Yala Season, 1979-2010



Source: Department of Census and Statistics, Sri Lanka

Table 3: Annual Growth Rates (%/year) of Rice Area by Season and Source of Water, 1979-2010

	Major	Minor	Rainfed
Maha	1.11	0.32	-0.93
Yala	2.14	1.25	-1.98
Annual	1.53	0.58	-1.25

Source: Authors' estimation

Factors Affecting Rice Production

Government policies played an important role in achieving self sufficiency not only in rice but also in other food crops. Policies in support of rice production mainly include provision of subsidies for producers, trade protection, guaranteed price scheme, development of irrigation infrastructure, credit and insurance programs. The impact of these policies on rice production has been investigated by many researchers. The most prominent policy is the input subsidy program which had a significant impact on rice production in the country (Ekanayake, 2006; Rajapaksa and Karunagoda, 2009; Weerasooriya and Gunarathne, 2009).

Furthermore, Rajapaksa and Karunagoda (2009) and Ekanayake (2006) confirmed that paddy production is more responsive to farm gate paddy price than input price hence, output price policies were important in the increase of paddy production. Rice marketing has undergone a series of changes in the last decade and government intervention was carried out through the expansion of market facilities. As a result, substantial improvement in rice marketing was observed, however, Karunagoda *et al* (2010) recommended further institutional development to obtain maximum benefits. In addition, Walisinghe *et al* (2008) reported that rice markets are well integrated indicating that efficiency in rice pricing was achieved through the development of market infrastructure.

On the other hand, technology improvement also had a positive impact on rice production as the institution on rice research introduced several HYVs. Widespread adoption of these varieties led to a positive effect on paddy production. Observing the importance of this activity, the government prioritized investments on rice research. Present investment on rice research needs to continue to cater to the future demand for rice to ensure national food security. With the present population growth rate, rice demand is expected to increase to 2.7 million tons in 2020 (Herath *et al*, 2010). Apart from population growth, rice demand depends on other factors such as price of rice and substitutes for rice, per capita income, food consumption diversification, and urbanization. Empirical studies that have estimated own price and cross price elasticities of rice and rice substitutes showed that urbanization may reduce the demand for rice. Despite an expansion of urban areas, rice consumption has shown an increasing trend (115 Kg/head/yr) over the years (Food Balance Sheet, 2010). In addition, recent climatic changes pose a severe threat to rice production from time to time.

Organization of Rice Research

The urgency and importance of increasing domestic rice production was recognized with the dawn of independence in 1948 and development of improved varieties through hybridization was considered the key approach to raising production. Accordingly, an extensive hybridization program was initiated in 1952 to meet the demand for four different maturity durations ranging from 5-6 months to 3 months. The initial success of the above hybridization program was a medium-maturity variety (125 days), H-4, which was released to farmers in 1958. Due to its wide adaptability to a range of soil and environmental conditions, H-4 rapidly gained farmers' acceptance. H-4 was soon followed by H-

7 (100 days), H-9 (150days), and H-10 (90 days). These varieties commonly identified as old improved varieties (OIV) combined blast resistance with moderate response to chemical fertilizers (Weerarathne and Senadhira, 1981).

With the release of OIVs in late 1950s and early 1960s, major changes occurred in the rice production system as the traditional system of single cropping was replaced by double cropping. H-4 was popularly grown in the *yala* season while H-7 and H-10 were widely grown in the *maha* season. The stagnant national average of 1.5t/ha in the 1950s was elevated to 2.0t/ha in the late 1960s. The plant type of the OIV was similar to the traditional cultivars but entailed reduced plant height. However, at high fertilizer levels, the OIVs were susceptible to lodging. Varieties with lodging resistance, a much needed characteristic that will complement the use of high levels of nitrogen, became available with the incorporation of the dwarf gene from IR 8. IR 8 is a semi-dwarf variety developed by the International Rice Research Institute (IRRI) that produced high yield when grown with fertilizers in irrigated fields.

The second stage of the hybridization program in the late 1960s and early 1970s used dwarf germplasm from IRRI. This hybridization program produced a series of new varieties called new improved varieties (NIV). NIVs such as Bg 3-5 (5-6 months photo-period sensitive), Bg 34-6 (3 1/2 months), and Bg 34-8 (3 months) have a combination of traits such as dwarf plant type, good level of tolerance to lodging, moderate resistance to prevalent diseases, and higher responsiveness to chemical fertilizer. When grown under proper management, NIVs have potential yields of 7 t/ha which was a significant improvement over the OIVs. This development increased national average yield to 2.8 t/ha in early 1970s. As farmers adopted dwarf plant types and adjusted management practices, further increases in yield were achieved in mid-1970s. Three new varieties, Bg 90-2 (4-4 1/2 months), and Bg 94-1 and Bg 94-2 (both 3 1/2 months), were released in mid-1970s. Yield potential of new varieties under favorable management approached a record yield of 10t/ha. Adoption of NIVs not only signified a change in the plant types grown by farmers but also a change in rice management practices particularly on the use of inputs such as fertilizer and pesticides. The NIVs, though characterized by high yield potential, lacked resistance to common insect-pests prompting farmers to use high levels of pesticides which then led to environmental problems. Therefore, incorporation of resistance to brown plant hopper (BPH) and gall midge (GM) in the breeding programs became essential. This resulted in the development of GM-resistant

varieties such as Bg 400-1 (4 months) and Bg 276-5 (3 months), and the BPH-resistant variety Bg 379-2 which were released in early 1980s.

Since 1980s, the varietal development program focused in developing varieties with adaptability to specific climate and soil conditions. Accordingly, regional development of varieties became a major aim of the breeding program. Regional stations in Ambalantota (At), Labuduwa (Ld), and Bombuwela (Bw) worked on developing varieties suitable to local conditions. Special emphasis was given to attributes such as better grain quality and tolerance to abiotic stresses such as iron toxicity and salinity. Adoption of NIVs and other associated production and protection technologies, on plant protection, use of fertilizer, and other crop management helped increase national average yield up to 4.5t/ha in 2010. In spite of desirable attributes of NIVs, a limited number of varieties were more popularly accepted by farmers. Identifying factors affecting varietal adoption is important in directing rice genetic improvement programs for developing varieties that cater to the needs of the farmers.

Investments in Rice Research

According to Niranjana (2004), in general, the nominal terms of expenditure in rice research has been increasing at a rate of Rs 922,636 per year in the period from 1959-1999. Abeysiriwardena (2004) reported that funding of rice research in Sri Lanka has been fluctuating at around Rs. 13 million in the period 1995 to 2004. Regardless of the amount of research funding, about 70% was utilized for rice breeding. This is a good indication of the relative importance of breeding as varietal improvement is paramount to increase the production in any crop. Abeysiriwardena (2004) also highlighted the importance of biotechnology in varietal development as plant biotechnologists incorporated the rice breeders in their genetic improvement work.

Out of the total resources available for rice breeding, RRDl utilized 95% for line development and evaluation and only 5% for germplasm enhancement from 1985 to 2000. However, by 2004, 5% of the allocation was diverted to plant biotechnology from the conventional breeding budget. The use of biotechnology in rice breeding is mainly on wide hybridization and haploid breeding.

Full Time Equivalent Analysis (FTE)

A survey of rice researchers' time allocation on rice varietal improvement was conducted using a structured questionnaire in 2010. Data was collected on rice research involvement by scientists from the Department of Agriculture, Agricultural universities and other related research institutes.

Following Pandey and Pal (2007), rice scientists' time allocation in rice breeding-related work was estimated using full-time equivalent (FTE). FTE is defined as the sum of percentages of time spent on a specific research over all researchers, divided by 100. An FTE value of one is equivalent to one person working full-time. FTE was also used as a proxy to investigate the resource allocation for different agro-ecological zones of rice.

Of the 41 researchers included in the survey, only 24 were working on rice breeding-related research of which 16 were plant breeders. The lone scientist in the field of bio-statistics was working on screening for drought-tolerant varieties and screening of aerobic rice varieties. Full-time equivalent of the 24 scientists was 18.5 in 2010. With a rice area of 1.05 million ha, FTE per million hectares was 17.5.

Increase in rice production that led to the country becoming self-sufficient in rice also led to farmers having marketable surplus. As a market for premium quality rice is emerging, breeding programs must be geared towards development of varieties with good grain qualities as desired by consumers. An assessment of time allocation by theme showed that varietal development is now addressing issues related to abiotic stresses and grain quality while they continue to develop varieties with high yield and pest and disease resistance (Table 4). The themes were identified by the researcher survey.

Table 4: Time Allocation of Rice Scientists Involved in Breeding-related Research by Theme, 2010

Theme	FTE	% Share in FTE
Abiotic stresses (drought, salinity, iron toxicity, heat)	3.7	20
Higher yield	2.6	14
Pest and disease resistance	2.4	13
Grain quality	2.3	13
Crop management (pest, disease, weed, nutrient)	2.0	11
Varietal selection	1.1	6
Molecular breeding	1.0	5
Grain quality and abiotic stress)	0.9	5
Aerobic rice	0.9	5
Conservation of germplasm	0.9	5
Pest and disease resistance and iron toxicity	0.8	4
Total FTE	18.5	

Source: Authors' estimation

The dry and intermediate zones were the main focus of rice resource investment in terms of scientists' time allocation as its share in FTE was 75% in 2010 (Table 5). This share in FTE was to a certain degree proportional to the area coverage of this agro-ecology which was 82% of rice area in 2010. Share in FTE of wet zone which covers 18% of rice area was 25%. With this share in FTE, more varieties are expected to be developed for the dry and intermediate zones.

Table 5: Time Allocation of Rice Scientists by Agro-ecology, 2010

Agro-ecology	FTE	% Share in FTE
Dry	2.90	16
Dry and Intermediate	10.40	56
Intermediate	0.50	3
Wet	4.7	25
Total	18.50	100

Source: Authors' estimation

Varietal Release Pattern and Farmer Adoption

Selecting a variety for cultivation requires careful consideration of climatic factors, soil type, irrigation facilities, farmer practices as well as consumer preferences (Weerakoon *et al*, 2005). Farmers consider the varietal traits when deciding on which variety to grow. Farmers prefer varieties which are high-yielding, with good eating and grain quality, semi-dwarf type, with good tillering and tolerant to abiotic stresses. On the other hand, farmers dislike varieties that are susceptible to pest and diseases.

Farmers also consider maturity in their varietal choices as short duration varieties will allow the cultivation of a second crop. As rice scientists incorporated maturity into their breeding work, varieties of different maturity were released over time (Table 6). Forty varieties released have 2 ½ - 3 ½ months' maturity. As shown in the table, breeders ceased to develop varieties with 5-6 months' maturity since the 1990s.

Table 6: Varietal Release Pattern by Maturity (number of varieties)

Maturity period	1958-1969	1970-1979	1980-1989	1990-1999	2000-2010	1958-2010
2 1/2 month	0	0	1	0	1	2
3 month	2	2	4	3	3	14
3 1/2 month	1	4	4	9	6	24
4-4 1/2 month	2	6	6	6	4	24
5-6 month	1	1	3	0	0	5
Total	6	13	18	18	14	69

Source: Rice Research and Development Institute

Table 7 presents varietal release by decade in different agro-ecologies. Of the 69 varieties released in Sri Lanka, majority are recommended for general cultivation and only a limited number is targeted towards specific agro-ecologies. Seventeen varieties are recommended specifically for the wet zone which covers only 18% of total rice area while 9% are recommended for unfavorable land which are areas with saline soils, acidic soils, iron toxicity, drought-prone and flood-prone. The trend has almost always been the same over time except in the 80s. Except for Bg 407 H, which is the first hybrid variety released 2005 in Sri Lanka, all others are inbred varieties.

Photoperiod sensitive rice varieties with long maturity (5-6 months) such as Bg 38 and Bg 745 are cultivated in lowland areas identified as *mawee* lands. These varieties can withstand extreme flood conditions in the early stage of crop growth. Rice cultivation in *mawee* land does not require weeding nor pesticides and is grown only in *Maha* season. Development of varieties for *mawee* cultivation was stopped in 1990s as the focus shifted towards development of short duration varieties.

Table 7: Varietal Release Pattern by Agro-ecology (Number of Varieties)

	1958- 1969	1970- 1979	1980- 1989	1990- 1999	2000- 2010	1958- 2010
Dry zone	1	0	0	0	1	2
Dry and Intermediate zone	0	0	2	1	0	3
Intermediate zone	0	0	1	0	0	1
Wet zone	0	3	6	5	3	17
General cultivation	4	8	5	9	9	35
<i>Mawee</i> land	1	1	3	0	0	5
Unfavorable land *	0	1	1	3	1	6
Total	6	13	18	18	14	69

* Unfavourable land areas with saline soils, acidic soils, iron toxicity, drought-prone and flood-prone.

Source: Rice Research and Development Institute

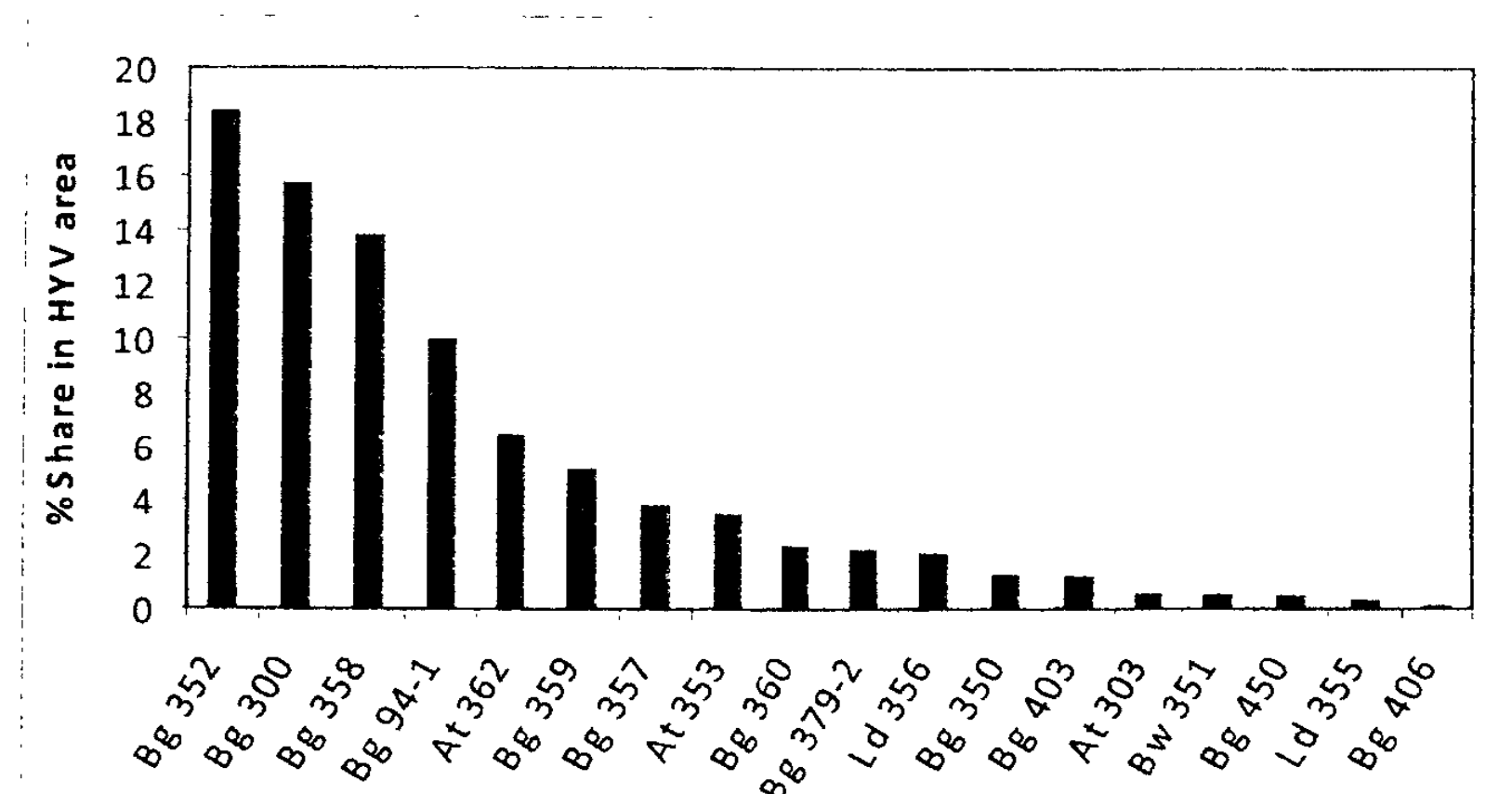
Varietal Adoption Patterns

Despite the government's active role in improving rice production and promoting new releases, HYVs cover almost 98% of total rice area. Despite the numerous traditional varieties (TV) existing in Sri Lanka, TVs are grown only in 0.15% of the total rice area and the remaining 1.4% is unknown varieties. Traditional rice varieties are grown mainly in areas with specific environmental constraints or for specific markets as they are perceived to be more nutritious than HYVs.

The top 4 HYVs in 2010 which cover 58% of HYV area, are Bg 352, Bg 300, Bg 358 and Bg 94-1 (Figure 3). Except for Bg 358 which was released in 1999, the popular HYVs were released before 1993. These varieties have maturity of 3-3 ½ months and are recommended for general cultivation with potential yield ranging from 6.0-9.5 t/ha. Bg 300 was reported by Wang, et al (2012) to be

dominant even in environments prone to abiotic stresses. Bg 300 is preferred by farmers for traits such as high-yielding, short maturity, and resistance to major rice pest and diseases. OIVs which are long duration varieties (H-series HYVs) are no longer grown as NIVs have completely replaced OIVs. Average varietal age of HYVs was estimated to be 18 years which indicates that varieties commonly grown by farmers in 2010 were those released in the early 1990s.

Figure 3: Major Rice Varieties Cultivated in 2010



Source: Rice Research and Development Institute, Sri Lanka

The study by Jayawardena et al (2010) showed that, out of the 68 rice varieties released by the Department of Agriculture up to 2009, farmers adopted 53 varieties. Among them, 15 varieties accounted for 68% of the total extent cultivated in Sri Lanka and four varieties (Bg 300, Bg 352, Bg 358 and Bg 94-1) dominate. Among the 15 popular varieties, 11 varieties belong to 3-3 ½ age class. The main reason for the adoption is high yielding ability in this group over other age classes. Alternatively, water shortage has influenced farmers to shift from long duration varieties to 3-3 ½ months age class. Rice varieties of 4-4 ½ months were highly adopted by farmers in 1980s. Adaptability of rice varieties varies across geographical locations in the country. Further, soil fertility, water availability, consumer preference, reaction to pest and diseases and other environmental factors affect the varietal spread.

Table 8 presents the percentage area grown to HYVs with different maturity. A large proportion of HYV area was grown to 3 ½ months in 2010 and these

varieties cover 72% of the HYV area. Although not popular, 3 month-maturing HYVs were also grown but in 20% of HYV area only. An even shorter duration HYV (Bg 250), which is a 2 ½-month variety, is grown in a small proportion as farmers have just started adopting the variety since its release in 2005. This ultra short variety is recommended for drought-prone areas as it can be harvested early allowing the crop to withstand drought. HYVs with 4-4 ½ months maturity were also being grown but to a limited extent.

Table 8: Varietal Adoption by Maturity, 2010

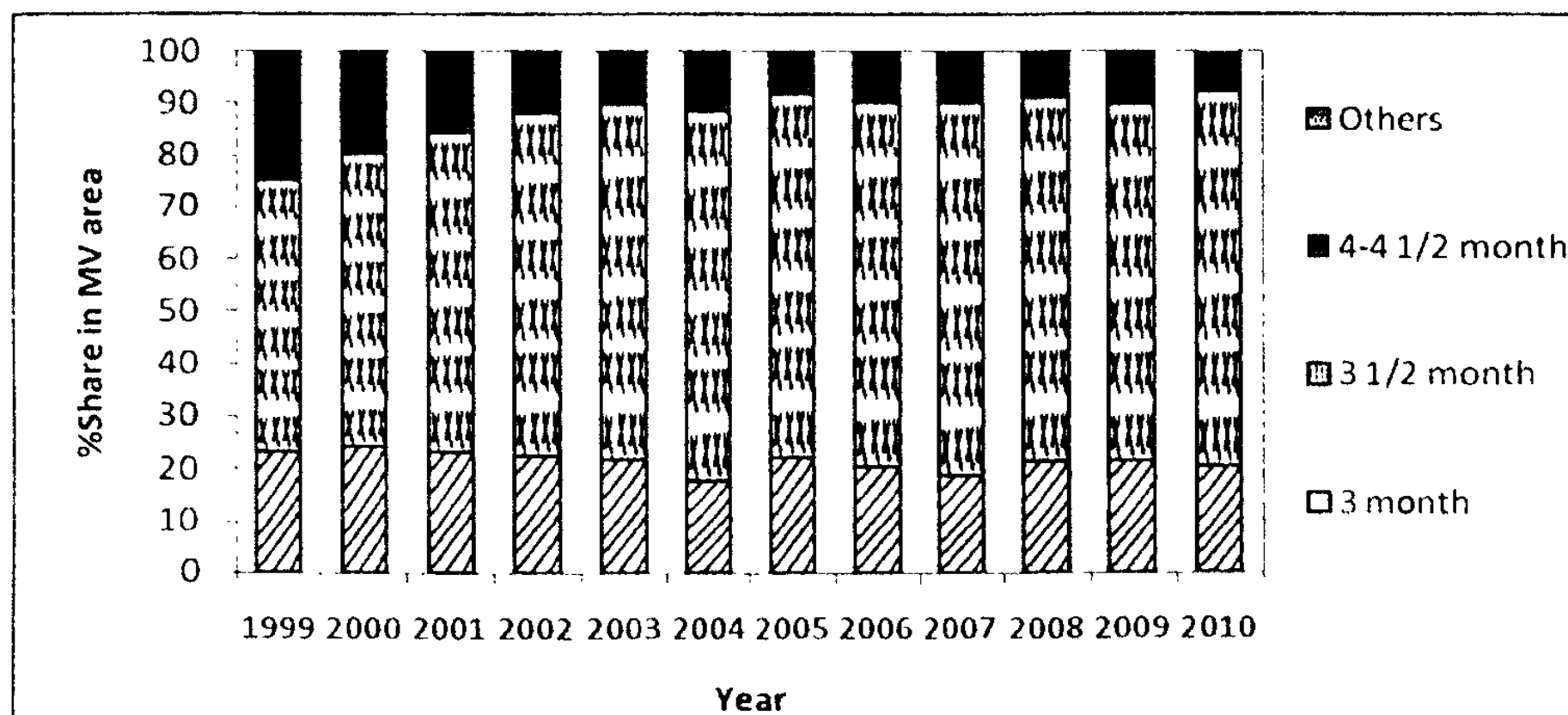
Maturity period	% Share in HYV area
2 1/2 months	0.3
3 months	20
3 1/2 months	72
4-4 1/2 months	7
5-6 months	0.1
Other HYVs	1.4

Source: Rice Research and Development Institute, Sri Lanka

Varietal Replacement Patterns

Results of the national surveys conducted yearly from 1999 to 2010 which contains varietal adoption data collected by the Rice Research and Development Institute of Department of Agriculture, Sri Lanka, and Department of Census and Statistics were used to show varietal adoption/dis-adoption pattern. Although 3 ½ month-maturing HYVs were already widely grown at 52% in 1999, adoption has further expanded to 72% in 2010 (Figure 4). A replacement of medium-duration HYVs (4-4 ½ months) with short-duration HYVs (3 ½ months) was observed. This replacement occurred mostly in the *yala* season in areas where irrigation was made available. Cultivation of early maturing HYVs during the *yala* season permitted the cultivation of a second crop. During the same period, area grown to 3-month maturing HYVs was observed to have stabilized at 22%.

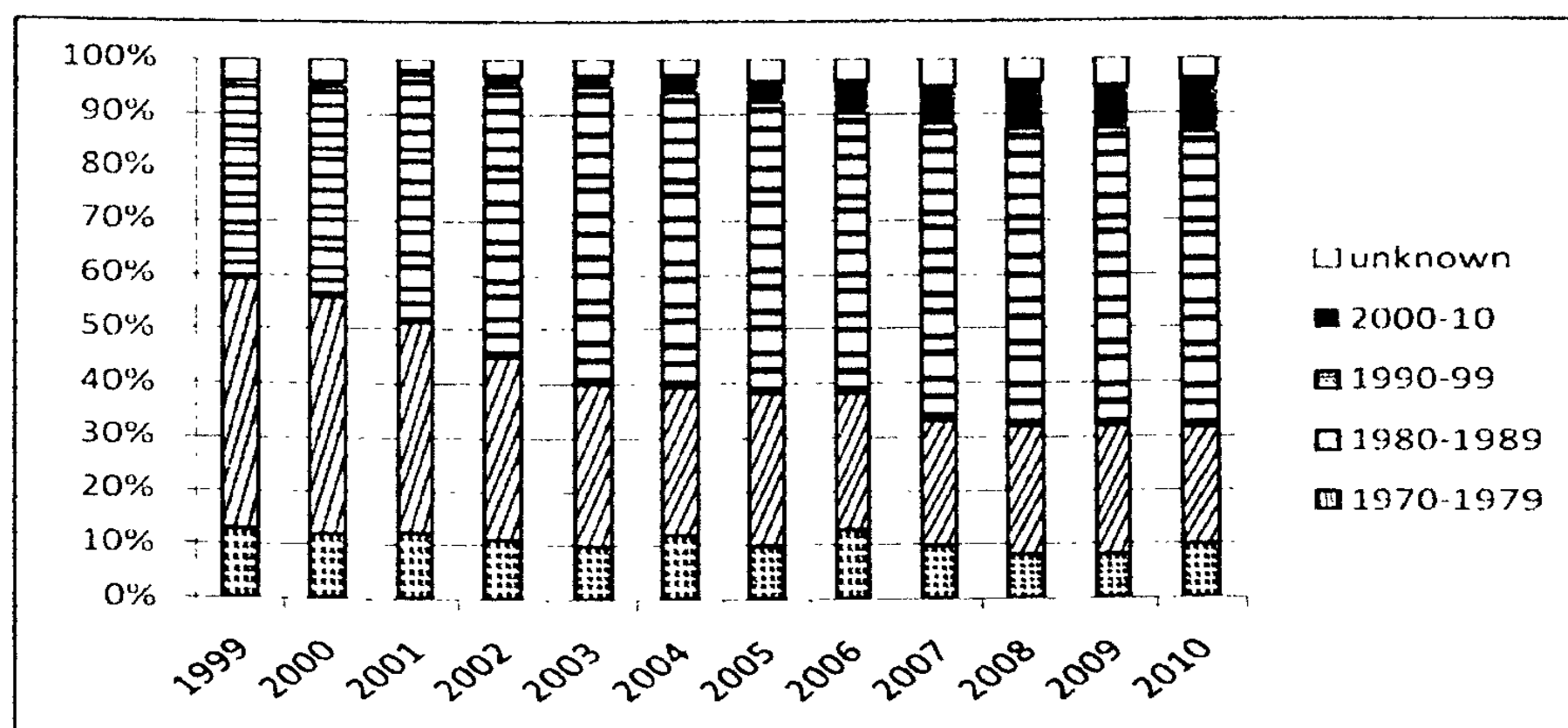
Figure 4: Trends in Varietal Adoption by Maturity, 1999-2010



Source: Rice Research and Development Institute

As expected, the trend analysis from 1999-2010 of varietal adoption by period of release shows a replacement of old varietal releases with new varietal releases resulting in a reduction of varietal age from 22 years to 18 years (Figure 5). Varieties released in the 1970s continued to be cultivated in about 11% of the HYV area within the period 1999-2010. Whereas, HYVs released in the 1980s were replaced with HYVs which are 10 years younger. HYVs developed in the last decade is slowly expanding and have reached 10% in 2010.

Figure 5: Trends in Varietal Adoption by Period of Release



Source: Rice Research and Development Institute

A comparison of varietal adoption between 2 periods, 1999 and 2010, is presented in Table 9. HYVs which were previously not grown as they were released only in 1999 and 2002 such as Bg 358, Bg 359, Bg 360 and At 362 collectively cover 27% of the HYV area in 2010. Old HYVs with 3 ½ maturity such as Bg 350, Bw 351, and Ld 355 and with 4-4 ½ maturity such as Bg 379-2, Bg 450 and Bg 403, showed a substantial decline from 32% to 6%. Most of these varieties were released before 1990. In significant proportion of HYV area 3 ½ month maturing HYVs are grown, which are more or less stabilized at 54% of HYV area and most of these HYVs were released in the early 1990s.

Table 9: Varietal Changes in the Period 1999-2010

Variety	Maturity	Year of Release	% Share in MV Area		Growth Rate (%/year)
			1999	2010	
Bg 358	3 1/2 month	1999	1	14	19
Bg 359	3 1/2 month	1999		5	35
Bg 360	3 1/2 month	1999		2	32
At 362	3 1/2 month	2002	0	6	48
Bg 350	3 1/2 month	1986	5	1	-12
Bw 351	3 1/2 month	1986	3	1	-15
Ld 355	3 1/2 month	1994	5	0	-26
Bg 379-2	4-4 1/2 month	1980	6	2	-7
Bg 450	4-4 1/2 month	1985	8	1	-20
Bg 403	4-4 1/2 month	1993	5	1	-10
Bg 94-1	3 1/2 month	1975	11	10	0
At 353	3 1/2 month	1992	5	4	-3
Bg 352	3 1/2 month	1992	13	18	3
Ld 356	3 1/2 month	1994	2	2	1
Bg 357	3 1/2 month	1997	2	4	6
Bg 300	3 month	1987	19	16	-1
At 303	3 month	1990	1	1	-3
Bg 406	4-4 1/2 month	2005		0	-6
Other HYVs			13	11	

Source: Authors Estimation

353 which was grown in 4% of HYV area is the only HYV that experts failed to identify as belonging to the top 10 popularly grown HYV.

Table 10: Estimates of Varietal Adoption from Expert Panel Elicitation and National Survey

	Expert Elicitation			National Survey
	<i>Maha</i>	<i>Yala</i>	Both Seasons	
%HYV area	100	100	100	98
Cultivar-specific adoption (%Share in MV area)				
Bg 352	20	16	18	19
Bg 300	15	20	17	16
Bg 358	14	14	14	14
Bg 94-1	9	8	8	10
At 362	7	6	6	7
Bg 359	6	5	5	5
Bg 379-2	4	1	3	2
Bg 360	3	2	2	2
Bg 357	2	2	2	4
At 307	2	3	2	1
Bg 250		0.15	0.06	
Other HYVs	22	26	23	19

Source: Authors Estimation

Lessons Learned

Expert panel elicitation method expedites the long process of data collection and tabulation mechanism which is characteristic of survey methods. For a rapid appraisal of the varietal spread, expert panel elicitation method is advantageous because of its cost-efficient and time-saving attribute compared to the conventional survey method. However, the method is highly dependent on proper identification of resource persons who are knowledgeable about varietal adoption in the specific area of interest. Expert elicitations conducted at sub-national levels such as regional or district level may be useful in planning, breeding and extension programs adaptable to the region or district. Expert elicitations may also be conducted for representative areas of different agro-ecological zones to improve the precision of the estimates.

Results of Expert Panel Elicitation

Although Sri Lanka has a system already in place for the collection of general statistics relevant to the agriculture sector, timely availability of reliable data is a constraint. As tracking varietal change is useful in assessing the impact of crop genetic improvement, particularly for a crop that is as important as rice, a method of obtaining quick and clean estimates of varietal adoption is necessary. In order to address problems related to the present data collection system, expert panel elicitation method was tested.

A panel of experts consisting of research administrators, breeders, extension agents, economists, seed and planting material experts, and resource persons representing the Department of Agriculture, state universities and private institutions was convened. Two farmer leaders were also invited to the elicitation meeting. These experts have served in different rice-growing areas and therefore have a fair understanding of varietal adoption in different agro-ecological zones. Farmer leaders provided knowledge based on their experience and experiences of their constituents.

The expert panel elicitation method used in Sri Lanka under the TRIVSA project is a modified Delphi method which involved 2 rounds of elicitation of varietal adoption in each season. Estimates of area coverage of different varieties were based on the perception of resource persons considered to be knowledgeable on varietal adoption. The first round involved elicitation of estimates for each season from individual experts. Experts were then grouped into 2 heterogeneous teams and a second round of elicitation was done for each season from each team. Annual estimates were obtained by aggregating estimates for each season. Aggregating season-wise estimates was done using rice area in each season as weights.

Results of the final round of estimation are depicted in Table 10. Expert estimates were validated using national survey results which contain varietal adoption data collected by the Department of Agriculture in collaboration with the Department of Agrarian Services and published by the Department of Census and Statistics. Area grown to all HYVs in both seasons was over-estimated by experts by only 2%-pts when compared with the national survey estimate. The top 9 HYVs based on area coverage as reported in the national survey were well identified by experts with a mean absolute error of 1%-pt. The top 6 HYVs ranked by experts were consistent with the rankings in the national survey. At

However, expert panel elicitation method may not be useful in Sri Lanka for the time being since there is already a system in place for collecting information on area coverage of different varieties. This method may be useful in cross-checking results of the national survey for accuracy. The high correspondence between the expert estimates and the survey estimates is because experts invited to the elicitation had access to reports on varietal adoption collected in the national survey. Hence it is important to invite experts with ground-level knowledge of varietal adoption if it is to be used to cross-check the survey results. Expert panel elicitation method will also be useful in the event that the activity on data collection of varietal adoption is terminated.

Conclusions

At the onset of the Green Revolution, increase in production through improvements in productivity was the motive of rice breeding programs. RRDI and its satellite stations continuously make efforts to elevate the genetic potential of rice varieties through conventional and heterosis breeding. Development of early-maturing high-yielding rice varieties complemented with improvements in irrigation infrastructure led to the increase in rice production and expansion in rice area which was more prominent during yala season. These changes contributed to the country becoming self-sufficient in rice and farmers having marketable surplus. As a market for premium quality rice is emerging, breeding programs must be geared towards development of varieties with good grain qualities as desired by consumers.

As allocation of rice research funds are not normally segregated by agro-ecology, comparison of rice investment by agro-ecology was made possible with the estimation of FTEs. By and large, investment on rice research is concentrated in high potential areas such as the dry and intermediate zones while unfavorable areas such as the wet zone receive low research investment. Such allocation of investment was found to be satisfactory as the resource investment for each agro-ecology was proportional to the share in area of the agro-ecology to a certain extent.

Government efforts in disseminating HYVs paid-off as 98% of rice area is grown with HYVs. However, despite the availability of 69 HYVs developed by RRDI, only a limited number of varieties are popularly cultivated in 2010. Four HYVs which have maturity of 3- 3 ½ months cover a total of 58% of the HYV area. NIVs have

completely replaced OIVs. Varieties commonly grown by farmers in 2010 were those that were released in the early 1990s.

Expert panel elicitation method piloted in this project showed results which highly corresponded with estimates from the national survey. The top 6 HYVs ranked by experts were consistent with the rankings in the national survey. However, this high correspondence is due to experts having access to reports of varietal adoption from the national survey. As there is a system already in place to collect data on varietal adoption, the new method may be useful in validating results of the national survey. Proper identification of resource persons knowledgeable in varietal adoption at the farm level in different rice-growing areas is important if the method is to be used to validate results of the national survey.

The study proves that the expert panel elicitation method is a cost-effective and rapid approach to estimate varietal adoption and may be used as an alternative to the conventional method of using farm household surveys. This method will provide timely available data on varietal adoption, which are useful to policy makers in allocating research investments and to breeders in assessing breeding programs.

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Appendix: Rice Varieties Released in Sri Lanka, 1958-2010

Year of Release	Release Name	Duration (months)	Recommendation
1958	H-4	4 - 4 1/2	General cultivation
1964	H-7	3 1/2	General cultivation
1966	H-8	4 - 4 1/2	General cultivation
1968	H-10	3	General cultivation
1968	H-9	5 - 6	<i>Mawee</i> land
1969	62-355	3	Rainfed/Manawari
1970	Bg 11-11	4 - 4 1/2	General cultivation
1971	Bg 34-6	3 1/2	General cultivation
1971	Bg 34-8	3	General cultivation
1971	Ld 66	4 - 4 1/2	Iron toxic soil and acidic soil
1971	MI 273	4 - 4 1/2	General cultivation
1973	Bg 3-5	5 - 6	<i>Mawee</i> land
1975	Bg 94-1	3 1/2	General cultivation
1975	Bg 90-2	4 - 4 1/2	General cultivation
1977	At 16	3 1/2	Southern province
1977	Bw 78	4 - 4 1/2	Low country wet zone, Iron toxic soil
1978	Bg 94-2	3 1/2	General cultivation
1979	Bg 276-5	3	General cultivation
1979	Bw 100	4 - 4 1/2	Low country wet zone, Iron toxic soil
1980	Bg 379-2	4 - 4 1/2	General cultivation
1980	Bg 400-1	4 - 4 1/2	General cultivation
1981	Bg 750	2 1/2	Low country intermediate zone
1981	Bw 266-7	3 1/2	Low country wet zone
1981	Bw 267-3	3 1/2	Low country wet zone, Iron toxic soil
1981	Bw 272-6B	3	Low country wet zone (suitable for mineral, half bog and bog soils)
1981	Bg 38	5 - 6	<i>Mawee</i> land
1981	Bg 407	5 - 6	<i>Mawee</i> land
1981	Bg 745	5 - 6	<i>Mawee</i> land
1982	Bg 380	4 - 4 1/2	Major irrigation in Dry and Intermediate zone
1985	Bg 450	4 - 4 1/2	General cultivation
1986	Bg 350	3 1/2	General cultivation
1986	Bw 351	3 1/2	High potential area (mineral soil) of Low country wet zone
1987	Bg 300	3	General cultivation
1987	Bg 301	3	Rainfed Dry & Intermediate zone
1987	Bw 302	3	Saline and acid
1987	Bw 400	4 - 4 1/2	
1987	Bw 451	4 - 4 1/2	Low country wet zone, saline soil

Year of Release	Release Name	Duration (months)	Recommendation
1990	At 303	3	General cultivation
1992	At 353	3 1/2	Saline area
1992	At 354	3 1/2	Saline area
1992	Bg 352	3 1/2	General cultivation
1992	At 401	4 - 4 1/2	Costal Saline area
1992	At 402	4 - 4 1/2	Southern province
1992	Bw 452	4 - 4 1/2	General cultivation
1992	Bw 453	4 - 4 1/2	Low country wet zone
1993	Bg 304	3	General cultivation
1993	Bg 403	4 - 4 1/2	General cultivation
1994	Ld 355	3 1/2	Southern Province
1994	Ld 356	3 1/2	Kalutara and Gall districts
1997	Bg 357	3 1/2	Island wide cultivation
1997	At 405	4 - 4 1/2	Dry and Intermediate zone with assured supply of water
1999	Bg 358	3 1/2	General cultivation
1999	Bg 359	3 1/2	Wet zone
1999	Bg 360	3 1/2	General cultivation
1999	Bg 305	3	General cultivation
2002	At 362	3 1/2	General cultivation
2002	Bw 361	3 1/2	General cultivation
2003	Bw 363	3 1/2	General cultivation
2004	At 306	3	General cultivation
2005	Bg 250	2 1/2	Drought and Flooded area
2005	At 307	3	General cultivation
2005	Bg 406	4 - 4 1/2	Northern region
2005	Bg 407H	4 - 4 1/2	High potential area
2005	Bg 454	4 - 4 1/2	General cultivation with assured supply of water
2006	Bw 364	3 1/2	Wet zone
2008	Ld 365	3 1/2	Wet zone
2008	At 308	3	General cultivation
2009	Bg 366	3 1/2	General cultivation
2010	Ld 408	4 - 4 1/2	General cultivation

Source: Rice Research and Development Institute

ADOPTION OF NEW RICE VARIETIES IN SRI LANKA

R.M. Herath¹, M.M.P. Muthunayaka² and L.M.Chandrawathi¹

Abstract

This study examined the adoption of newly released rice varieties and variety groups in the farmers' fields; measured the replacement rate of newly released varieties using data on varietal spread of RRDl database. Data showed that Bg 94-1, Bg 300 and Bg 352 are enduring varieties from 1970s, 1980s and 1990s respectively and Bg 358, Bg 359 and At 362 are widely planted new varieties. The new improved varieties released from mid 1960s were popularly planted with an observed decrease of the use of old improved varieties and traditional varieties. Replacement period of new rice varieties has declined over time and current replacement period is around 16 years with lower adoption rates of newly released rice varieties. While policy makers are encouraged to continually support and strengthen the current efforts of rice breeding research and extension, the policy of variety release and promotion needs to be strengthened focusing the emphasis on accessibility of seed and information on new varieties to farmers.

Key words: Adoption rate, replacement rate, rice variety

Introduction

Development of rice varieties is crucial for sustaining food security in Sri Lanka. Indeed, notable progress in rice production has been achieved over the last four decades through development and adoption of new improved varieties. The rice research system has been continuing the release of new rice varieties. By 2010, the Department of Agriculture (DOA) has released 67 rice varieties for different agro-ecological conditions. Evenson and Gollin (2003) viewed that varietal releases are not necessarily good measures of the success of varietal development programs: a better measure is the use of these varieties in farmers' fields. According to the paddy statistics (2009/10 *Maha*) published by the Department of Census and Statistics, about 98 percent of the country's rice area

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Is planned to new improved varieties released by the DOA, but these statistics have grouped all rice varieties released since 1968 into three categories and adoption trend of specific rice variety cannot be distinguished.

A more detailed understanding of the development and adoption trends by specific variety wise in farmers' fields is important because it relates to the impact of continued public plant breeding research program. Recent study by Jayawardena et.al (2010) assessed the adoption by variety wise and revealed that a higher percentage of total rice area is still occupied by varieties that were released more than 15 to 20 years ago. However, this study used the data only at particular point of time and change of adoption over time with release of new varieties has not been studied. Further, at the Provincial Working Group Meetings and Coordinated Rice Varietal Testing (CRVT) meeting of the DOA, it is often discussed that replacement of old varieties with new varieties is very slow and it is blamed to a weak research-extension linkage, less effective public sector extension system and the absence of seeds in adequate quantities of new varieties. However, to what extent farmers have been changing from the "old" varieties to the "new" ones, and the reasons for low level of replacement of old varieties with new varieties if the rate of replacement is low, are the issues that have not yet been rigorously studied.

In this context, it is useful to have an updated measure of the adoption trend of varieties and to the extent which farmers use these varieties. Adoption rates of new varieties indicate the impact of the breeding program that continues to develop and release new varieties on rice production in the country. Brennan and Byerlee (1991) indicated that "for a given rate of variety release, a rapid rate of variety replacement in farmers' fields leads to higher returns to public plant breeding research because the lag between variety release and adoption by farmers is reduced". This paper aims to analyze the adoption trends of released rice varieties and the rate of variety replacement in farmers' fields using the aggregate time series data set of the data base of the Rice Research and Development Institute (RRDI).

Methodology

Data

The study used data from the data base of the Rice Research and Development Institute (RRDI). This is the only time series data set available on rice varieties cultivated in Sri Lanka. The Department of Census and Statistics (DCS) publish data seasonally on rice cultivation but they are classified only to area harvested

to old improved varieties, new improved varieties and traditional varieties. One limitation of RRDI data is that “other variety category” which stands for varieties which are not identified by name represents substantial percentage (10%- 14%). This is possible when the farmers may not be able to identify variety by name correctly or recall the varieties they planted.

Analysis

Conceptually, a promising line undergoes a series of field performance tests and evaluation trials before it is released as a recommended variety. A promising line coming from preliminary and major yield trials conducted in the breeding station is subjected to National Coordinated Rice Varietal Testing (NCRVT) and Varietal Adoptability Testing (VAT) and Large Scale Varietal Adoptability Testing (LSVAT). The standard check varieties usually used are the best available existing variety. Therefore, newly released varieties are expected to perform similar to if not better than the existing varieties in the given environment for which it is recommended. When a farmer chooses to adopt a new variety in place of an older variety, it reflects the farmer’s judgment that the new variety offers some net benefit or advantage (Evenson and Gollin, 2003). With this in mind, simple indices were calculated to understand more the dynamics of rice variety adoption, especially of the newly released varieties. Indices such as the proportion of recent varieties and weighted average age of varieties were calculated to determine the adoption rate of the newly released varieties following Brennan (1984) and Launio et.al (2008). The proportion of recent varieties is the proportion of the total area where are planted recently released varieties.

This index, q_{it} , is computed as follows:

$$q_{it} = p_{it} \text{ if year of release } \geq t - m,$$

$$q_{it} = 0 \text{ if year of release } < t - m,$$

where p_{it} is the proportion of the area sown to variety, i , in year, t ; m is the number of years used to define “recent.” Then

$$I_t = \sum_i q_{it}$$

where I is the proportion of the total area that is sown to varieties released in the previous m years. In this study, it was assumed a lag period between the release of a variety and its availability to farmers is 2 years and recent variety is defined as a variety that is available to farmers for eight more years. The number of years used in this study to define “recent” is 10 years ($m=10$).

The weighted average age of varieties (following Brennan and Byerlee, 1991), on the other hand, consists of the weighted average age of varieties grown by farmers in a given year, measured in years from varietal release and weighted by the proportion of area each variety is sown at that time. This index, WA_t , is computed for a given year, t , as follows:

$$WA_t = \sum_i p_{it} R_{it}$$

where R_{it} is the age of the variety in terms of the number of years (at time t) since the release of variety i . This measure avoids the use of an arbitrary definition of "new" or "recent" varieties (Brennan and Byerlee, 1991). These indices (I and WA) were calculated at four points of time taking years; 1980, 1990, 2000 and 2009 as t . For year 2009, $m = 9$. The oldest and newest varieties planted were also identified in the four points of time and it provided an additional indicator of the age of the varieties that are observed in farmers' fields.

Results and Discussion

Varieties released by the Department of Agriculture

The characteristics of the varieties released by the DOA are presented in Appendix 1 and 2. The number of varieties released in the 2000 decade was 12, compared to 18 in the 1990s, and 18 in the 1980s and 13 in 1970s. Of 67 rice varieties released, five varieties fall into 5-6 months age group, 23 into 4-4.5 month age group, 23 into 3.5 month age group, 14 into 3 months age group and two into 2.5 month age group. Varieties have been released by the DOA under two categories. The first category is for general cultivation. The second category is for specific region/problem soils/quality attributes. Out of 67 varieties, 32 varieties are for general cultivation and 35 varieties are for specific region/problem soils/quality attributes.

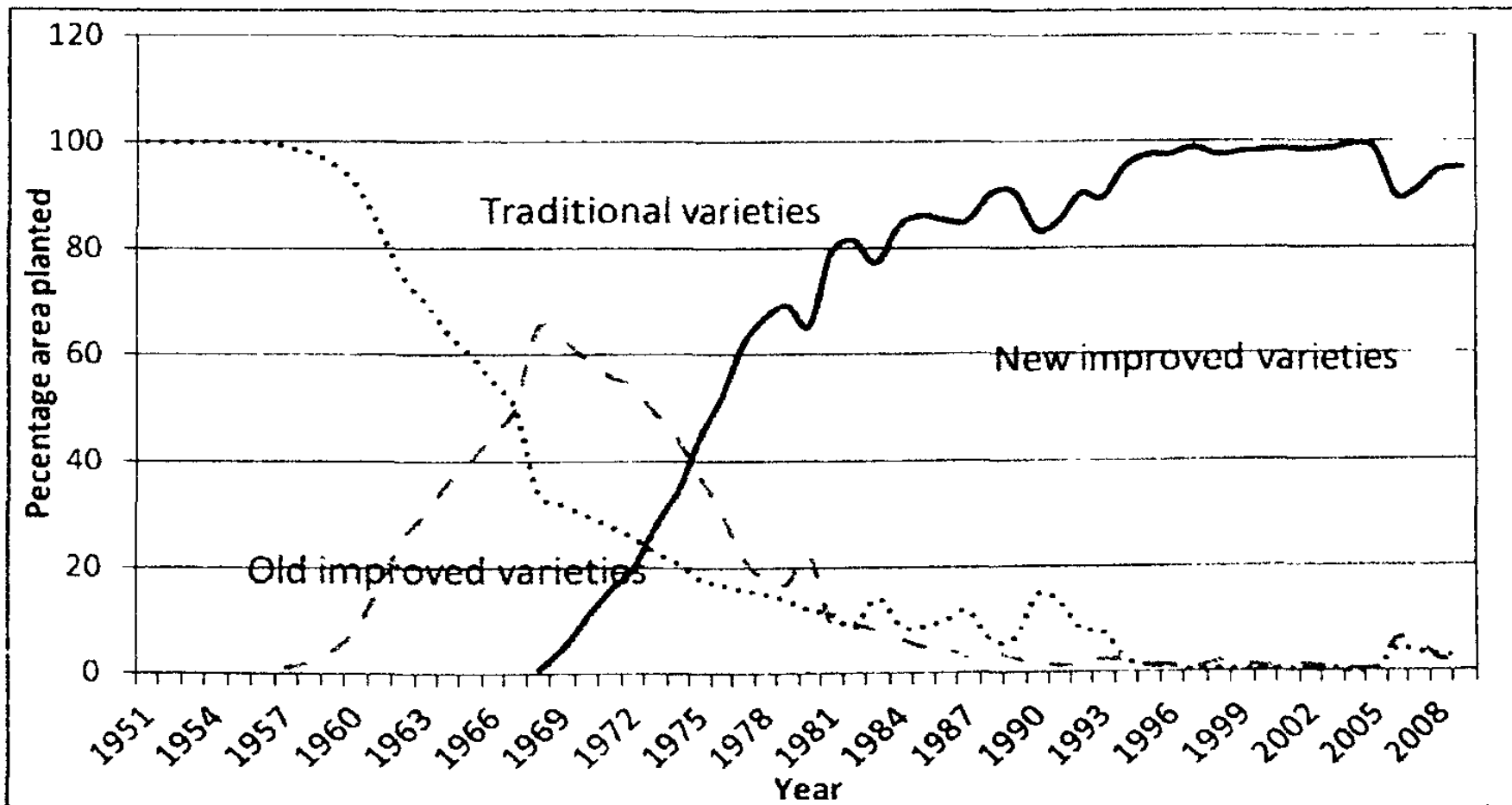
The potential yield of Bg 90-2 released in 1975 has not yet been surpassed by any new variety of that age group although five varieties of 4-4.5 months age group have been released for general cultivation after it. In addition, any new variety of this age group has not been released after 1993. For general cultivation, 13 varieties of 3.5 months age group have been released and of them, 7 varieties have been released after 1993. Of these seven varieties, six varieties surpassed potential yield of varieties released before 1993. Under 3 month age group, 10 varieties have been released for general cultivation. The yield of Bg 276-5 and Bg300 released in 1979 and 1987 respectively was

surpassed only by Bg 304 and Bg 305 released in 1993 and 1999, respectively. It appears that breeders have given the priority to develop short age variety in their breeding program recognizing the importance of water saving and demand of farmers for short age varieties.

Rice Varieties Cultivated by Farmers

The percentage of area planted with rice varieties based on major categories; Old Improved, New Improved, and Traditional are presented in Fig. 1. It did not take long for farmers to adopt New Improved Varieties (NIV). After their introduction in the end -1960s, more than 50% of the total rice area was planted with NIVs by 1978. This adoption rate steadily grew, and by 1984, around 95% of the rice area was planted with NIVs. The 2009 data showed that, almost 100% of the total rice area is cultivated with NIVs.

Figure 1: Percentage Area Planted by Categories of Rice Varieties (1951-2008)



Source: Paddy statistics (various issues), Department of Census and Statistics

The percentage areas planted by variety in different seasons at four points of time are presented in Table 3. The most popular varieties released in the 1970s were Bg 11-11, Bg 34-8 and Bg 94-1. Bg 94-1 and Bg 34-8 ranked first or second respectively until the 1990. By 2000, Bg 300, a 3 month variety released in 1987 was widely cultivated along with 3.5 month Bg 352 released in 1992 and Bg 94-1 released in 1975. Bg 300 still ranked first while Bg 352 released in 1992 and Bg 358 released in 1999 were also widely used in both seasons in 2009. Some

varieties have become popular to a considerable level certain level within a short period of time after their release and sometimes even before they are officially released. For example, Bg 300 released in 1987 has occupied 12 % of the total rice area by 1990 *yala* season. At 362 officially released in 2002 was reported in farmers field in 2000 *yala*. This is possible because seeds of new varieties are given to farmers for research purpose (VAT and LSVAT) before release and through these seeds those varieties are spread in farmers' fields.

Table 1: Percentage of Total Cultivated Extent by Variety and Season and the Year of Release for each Variety

Variety	Year release	79/80 Maha	80 Yala	89/90 Maha	90 Yala	99/00 Maha	00 Yala	08/09 Maha	09 yala
H 4	1958	0	0	3	0	1	0	0	0
Bg11-11	1970	24	4	5	1	1	0	0	0
Bg 34-8	1971	19	30	13	16	0	0	0	0
Bg 34-6	1971	8	9	4	3	1	0	0	0
Bg 3-5	1973	1	0	0	0	0	0	0	0
Bg 94-1	1975	17	28	23	27	10	11	8	9
Bg 90-2	1975	5	3	0	0	0	0	0	0
At 16	1977	1	1	0	0	0	0	0	0
BW 78	1977	1	1	0	0	0	0	0	0
Bg 94-2	1978	1	1	0	0	0	0	0	0
Bg276-5	1979	0	1	6	6	0	0	0	0
Bg379-2	1980	0	0	9	5	7	4	2	3
Bg400-1	1980	0	0	7	3	1	0	0	0
Bg272-6b	1981	0	0	2	3	0	0	0	1
Bw 266-7	1981	0	0	0	1	2	0	0	0
Bw 267-3	1981	0	0	1	2	1	2	0	0
Bg 380	1982	0	0	4	2	0	0	0	0
Bg 450	1985	0	0	5	1	8	1	1	0
Bg 350	1986	0	0	6	9	5	6	1	2
Bw 351	1986	0	0	3	5	3	3	1	0
Bg 300	1987	0	0	5	12	21	21	19	17
At 303	1990	0	0	0	0	1	1	1	1
Bg 352	1992	0	0	0	0	11	17	18	16
At 353	1992	0	0	0	0	5	9	3	3
At 354	1992	0	0	0	0	1	1	0	1
At 402	1992	0	0	0	0	1	0	1	0
Bg 304	1993	0	0	0	0	1	1	0	1

Bg 403	1993	0	0	0	0	5	2	2	1
LD 355	1994	0	0	0	0	5	5	0	1
LD 356	1994	0	0	0	0	2	4	2	4
Bg 357	1997	0	0	0	0	2	2	2	5
Bg 305	1999	0	0	0	0	0	0	1	1
Bg 358	1999	0	0	0	0	2	3	16	13
Bg 359	1999	0	0	0	0	0	0	5	7
Bg 360	1999	0	0	0	0	0	0	3	3
Bw 361	2002	0	0	0	0	0	0	1	1
At 362	2002	0	0	0	0	0	1	6	5
Bw 363	2003	0	0	0	0	0	0	0	1
At 307	2005	0	0	0	0	0	0	1	1

Note: Varieties with 0 values for all seasons were ignored. Since the area under other category can not be separated out into varieties falling into general cultivation and specific areas and varieties released for specific areas are cultivated in the areas where varieties released for general cultivation are cultivated all varieties were considered together in the calculation of percentage.

Source: Rice Research and Development Institute, Batalagoda

Adoption of New Rice Varieties and Replacement of Old varieties

The proportion of the total area planted to new rice varieties (varieties released in the previous 10 years from the time of point concerned) are presented in Table 2. In the 1979/80 *maha* and 1980 *yala*, varieties released during the period from 1970 to 1979 covered around 77 to 78 percent of the total rice area planted. In 1999/00 *maha* new rice varieties (varieties released during the period from 1990 to 1999) occupied only 33 percent of total rice area planted. In the 2000 *yala* season it was only 26 percent. This implies that rice varieties released before 1990 dominate in farmers' field even in 2000. On the other hand, it indicates the low rate of adoption of newly released varieties.

A close look at the weighted average age of varieties as an index of adoption rate of new varieties reveals a comparative in lower adoption of new rice varieties. The weighted average age of varieties planted has increased over time. This shows that replacement period of rice varieties have increased over time despite the high rate of release of new varieties. In 1980, it was 5 to 6 years. In 2009 it was 16 years. This implies a low rate of adoption of new varieties or low rate of replacement of old varieties with new varieties. This confirms the previous observation that higher percentage of rice area is planted to old varieties which was released before 10 years. The information on the old and new variety cultivated indicates that some varieties such as Bg 94-1 (1975), Bg 379-2 (1980), Bg 300 (1987) released more than 20 years ago are still cultivated by farmers.

Table 2: Indices of Adoption of New Varieties by Season

Season	Number of released varieties during the given period	Proportion sown to recent varieties (I _t %)	Weighted average age of varieties (WA _i , Years)	New varieties (Varieties released during the previous 10 years from the time of point concerned)	Old Varieties (Varieties released 10 years prior to the time of point concerned)
1979/80 <i>maha</i>	13 (1970-1979)	77	6	Bg 34-8, Bg34-6, Bg 94-1, Bg 11-11 Bg 90-2, Bg 94-2, Bw78, At16,	
1980 <i>yala</i>	13 (1970-1979)	78	5	Bg 34-8, Bg34-6, Bg 94-1, Bg 11-11 Bg 90-2, Bg , 276-5 Bw78, At16,	
1989/90 <i>maha</i>	19 (1980-1989)	42	11	Bg 379-2, Bg400-1, Bg 350, Bg 450, Bg 300, Bg380 Bw 351, Bw 267-3	Bg 94-1, Bg 34-8, Bg 276-5, Bg 11-11, Bg 34-6, H4
1990 <i>Yala</i>	19 (1980-1989)	43	11	Bg 379-2, Bg400-1, Bg 350, Bg 450, Bg 300, Bg380 Bw 351, Bw 267-3	Bg 94-1, Bg 34-8, Bg 276-5, Bg 34-6,
1999/00 <i>maha</i>	18 (1990-1999)	33	12	Bg 352, Bg 403, Bg 358, Bg 357, Bg 304, At 353, At 303, At 354, Ld 355, Ld 356	Bg 300, Bg 94-1, Bg 450, Bg 379-2, Bg 350, Bw 351
2000 <i>Yala</i>	18 (1990-1999)	26	12	Bg 352, Bg 403, Bg 358, Bg 304, At 353, At 303, At 354, Ld 355, Ld 356	Bg 300, Bg 94-1, Bg 379-2, Bg 350, Bw 351
2008/09 <i>maha</i>	12 (2000-2008)	8	16	At 362, At 307, Bw 361	Bg 300, Bg 352, Bg 358, Bg 94-1, Bg 359, Bg 360, Bg 379-2, Bg 357, Bg 403, At 353, Ld 356,
2009 <i>yala</i>	12 (2000-2008)	8	16	At 362, At 307, Bw 361, BW 363	Bg 300, Bg 352, Bg 358, Bg 94-1, Bg 359, Bg 360, Bg 379-2, Bg 357, At 353, Ld 356,

Source: Authors' Calculation

Conclusions and Policy Implications

A progression in the use of New Improved Varieties is evident from the decreasing trend in the use of traditional and Old Improved Varieties and the increasing trend in the use of New Improved Varieties. This information can be used to encourage policymakers to continually support and strengthen the current efforts of public rice breeding research and extension. However, data showed that varieties (new improved) released more than 20 years ago are still planted in farmers' fields and there is also evidence of the slow rate adoption of newly released varieties.

On the adoption of new varieties, the study showed accounts of late adoption of new varieties. The replacement period of rice varieties in the country is increasing despite the high rate of release of new rice varieties. Does this reflect that in general, new varieties are inferior to the old ones? These findings should be considered in the policy of variety release and promotion, as it is possible that newly released superior varieties which may not have diffused yet will be crowded-out by more recent variety releases.

It is important that the seed network responsible for promoting new varieties be strengthened therefore, all new varieties would have at least been tried by farmers and taken its potential advantage before it will be crowded-out by varieties tested superior in other locations. The successful performance of new varieties in village demonstration sites, proper information flow of these successes, and the timely availability of certified and registered seed immediately after release must be ensured not to delay the diffusion of the variety. In addition, some farmers' selection varieties such as the case of Pokuru Samba are adopted in farmer fields even though it is not officially released. Thus, participatory breeding and consideration of farmers' selection as strategies for variety testing should continually be explored and pursued.

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Appendix Table 1: Characteristics, Year of Release and Pedigree of Rice Varieties Recommended for General Cultivation

Variety	Year of release	Pedigree	Maturity duration (days)	Higher yield recorded (t/ha)	Attributes
4-4.5 months					
H-4	1958	Murungakayan 302/Mas	135	4.5	Red pericarp, Resistant to BLB
H-8	1966	H-4/podiwee A8	135	4.5	White pericarp, Samba type, moderately resistant to BL
Bg 11-11	1970	Engkatek/H-8	135	6.5	Samba type
MI 273	1971	Gamma irradiated H-4	135		Red pericarp, resistant to BL
Bg 90-2	1975	IR 262/Remadja	120	8.5	High yield
Bg 400-1	1980	Ob678/IR20/H-4	130	8.5	Resistant to GM-1 and BB
Bg 379-2	1980	Bg96-3/ptb33	135	8.5	Resistant to BPH and BB
Bg 450	1985	Bg 12-1/IR42	130	6.0	Samba type, resistant to GM-1
Bw -452	1992	Honadarawala 502/c104	135	5.0	Red pericarp
Bg 403	1993	83-1026/Bg 379-2	120	8.0	White pericarp, resistant to BL, BLB
3.5 months					
H-7	1964	PP/Mas/H-5	105	3.5	Good grain quality
Bg 34-6	1971	IR8-246/PPP/Mas/H501	105	6.5	Red pericarp
Bg 94-1	1975	IR262/Ld66	105	8.5	White pericarp
Bg 94-2	1978	IR 262/Ld66	105	8.5	White pericarp
Bg 350	1986	Bg 94-1/Bg401-1/80-3717/Bg94-1	105	8.5	Red pericarp, resistant to GM-1
Bg 352	1992	Bg 380/Bg 367-4	105	6.0	White pericarp, resistant to BL and BPH
Bg 357	1997	Bg 797/Bg 300//85-1580/senerang M-17	106	9.5	Resistant to BPH, GM 1 and 2 MR to thrips, R/MR to Blast, MR to (Iron toxicity) and low temperature White pericarp. L/M
Bg 358	1999	Bg-12-1/Bg 1492	105	9.5	Samba type, resistant to BL and BLB
Bg 360	1999	84-3346/IR36/Senerang	105	6.5	Good grain quality, resistant to GM I and II
Bw 361	2002	IR36/Bw267-3-11M	105	10.0	Red pericarp Moderately resistant to GM, BPH, BL
At 362	2002	At 85-2/Bg 380	105	10.0	Red pericarp, Moderately resistant to BLB, BPH, BL
Bw 363	2003	IR36/Bw267-3-11M	105	10.0	Moderately resistant to BLB, BPH, BL, GM
Ld 365	2008	Sel Ld 365	105	9.0	Red pericarp, Resistant to BPH, BL, Moderately resistant to GM

Variety	Year of release	Pedigree	Maturity duration (days)	Higher yield recorded (t/ha)	Attributes
3 months					
H-10	1968	PP/Mas/H-5	90	3.0	Red pericarp
Bg 34-8	1971	IR246/pp/Mas/H-501	90	6.5	High yield
Bg 276-5	1979	Ob678/Bg 34-8	90	7.0	Resistant to GM-1
Bg 300	1987	Bg 367-7/IR 841/Bg 276-5	90	7.0	Resistant to GM-1, BPH,BL,BB
At 303	1990	At 66-2/Bg 276-5	90	5.0	Red pericarp, resistant to BL
Bg 304	1993	Co10/IR 50/84-1587/Bg 731-2	85	7.4	White pericarp, resistant to BPH,GM I and II, BL and BLB, good grain quality
Bg 305	1999	Bg 1203/Bg 1492	90	8.0	White pericarp, resistant to BPH,GM I and II, BL and BLB,
At 306	2004	OB2273/At05	90	6.0	Basmathi grain quality Moderately resistant to BLB and GM, resistant to Blast and BPH
At 307	2005	Bg 2225-1/Bg 96-3298	90	7.0	White pericarp, resistant to BPH,RGM and Blast
At 308	2008	Bg 2225-1/Bg 2426-2	90	7.0	White pericarp, Samba type, Moderately resistant to BPH,BL,BLB, moderately susceptible RGM

Source: Rice Research and development Institute, Batalagoda

Appendix Table 2: Characteristics, Year Release and Pedigree of Rice Varieties Recommended for Specific Area/Problem Soils and Quality Attributes

	Year of release	Pedigree	Maturity duration (days)	Higher yield recorded (t/ha)	Attributes
5-6 month					
Specific area- Mawee Lands					
H-9	1968	C104/Mas/Panduruwee	150-180	3.5	Photoperiod sensitive
Bg 3-5	1973	Panduruwee/Mas/Engkatek	150-180	5.5	Photoperiod sensitive
Bg 407	1981	IR5/Panduruwee	150-180	7.5	Photoperiod sensitive, resistant to BB
Bg 745	1981	71-554/podiwee A8	150-180	6.0	Photoperiod sensitive, samba grain
Bg 38	1981	Engkatek//H-4/Podiwee A8	150-180	6.0	Photoperiod sensitive, samba grain
4-4.5 month					
For iron toxic and acidic soils In LCWZ					
Ld 66	1971	H-501/deo-Geo-Woo-gen	135	5.0	White pericarp
Bw 78	1977	H-501/Podiwee A8/H-5	135	5.0	White pericarp, samba grain Resistant to BL
Bw 100	1979	H-501/Podiwee A8/H-5	135	6.0	White pericarp, samba grain Resistant to BL
Bw 400	1987	Bw 259-3/Bw242-5-5	120	6.5	Red pericarp
Bw 451	1987	Bg 400-1/Bg 11-11	135	6.0	White pericarp
Bw 453	1992	IR2071-586/Bg 400-1	135	7.0	White pericarp, resistant to GM-1
At 401	1992	Bg 94-1/ Pokkali	120	5.0	Red pericarp
For dry and intermediate zone with assured water supply					
Bg 380	1982	Bg 90-2/Ob677	120	10.0	Resistant to GM-1
At 405	1997	At 402/Basmathi 442	120	5.6	Basmathi grain quality Moderately resistant to BPH
Bg 454	2005	MR 1523/87-519	128	9.0	White pericarp, resistant to GM, Moderately resistant to blast, BLB
Bg 407H	2005	Bg CMSIA*IR54742-22-19-3R	120	13.00	Hybrid, white pericarp, resistant to Blast, BPH, GM
For southern province					
At 402	1992	IR4432-52-6-4/Bg 90-2/76-3990/ob678	120	7.5	Red pericarp
For Northern Region					
Bg 406	2005	Bg 73-797/ptb33/ob678	120	7.0	Red pericarp, resistant to BPH
3.5 month					
For Southern Province					
At 16	1977	IR8/H-4	105		Red pericarp, resistant to BL
Ld 355	1994	Bw 451/IR50	105	4.5	Samba grain, resistant to BL, BLB

For iron toxic and acidic soils in LCWZ					
Bw 266-7	1981	BW242-5-5-5/ob677/Bg 90-2	105	4.5	White pericarp, resistant to GM-1
Bw 267-3	1981	Ld 125/Bw248-1	105	4.5	White pericarp, resistant to BL
Bw 351	1986	Bg 90-2/Bg 401-1	105	5.0	Red pericarp, Moderately resistant to sheath blight
Saline Area					
At 353	1992	Bg 94-1 ^o /Bg 400-1//Bg 94-1	105	6.5	Red pericarp, MR to Blast and BB good for potential acid saline conditions found in Nilwala scheme
At 354	1992	Bg 94-1/Pokkali	105	5.0	White pericarp saline resistant, resistant to lodging
Kalutara & Galle District					
Ld 356	1994	Bw 451/Bw 351	100	4.5	Short round grain/moderately tolerant to iron toxicity resistant to seed spots and rice gall midge
Wet Zone					
Bg 359	1999	88-5089/Bg 379-2	105	7.0	Resistant to GM 1 and 11 BPH, BL moderately tolerant to iron toxicity
Low Country Wet Zone					
Bw 364 (Bw 1046)	2006	IR 36/Bw 267-3-11M	105	8.0	BPH-MR/MS, BL-MR, BLB-MR/MS, GM-R/MR
3 month Rainfed /Manawari					
62-355	1969	PP/H-5	90	3.0	Red pericarp, tolerant to drought
Low Country Wet Zone, (suitable for mineral half bog and bog soils)					
Bw 272-6b	1981	Bw 259-3/Bw 242-5-5	90	4.0	Red pericarp replacement for Herath Banda, Batapolai, resistant to BL, Resistant to lodging
Rainfed/Dry and Intermediate zone					
Bg 301	1987	1280/H-4	90	6.0	Red pericarp resistant to drought, BL and BB
Saline and Acid					
Bw 302	1987	Bw 259-3/Bw 242-5-5	90		Salinity and acid sulphate soils
2-2.5 month					
Low Country Intermediate Zone					
Bg 750	1981	Ainantsao//75-1870/pp	70	3.0	Ultra short maturity
Drought and Flooded area					
Bg 250	2002	Selection from farmers field	80	4.5	Ultra short maturity RGM-MR/ME, BPH-R/MR, BL-R/MS

Note: BL- Blast, BPH- Brown plant hopper, GM-I -Gall midge (Biotype I) PS- Photo sensitive

Source: Rice Research and Development Institute, Batalagoda

DEVELOPMENT OF HUMAN CAPITAL, A PREREQUISITE TO THE ECONOMIC DEVELOPMENT OF SRI LANKA

P. Chathura Jayampathi De Silva

Abstract

Human factor is considered important to the economic development of a country as it was never before. Human capital refers to the stock of productive skills and technical knowledge embodied in labour. The process of building of human capital should involve investment in basic human development and the development of skills, training as well as the insight of the labour force.

In Sri Lanka, although the indicators of basic human development on the whole are satisfactory in comparison with other developing countries, when the skills development is considered, in terms of training as well as the insight of its labour force, the country seems lagging behind the demand of the global market. This article explains what human capital is, the present human capital situation in the country and why Sri Lanka has so far failed to achieve a competitive advantage in terms of human capital in spite of its commendable success in basic human development achieved over the years. Further it makes some basic suggestions to develop the standard of human capital of the country to match a knowledge based economy and harness the advantage of the ever competitive global market.

Introduction

It is common sense that more than ever, today, it has been prominent the need as well as the importance of the skills and talents of the people for the development of an economy. This is further evident when examining the role human capital has played during the last couple of decades for major and newly developed countries in achieving that height in their respective economic development.

Definitions of human capital are many and varied. A summarized and generalized idea can be produced as the talents and skills developed within human beings by

learning, training or experience which ensure a better performance of their labour.

"Human capital refers to the stock of skills and knowledge embodied in the ability to perform labour so as to produce economic value" (Ratchford -2011)

According to Ratchford's definition, human capital is basically knowledge, skill, or expertise embodied in people and acquired through investment, training or learning by doing.

As Bekers (1923) states, *" Notion of human capital has traditionally been applied to returns on investment in schooling and training , and the relationship between investments in human capital and economic growth"*(p.16)

The view of Foulkes (1975) who emphasizes the importance of human capital to the development is as follows;

"For many years it has been said that physical assets or the capital as the bottleneck for the development. I don't, think this any longer holds true. I think it's the work force that does constitute the bottle neck for development. And I think this will hold true even more in the future,"(p.71)

According to above definitions and accounts, it is clear what human capital means, how it is formed as well as the importance of it in the development of an economy. It is accepted that among the causes of strong growth or poor performance of the economies, the level of commitment of the particular economies to the human capital is highly significant. The other influential factors consist of nature of investment in infrastructure, efficiency in absorption of advanced technology and stability of political environment (Jones -1993)

Human capital is largely related to the human development of a country and a higher standard of human development very often leads to a better or the improved standard of human capital as well. It is fair to say that the standard of human development in a country primarily depends on the level of economic development of the particular country. As such, it is natural for economically strong countries to have a better standard of human development than developing countries. However, as the level of human development is crucial to the formation of human capital which is very much important to achieve the competitive advantage of the global market, it is essential and a prerequisite for the developing countries to pay more attention to develop the level of human capital. Nevertheless, many developing countries are still lagging behind in their

development of human capital to match the competition in the global market. Human development records of many developing countries are far from satisfactory. Many African as well as Asian countries, except those East Asian countries which have shown a significant economic development in the recent past, are still very much backward even in their primary human development indexes. According to many critics, the poor economic development of the South Asian region in comparison to East Asian countries has to a great extent caused by the difference in human capital development in the two regions over the years.

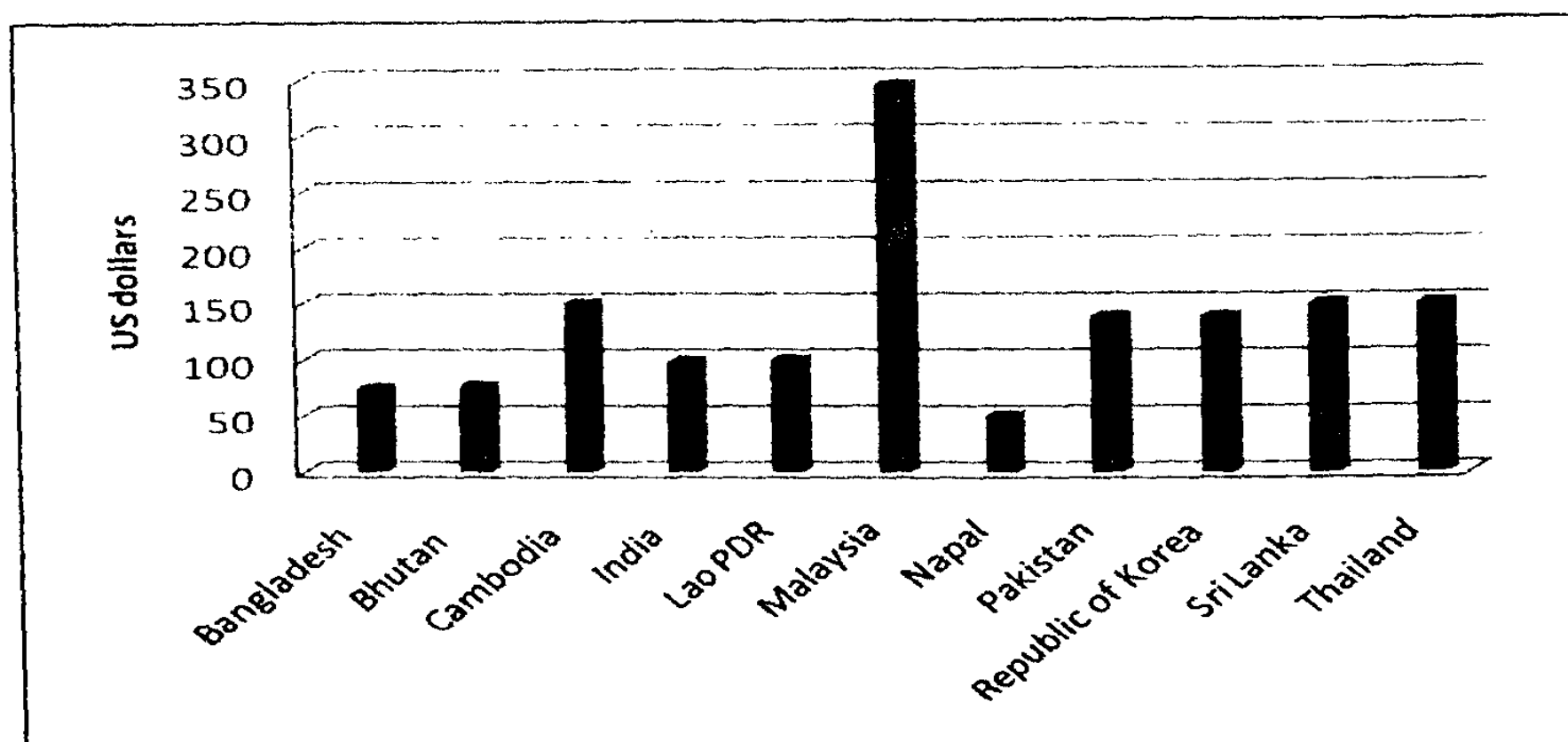
The role of human capital in economic growth and development is receiving its due theoretical recognition and value. In the traditional neoclassical growth models developed by Robert Solow and Trevor Swan in the 1950s, the output of an economy grows in response to larger inputs of capital and labour (all physical inputs). Non-economic variables such as human capital and or human health variables have no function in these models. As a result, these models were not sufficient to explain the exceptions caused by non economic variables in the economies. This caused the emergence of new paradigm in the literature, mostly due to Paul Romer (1986). This paradigm is now commonly known as "endogenous growth models". By broadening the concept of capital to include human capital, the new endogenous growth model argues the validity of the law of diminishing returns to scale phenomenon of the neoclassical growth models. In simple terms, what this means is that if the firm which invests in capital also employs educated and skilled workers who are also healthy, then not only will the labour be productive but it will also be able to use the capital and technology more efficiently.

Just in line of the above logic, it can justifiably be argued that East Asian countries which were in the same level of per capita income as the south Asian developing countries and the other less developed Asian countries in 1960s could achieve a remarkable economic development today by passing the latter groups among other things due to giving the proper concern to develop human capital at the right time. As Figure 1 shows, Sri Lanka enjoyed the highest per capita income than all other countries after Malaysia in 1966 while the Republic of Korea had less per capita income than Cambodia, equalling with Pakistan.

In the light of this phenomenon, the pertinent question that emerges is what factors led East Asian countries to achieve an overwhelming economic development in the last four decades in terms of their GNP per capita income which has risen to a surprising level in comparison with South Asian countries and other less developed Asian countries. Evidently the factors could be

numerous from social to cultural, from economic policies to institutional development, geographical location to opportune time. Yet it is argued and accepted that the impact of human capital dimensions blended well with the right formation of up physical assets contributed to the difference.

Figure: 1. GNP per Capita Income (in US\$) of Selected Asian Countries, 1966



Source: <http://www.adb.org/data/statistics>

Objectives of the Paper

The prime objective of this paper is to elaborate the importance of human capital development to achieve a higher economic development of the country.

The other objectives are,

- Pointing out that the changes should take place in the present education system to produce more skilled and talented labour force
- Emphasizing the need of proper English education for children to make them fit well to the looming knowledge economy
- Emphasizing the need of proper and relevant on the job training for every category of workers for better performance
- Pointing out the importance of right investment on Research and Development for the development of human capital
- To emphasize the need to improve the level of ICT in the process of becoming a knowledge hub
- To explain the need to promote the technical & vocational training to infuse the talents and skills of the majority of the labour force

Level of Human Development in Sri Lanka

Among developing countries, the achievement of primary human development standard of Sri Lanka is outstanding and commendable. A comparative description of some of the indicators with its south Asian neighbours is given below in the Table no. 1. These achievements of Sri Lanka in human development is significantly outstanding not only among those of most of its close neighbours in South Asia but also closely tally with those indexes of most of the developed countries as well.

Table No: 1. Primary Human Development Indicators of South Asia

Index	Country							
	Afghani stan	Bangla desh	Bhutan	India	Maldi ves	Nepal	Pakis tan	Sri Lanka
Life Expectancy at birth (%)	49	69	68	67	78	70	66	75
Adult Literacy (%)	29	57	47	61	93	60	55	91
Net Primary Enrolment (%)	–	94	–	92	95	79	72	99
Population Growth (%)	2.7	1.2	1.7	1.4	1.3	1.7	1.8	1.0
Fertility Rate (%)	6.2	2.2	2.3	2.6	1.7	2.7	3.3	2.2
Under Five Mortality Ratio (per 1000 live birth)	101	46	54	61	11	48	72	12
Maternal Mortality Ratio (per 100,000 live birth)	460	220	180	200	60	170	260	35

Source: [http://www. data.worldbank.org-2008/2011](http://www.data.worldbank.org-2008/2011)

When comparing above human development indexes of other South Asian countries with those of Sri Lanka, it is fair to say that Sri Lanka's record is far excellent.

However, though Sri Lanka has not achieved a high economic development and still falls into the category of lower middle income countries, it is surprising how the country managed to achieve a basic human development record which closely tallies with that of economically developed countries.

Table No. 2: Per Capita Income of Sri Lanka

Per Capita Income of Sri Lanka				
	2008	2009	2010	2011
At current Prices (Rs)	212,972	233,716	267,967	310,059
At current Prices(US \$)	1,966	2,033	2,370	2,804
At Constant (2002) Prices (Rs)	114,269	118,384	126,500	135,719

Source: <http://www.Statistics.gov.lk>

The basic human development indexes of several fast developing economies in Asia presented in the Table No.3 is a better comparison to show how closely the record of Sri Lanka's human development tallies with them.

Table No. 3: Human Development Indicators of Several Fast Developing Countries in Asia

Index	Country				
	Hong Kong	Malaysia	South Korea	Singapore	Sri Lanka
Life Expectancy at birth (%)	81.9	73.7	77.9	79.4	75
Adult Literacy (%)	-	88.7	-	92.5	91
Net Primary Enrolment (%)	93	95	99	-	99
Population Growth (%)	0.9	1.6	0.3	1.1	1.0
Fertility Rate (%0	0.9	2.9	1.2	1.4	2.2
Under Five Mortality Ratio (per 1000 live birth)	-	12	5	3	12
Maternal Mortality Ratio (per 100,000 live birth)	-	30	20	14	35

Source: <http://www.data.worldbank.org-2008/2011>

Causative Factor of Basic Human Development in Sri Lanka

It is obvious that Sri Lankans enjoy a higher level of human development standard in comparison with those other developing nations as pointed out above. However, this is not a recent trend. Well over five decades this high level

of human development has been experienced by the people in the island. With comparatively lower income conditions, enjoying some almost equal basic human development indicators with economically developed countries is a surprise. This contrasts the opinion of mainstream economists who held the view that improvement in human development indicators generally follow rather than precede economic growth and the rising levels of income. The answer for this particular question as to how Sri Lanka was able to raise the human development levels of its people considerably before their economy attained any sustainable level is through welfare interventions.

Welfare measures to ensure a better life standard for the whole population in the country was initiated broadly when the country was still under the British rule.

Changes of Governance and Welfare Interventions

In 1931, under the Donoughmore constitution, significant political power was given to the local population. Universal adult suffrage granted by the Donoughmore commission made government responsible for the people, raising the number of voters from around 0.2 million to 1.5 million. The legislature of the new constitution also had fifty members elected on universal adult suffrage and a Board of Ceylonese Ministers chosen among the elected members. This made the legislature more responsive to voters' demands. Education and the health services so far limited to a few in urban as well as the estate sector, took momentum of extension in response to a clamor from the electorate in the mid 1931 and 1936. The state assumed much more responsibility for the provision of education and health service. The government appointed a Special Committee on Education to investigate all aspects of the education system including the education related problem arising from the heterogeneous nature of the Sri Lankan society and the competing interests of the state and private organizations controlling the education system. In accordance with the recommendation of the committee (Sessional Paper xxiv of 1943) education was made free from kindergarten to university in 1945.

Medical treatment was also provided free, subject to an income limit, in all hospitals, clinics and dispensaries, but the income limit was rarely enforced as there was inadequate machinery for the investigation of income. During the 1930s, there was some increase in the number of hospital beds, health institutions, and health personnel provided through the country. After independence, the development of health services and education facilities was expanded further. In the health sector, the number of western-type health

institutions increased rapidly. During 1950-60, the number of hospital beds went up by 49 per cent and the major categories of curative health personnel doubled, thus keeping well ahead of the population increase. (Lakshman -1997)

Table No. 4: Growth of Health Facilities

Facility	1926	1930	1940	1950	1960	1970	1980	1991	2005	2010
Beds	8089	9477	11992	19959	29816	37735	42275	42437	60237	69,501
Hospitals	98	112	138	370	397	408	384	365	619	568
Central Dispensaries	543	595	632	240	283	332	339	275	413	475
Doctors	285	341	404	674	1173	1932	2055	2934	10198	15283
Nurses	437	605	744	1387	3232	5542	6834	9934	19934	27494
Indoor Patients (Mn)	0.21	0.21	0.38	0.90	1.40	2.10	2.89	2.63	4.34	5.47
Outdoor Patients (Mn)	2.9	3.9	5.4	14.1	24.6	23.0	26.9	28.6	42.5	48.78
Population per bed	609	554	534	385	332	332	349	406	326	297
Population per Health Worker*	4472	3876	3693	2805	1795	1442	1489	1226	594	482

Notes: * Doctors, Nurses and Assistant and Registered Medical Officers (AMO/RMO)

Sources: Social Policy in Sri Lanka, Patricia J. Alima in *Dilemmas of Development*, 1997 and Department of Census and Statistics, 2005, Ministry of Health, Family Health Bureau, 2007, OECD/World Health Organization (2012)

On the other hand, educational facilities were made as widely available as possible, so that those with ability might compete for the best jobs, irrespective of their background. The original emphasis of the education system on general literacy and turning out persons for middle-class occupations continued.

In addition to the provision of free health and education facilities, in the 1940s state intervention started to maintain minimum consumption levels as well. Provision of free mid-day meal to some categories of school children started in 1945 and extended to all school children by 1950. The most significant measure undertaken in this line was the attempt to relieve food shortages during the war by the creation of Department of Food Supply in January 1942. The main activity of the department was to distribute essential food items including rice, sugar, curry stuffs and milk foods to the whole population on a scheme of rationing. After the war, although food shortages eased gradually, the schemes introduced during the war were carried on as means of stabilizing the cost of living.

The above mentioned welfare measures initiated by the state could be continued only for a few years after the political independence in 1948 without being a much burden to the government budget. The accumulation of external assets during the Second World War, which resulted from severe import restrictions and high prices fetched by major exports was considerable, hence the welfare measures could be adopted fairly well during the period short after the war. But the questions were raised about the continued viability of these measures during the 1950s. However, the election of a government with strong social democratic ideals in 1956 ensured that the maintenance of these measures continued well into the 1960s. The growing financial burden of maintaining the welfare state compelled subsequent governments to make ad hoc adjustments in the policy regime, but until 1977, the UNP government introduced open market economy, no fundamental readjustment of policy was undertaken to give lower priority to welfare objectives. However, it would be wrong to argue that objectives of social welfare were totally neglected or abandoned even after 1977. While the budgetary allocations for the health and education services were not trimmed or cut off, food subsidy was abandoned with the introduction of the food stamp scheme in 1977.

Even though successive governments which came to power after 1977 accepted market economy as a policy, continued with free health and education services while operating some social safety networks such as Janasaviya and Samurdhi to minimize the impact of high inequality of income distribution. However, all these measures act as a mark of the commitment of Sri Lankan state to further continue the social welfare of the people on one hand, it can also be easily argued that these measures have been used by politicians by and large for their own political survival throughout the post independent era.

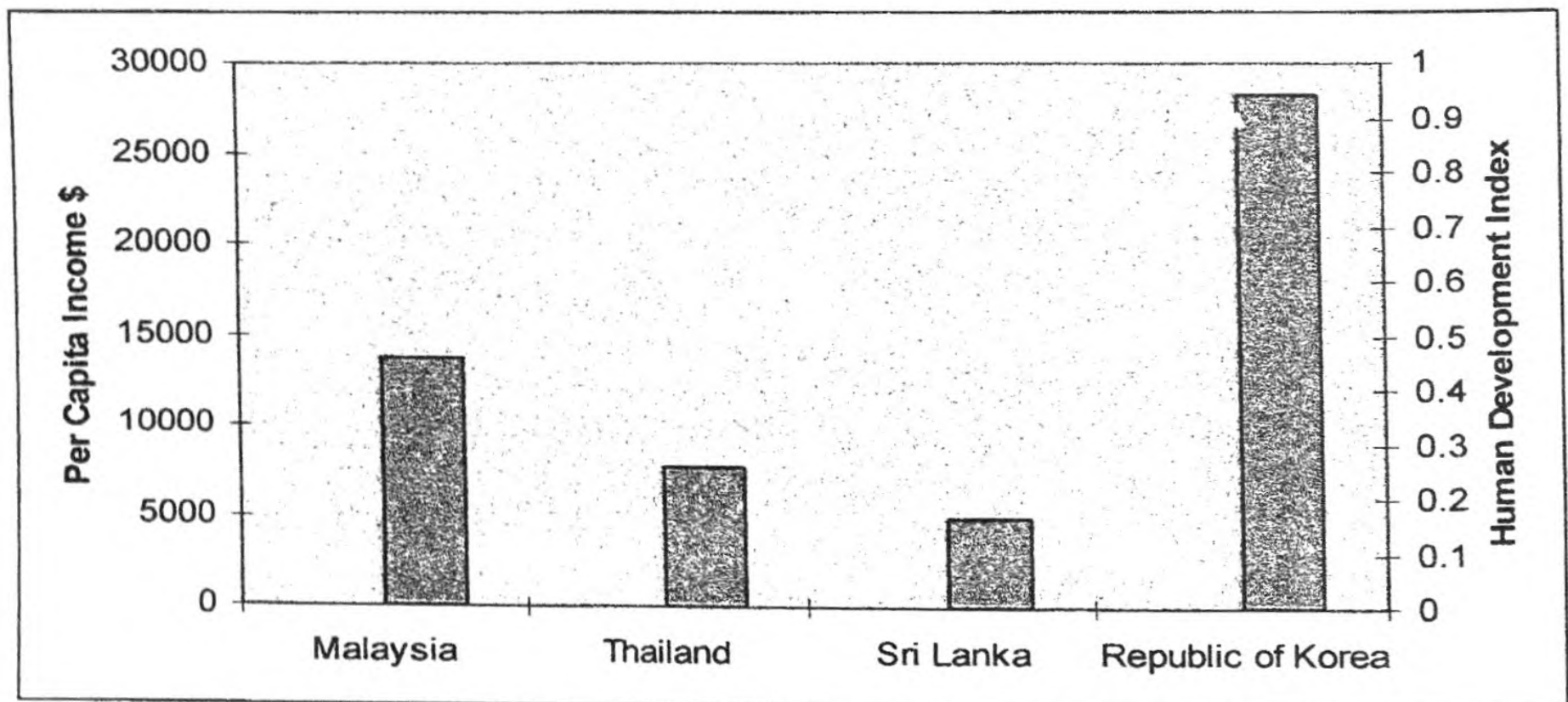
Level of Human Capital in Sri Lanka and its Determinants

It is evident from above, the commitment of Sri Lanka to develop and maintain a higher basic human development standard from the time it was under the British rule to date, has paid rich dividends. This is evident not only in comparison with its neighboring countries but also with other developing countries. However, one may also justifiably argue that this basic human development standard of the country is rather than genuinely purposed, is a by-product of the means, by and large used by the politicians especially after 1950s to maintain their popularity and political survival. More over the majority of the policy makers were blind to the genuine concerns of the country's real economic development and were inclined more to the measures of social- welfare which help wield political power.

This affected negatively in building of physical assets and promotion of especially skilled labour and talents which is the real human capital more productive to the economy. Priority in allocation of limited resources seems very often had given to perpetuate the irrationally planned subsidies and average well being, rather than to foster an overall economic development. Consequently, this phenomenon has caused the country to fail in achieving an economic development commensurate with its basic human development.

The following graph shows the Human Development Index (HDI) and the per capita GNI of Sri Lanka and the several South East Asian countries. This evidence shows despite the country's comparatively closer tally with the South East Asian countries in terms of HDI, how far it is away from achieving the corresponding economic development.

Figure 2: Sri Lanka's Level of HDI Relatively to Several Selected Asian Countries



Source: undp.org/en/data/profiles

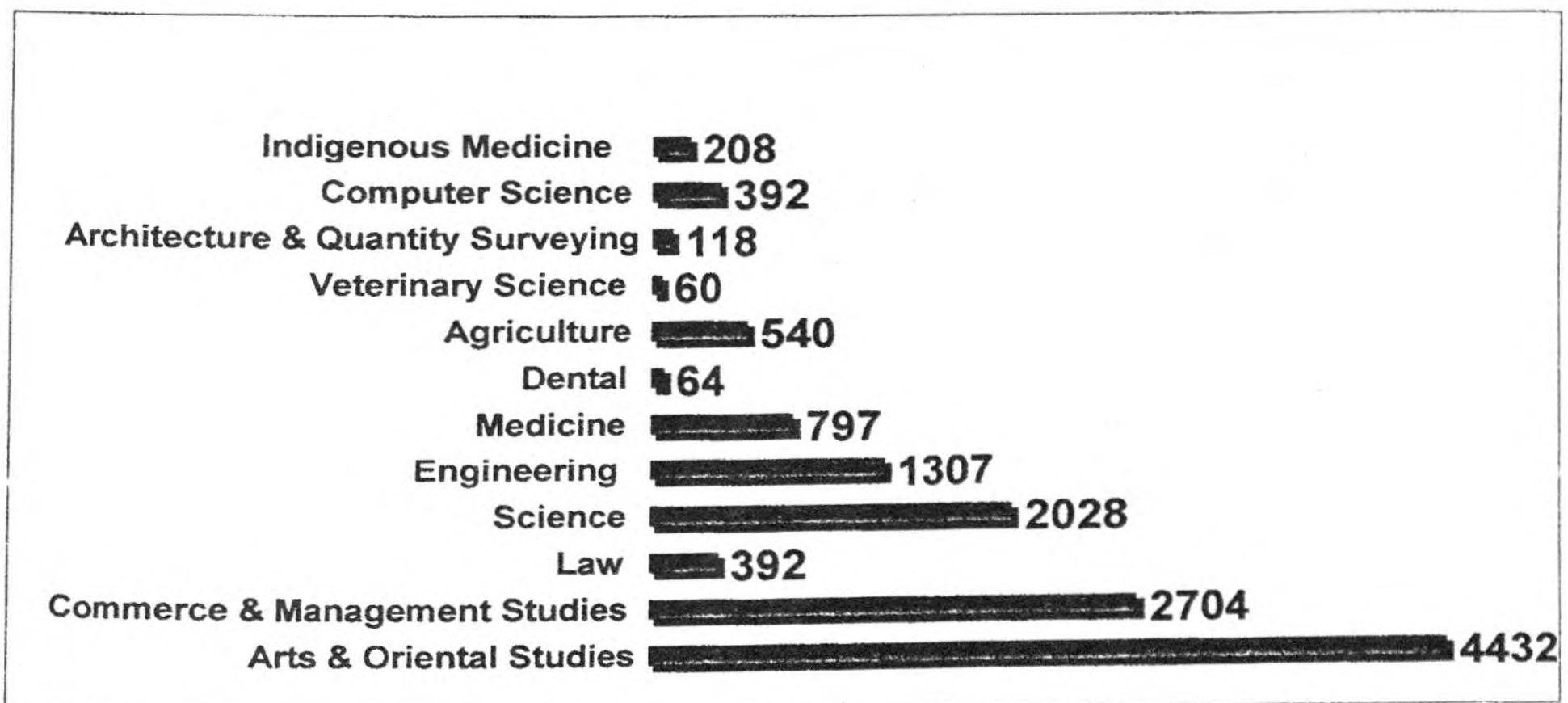
As widely accepted, in Sri Lanka among other things the inherent lapses in the education system have hindered the formation of human capital. It is not an exaggeration, that firstly with the throwing away of English as the medium of instruction in schools and universities gradually degraded the quality of education of the country. Due to this, critics opine that the free education as envisaged by Dr. C.W.W Kannangara, the father of free education, has not become a 'pearl of great price' instead a cheap imitation and not a genuine ornament. Over the decades, it became clear that in the modern world education received exclusively in and

through Sinhala or Tamil prevented children from rising as far as their natural talent could take them.

The majority of graduates educated with the public finance as alleged by critics have become unproductive or unemployable resulting in a huge loss to the country. They opine that because of the outdated and improper educational policies and systems that operate in the country. In contrast to a country like China, South Korea, Singapore where more than 50 percent of the total undergraduates enrolled in the courses of Science and Technology, in Sri Lanka the majority of undergraduates enroll in courses which are of less contribution to the direct enhancement of the economic productivity of the country. Eventually, this has been the reason for those virtually blessed with the opportunity of entering the university after a huge competition to be labelled as a heap of heads with no much use or validity in the development process.

Following graph shows the total enrolment of the undergraduates in the university system in 2011.

Figure 3: Intake of Undergraduates to Universities - 2011



Source: <http://www.ugc.ac.lk/en/university-statistics-2012.html>

It is also obvious that there has been no proper planning or thinking given fairly in advance for the development of a skilled, trained and professional human resource at an adequate pace to face the country's future challenges. As a result,

the country is currently lagging behind in terms of the skilled, trained and knowledgeable human resources to suit the demand at global level.

Sri Lanka is a lower middle-income country. It is required to accelerate economic growth and enable Sri Lanka to become a high-middle income country. In the promotion of growth, developing knowledge-based industries and services is imperative. This is also a prior condition for the country to develop as a knowledge hub. Talents, skills and Knowledge are central to the transformation of the economy, as they are the key ingredients of growth in the modern global economy. Education system of a country bears this utmost responsibility of developing its human capital to support the economic development. As a result, the authorities should realize that the country's education system changes and develop to meet the challenge.

Future Challenges in Education

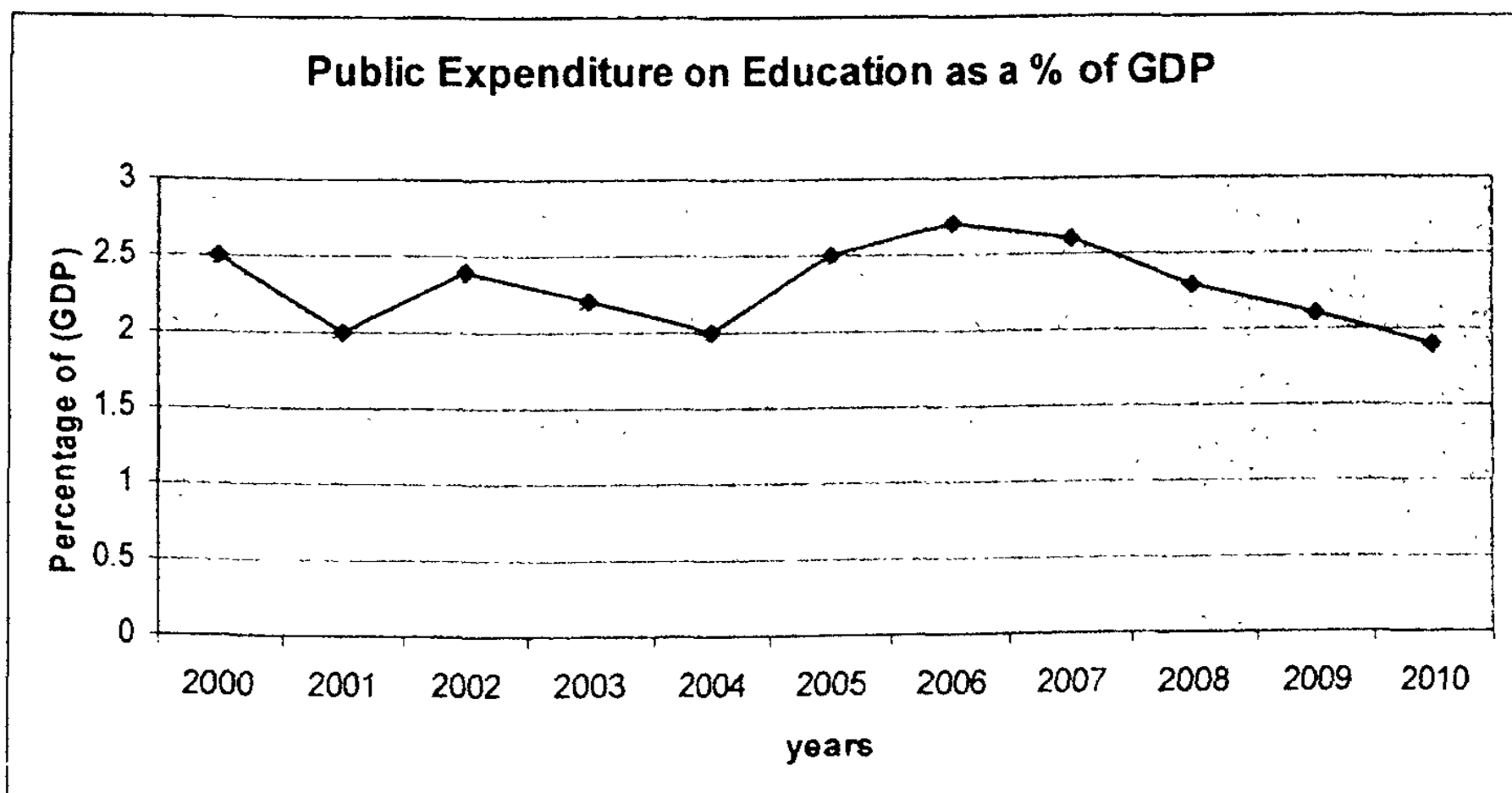
Firstly, the skills and competencies required for modern knowledge-based economic activities have become considerably more complex in comparison to the past. For instance, while many jobs in the past could be performed with routine manual and cognitive skills, today, many jobs require expert thinking and non-routine analytic skills; such as the ability to identify and solve new problems, and complex communication and non-routine interactive skills; such as the ability to elicit, utilize and communicate critical information. The main focus of policy attention in the past was on basic education. However, there now needs to be a greater policy focus on secondary education, which has to be transformed into a human capital production system that generates complex skills broadly to enable the country to compete in the knowledge economy.

Secondly, key skills for a knowledge hub, such as proficiency in English language as already mentioned, information and communication technology, science and mathematics need to expand considerably. The capacity of the secondary education system to produce these skills and talents in proportionate to the adequate standards of quality has been poor. Fluency of English language, which was not promoted adequately in Sri Lanka from 1956 onwards is particularly an acute constraint on the entire education system and the labour market. Science and mathematics skills are also acutely limited. For instance, there are about 2,650 secondary schools offering GCE A/L courses (ages 16-18) in the country. Yet, only about 600 schools (23 percent of secondary schools) offer GCE A/L science and mathematics. Further, nearly all the students who are enrolled in science-based university degree programs, such as medicine, engineering, IT and the sciences come from about 200 of these schools. This suggests that only 8

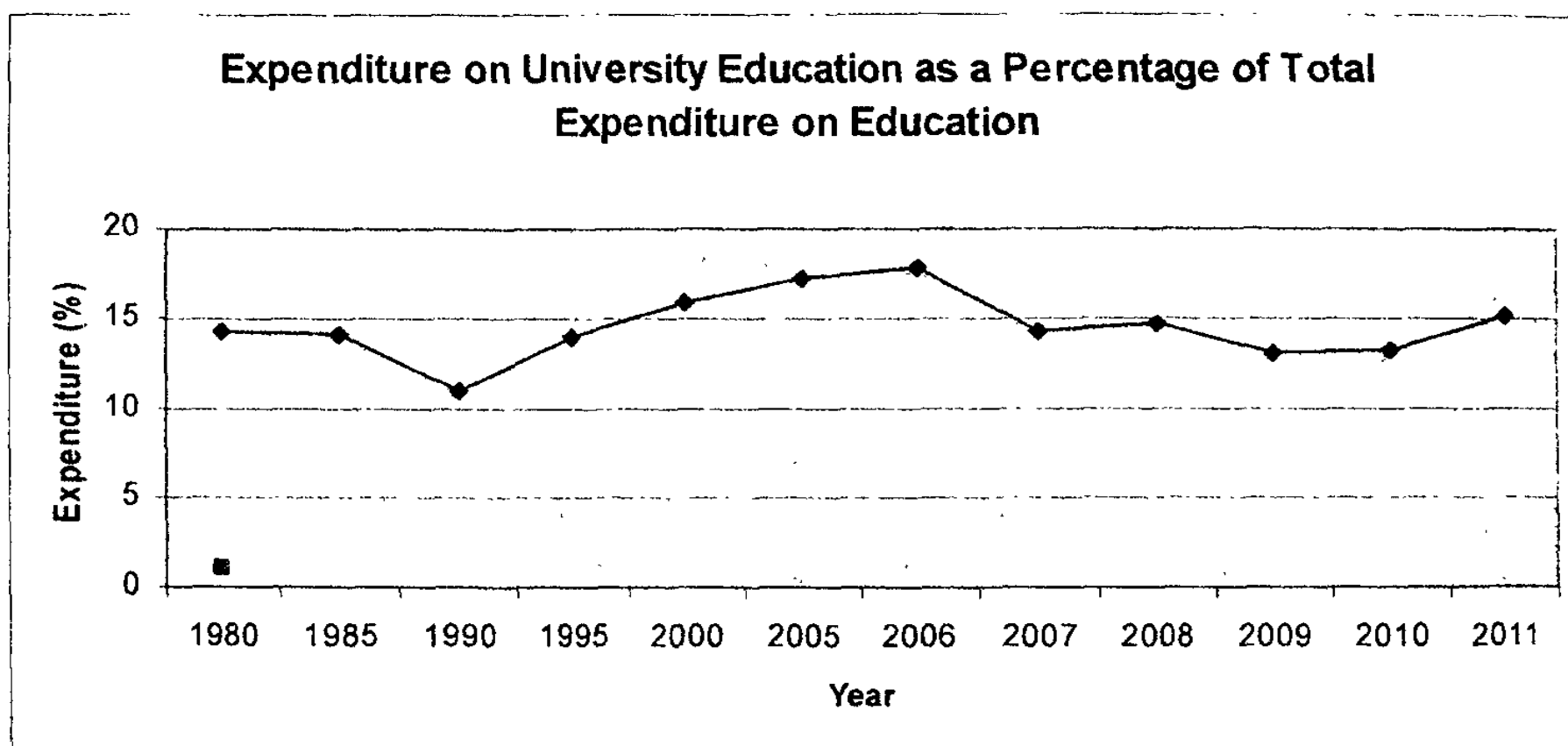
percent of secondary schools are currently of adequate standard to support a knowledge-based economy (Sri_Lanka_education_information_2010).

Thirdly, there are wide regional disparities in the current education system, which need to be addressed urgently in the interests of equity. Differences in education outcomes between the developed Western Province and some of the other less developed provinces are sharp. On the whole, the country's expenditure on education apparently low and being eroded annually despite the challenge of developing the quality of human capital required for knowledge economy. In the following figures numbering 3 and 4 respectively show the share of government expenditure from GDP on education as a whole and that of university education in particular.

Figure 4: Government's Expenditure on Education



Source: http://www.ugc.ac.lk/en/university_statistics-2012.html

Figure 5: Government's Expenditure on University Education

Source: <http://www.ugc.ac.lk/en/university-statistics-2012.html>

Until recently, Sri Lanka apparently had not paid due attention to improve computer literacy as well. A survey conducted by the Department of Census and Statistics in 2006/2007 revealed how poor the level of computer literacy of the school teachers in the country. This while being clearly an obstacle for the teachers to improve their knowledge to keep up with the rapid changes in the global level also invariably affects the quality of their teaching.

The following table shows the level of internet use in some Asian countries. It is an evidence to how backward Sri Lanka had been in that aspect even as recent as the year 2008.

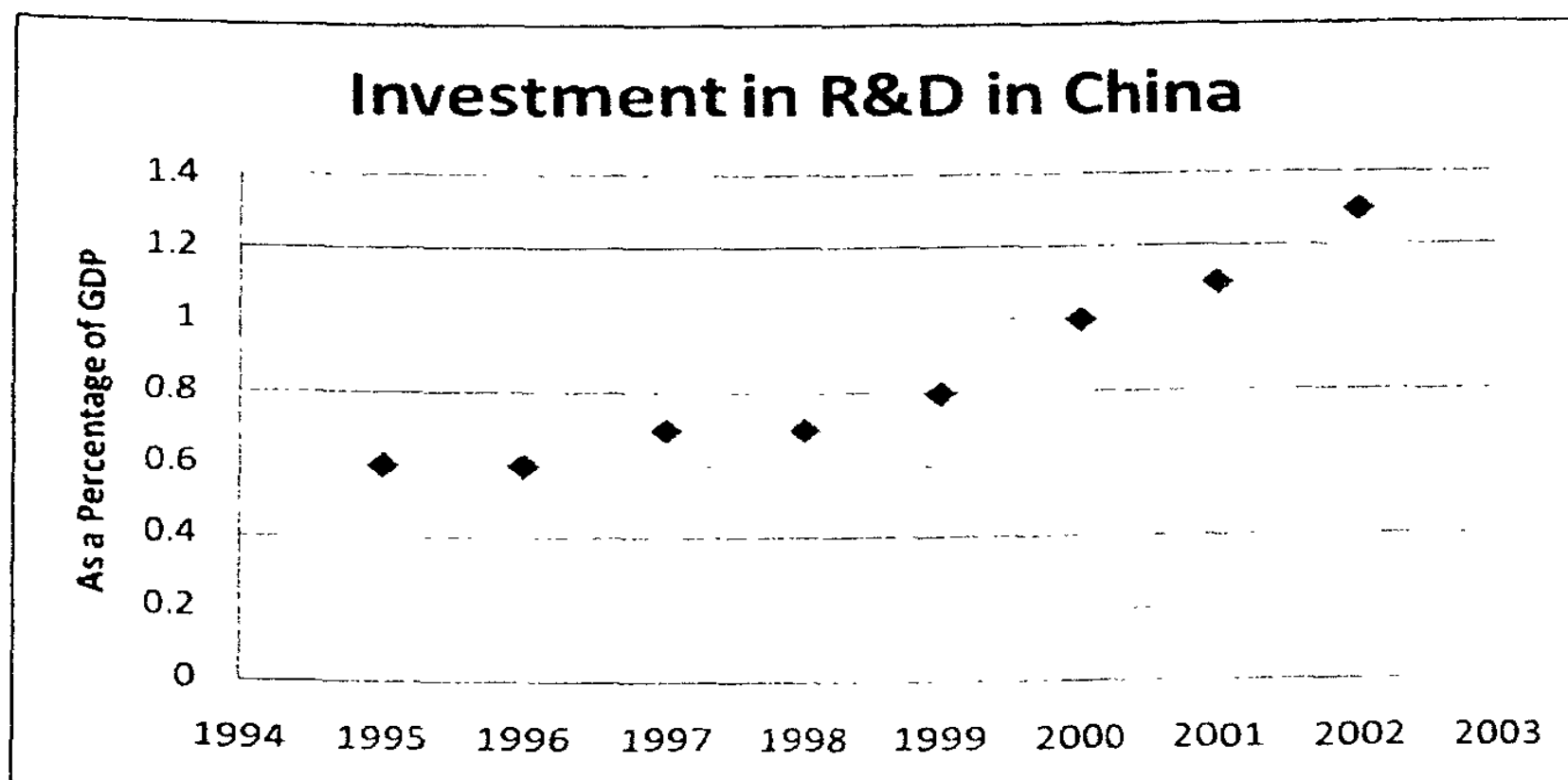
Table 5 shows, in spite of a high literacy record, Sri Lanka's poor performance in terms of the decisive capabilities demanded by the today's knowledge economy.

Table No. 5: Level of Internet Use of Some Selected Asian Countries

Country	No. of People (Per 1000 Persons)
Bangladesh	03
Bhutan	39
India	55
Indonesia	73
Malaysia	435
Maldives	59
Nepal	04
Pakistan	67
Singapore	571
South Korea	684
Sri Lanka	14
Thailand	110

Source: http://www.undp.org/en/media/HDR_2007/2008

This ground reality indicates that Sri Lanka has a long way to go to become a knowledge-based economy and enjoy competitive advantage in the global market. In a knowledge economy ICT, R & D and S & T play a critical role. But in Sri Lanka, the investment in those spheres has not been satisfactory. Nevertheless, technologically developed countries have fairly well invested on the particular aspects in their journey to success. For instance, the following graph shows the priority given by China to the sphere of R&D over the years.

Figure 6: China's Expenditure on R&D

Source: OECD, *An Emerging Knowledge-Based Economy in China?* 2004

Development of Skills and Talents

As already mentioned, the lack of skills and talents in the majority of Sri Lanka's labour force is a significant weakness and it prevents the formation of economically worthwhile human capital. This is indicated in many fronts. Very often administrators from leading private companies are complaining of the lack of qualified people to fill their vacancies while a huge number of educated young people in the country are unemployed. This is caused as they do not possess the skills and talents required by the particular jobs. Poor knowledge of English, computer, lack of experience and training are the major factors. It is evident that this has compelled many private sector companies to look for overseas sources to find suitable candidates to fill their top level vacancies. The biggest danger of this lies in the foreign investment in Sri Lanka in the future as investors are also concerned on the human resource aspect among other factors which are favourable to safe investment. If our human resource or human capital cannot cater to the interests or the requirements of the investors, they may turn back incurring huge losses to the economy.

Lack of talents and skills in our manpower is again evident when considering the low or unskilled overseas jobs in which majority of Sri Lankans are engaged. If the country possesses skilled labour, it alone would be a substantial source of foreign exchange. As a result, it is imperative to have skilled people to get the best advantage of the overseas employment opportunities. The demographic changes and the results in labour shortage looming in most of the developed countries would create more overseas job opportunities in the future, which would require right resources to harness the benefit.

According to the available records more than 90 percent of the Sri Lanka's overseas employees are unskilled. This is a huge loss both to the country as well as to the employees themselves. But in contrast India, though records a lower literacy rate than Sri Lanka in general, has been able to employ many thousands of her people in well-paid jobs requiring high skills and knowledge such as Information Technology in United States and many other western countries. This shows that not in one form of literacy but we should be geared in all the aspect and skills which form the human capital.

Other than that, in Sri Lanka especially the public sector work force is very often criticized for poor performance and the resulted inefficiency of the sector. Their talents and professionalism is often challenged and criticized. This is to a certain extent, while not without, a reason seems a result of inadequacy of the effort and interest taken to improve their skills and attitudes. On the job training is

the best solution to counter the situation and improve the quality of the work force in case right recruitments have not been made. However, within the context of public service of Sri Lanka, on the job training often seems rare, limited, or not to the satisfaction of the employees themselves too.

Though there are ample instances to prove this, just one example is presented here with regard to the Agricultural Research and Production Assistants (ARPAs) widely known as *Krupanisa*, a post of village level officers in the Departments Agrarian Development.

The particular post was created in 1996 with around 9500 employees extracted from the Samurdhi Movement and employed in Agrarian Development Centers (ADC) through out the country. Among the various assignments given, they were also made to support Agricultural Instructor (AI) to carry out extension activities at the village level to fill the vacuum created by the abolition of KVS (*Krusi Viyapthi Sevaka*) post in 1989. However, the ARPAs, not recruited with the qualification to carry out any extension service, have been forced to provide certain extension duties at the grassroot level and understandably have not been able to render a satisfactory service due to having no adequate knowledge to suit the job. In addition, training ARPAs for the job has been irregular, poorly planned and not properly carried out. This is clear from the fact that just only around 1500 of all recruited, receiving training even after a decade since the post was first established. Other than this, it has also been revealed that even the ARPAs as well are not interested in undergoing the training provided for them as one year and two year diploma courses. This is due to the absence of incentives in respect of the successful completion of the training.

This situation has led to the deterioration of the extension support available for farmers at grassroots' level and resulted in a number of issues which hamper the development of the domestic agricultural sector in the country.

The following table, comprising of the data obtained from a survey conducted on the job satisfaction of ARPAs using a sample of 226 officers shows the educational background of the officers. This indicates the need for a better training to them.

Table No. 6: Educational Background of the Agricultural Research and Production Assistants

Level of Education	District							Total
	Matale	K'gala	H'tota	A'pura	Badulla	Kandy	Kalutara	
Up to G.C.E (O/L)	02	01	01	02	01	—	03	10
Passed G.C.E (O/L)	11	14	15	13	03	01	05	62
G.C.E (A/L)-Arts	13	28	12	14	05	03	06	91
G.C.E (A/L)-Commerce	02	09	02	09	05	02	07	36
G.C.E. (A/L)-Science	02	05	06	04	03	00	03	23
Graduates (Arts)	-	03	-	03	01	-	-	07
Agriculture Diploma	—	—	—	—	—	—	02	

Source: Lurdu et al-2007

Measures Needed to Develop the Standard of Human Capital of the Country

It is clear that prevailing situation in relation to the country's human capital poorly matches the both, the current demand of the local as well as the global market. As a result, it needs urgent attention to counter the situation. Due to the fact that we have already achieved a satisfactory development in basic human development, achieving a comparatively better level of development in human capital as well is not a difficult issue. What is needed is taking correct policy measures and making the right investments.

Especially, the education sector of a country is very vital in this aspect. It should necessarily be oriented towards the developing of human resource of the country. The optimum result of the education today is considered as the skills development of the people for economic development. It has been the broad opinion that Sri Lanka's system of education has not properly oriented to produce skilled, trained and productive personals who fit well into the present global market requirements. This mismatch of education and the needs of the global market has become a severe impediment in harnessing the economic

benefits. To rectify this situation necessary changes have to be made in the education system as soon as possible.

As authorities at least belatedly have become cognizance of the need for the changes in education in view of matching it with the current demand of the global market, it is their responsibility to act promptly. To make higher education, in any field of study or discipline more meaningful, relevant changes are necessary in the existing structure of the Universities. The changes need to be made from the point of view of global standard enabling Sri Lankan Universities to become global players in highly competitive global market of higher education. The whole university system in the country, including the academic staff has come under stark criticism for the process of producing graduates who are low in quality. Thus the authorities concerned should pay their attention to change this outlook of the university system because it definitely damages to the intellectual life of the country.

Besides, all institutions of higher education today should cater to the demand of a knowledge economy. A knowledge-based economy needs to add new knowledge and new techniques continuously and be innovative in order to remain competitive in this highly integrated or the globalized world.

However, apart from making necessary changes in the curricula of higher education and introducing innovations to improve the quality of academic staff, it is also a requirement to enable many qualified young people who fail to enter the national universities due to remarkable low intakes, carry on their tertiary education. It should be accepted that the government which makes a very low expenditure on education (In some instances lower than other South Asian countries) is unable to ensure the tertiary education in national universities for all who qualified in the A/L examination. Considering that aspect making joint efforts with the private sector to provide opportunities for those interested to continue their higher education is commendable. That is due to the fact that tertiary education for a significant part of the population is essential in a knowledge economy where human resource is a key player.

Similarly partnership with the private sector to address the demand for higher education will definitely be a solution to the problem in two ways. On one hand it may help retain a huge sum of money that is drained out of the country on overseas education and on the other hand it can provide study opportunities to those who cannot afford overseas education at a reasonable rate within the country. In addition, the extended opportunities for a quality higher education

especially due to the private sector involvement would definitely ensure the ability of our labor to match the standards expected in the global market.

Taking further measures to introduce and popularize vocational training among school leavers is yet another requirement to develop the level of skilled human capital in the country. As vocational training is completely oriented to skill development, it is a better solution to relieve pressure of unemployment in the country while producing skilled labour which is in demand in the labour market. It is also evident that investment in promoting vocational training fetches multiple advantages. For example, investment in vocational training may work as an investment in alleviating the possible youth unrest which may threaten the social stability due to unemployment.

In the attempt of promoting vocational training, further to introducing courses in demand in the global market, attention should also be paid to take these centers as well as courses beyond main cities to rural areas as well to make it more accessible and beneficial to students.

Another factor which makes a huge impact to dry up a country of quality intellectuals and skilled people is brain drain. This may happen due to many reasons such as the interest of higher income and better life standards, absence of justice and fair play, absence of social and political security as well as the want of quality education for the children. Introducing and implementing of required reforms in education while trying to establish a trouble free, business friendly peaceful environment and a just society which ensures the rule of law are the necessities to halt this situation. However, Sri Lanka should at any cost arrest this growing trend of brain drain, as a developing country Sri Lanka cannot afford to lose its best human resource.

Investment in the field of Science and Technology is also imperative to develop the level of human capital in a society. High exposure to new technology broadens the knowledge as well as the skills of the people while accelerating the economic development. For example, especially in today's knowledge-based world, Information and communication technology (ICT) plays a central role in economic growth and productivity. It has been estimated that an increase of 10 mobile users per 100 people can boost GDP growth by almost 1 percent. One percent increase in the number of internet users can boost GDP growth by 4.3 percent according to the World Bank Report- (www.worldbank.org-2008). As a result, it is understood that investment in this sphere is essential. The best way to encourage a high quality and low cost network to develop is by establishing

liberal regulatory structures that allow for competition and private sector participation.

Finally, though Sri Lanka boasts of a high standard of basic human development record, country also records a considerably high percentage of underweight children amounting to 30% among those of less than five years. Similarly around 21 % of the children and 30% of mothers are suffering from anemia. This situation of poor nutrition among those crucial for the future of a country, may definitely lead to creating generations with low mental capacity as well as poor physical vigor, resulting in huge damage to the country in many aspects. As a result, it is very important that the government takes urgent action to rectify the situation.

Conclusion

Human capital and its formation refers to the process of labour force acquiring and increasing the skills, education and experience which are critical especially for the economic development of the country. Sri Lanka, though over the years has been able to acquire and sustain a very satisfactory overall basic human development level for a developing country, its level of human capital obviously requires much concern for improvement. In a world order which recognizes what is detrimental to development of an economy is nothing else but knowledge, human capital formation should grow at a higher rate than the economic growth and the growth of labour force. In the particular process of formation of human capital, undoubtedly the foundation is the country's education. As a result, appropriate changes are urgent while paying prompt attention to the other priorities as well such as right investment in R&D and S&T which help infuse the skills and knowledge in the work force. Skilled human resources plus the rest of the pillars of the Knowledge Economy such as Business Environment, Information Infrastructure and an innovation system eventually would ensure an edge over other countries in the ever increasing global competition to actualize the dream of becoming the miracle of Asia.

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Growth and Instability Analysis for Selected Other Field Crops (OFC) in Sri Lanka

Subashini Perera

Abstract

Sri Lanka government has initiated various production-oriented programmes time to time, which have exaggerated the intensifying level of production of domestic crop sector especially paddy and other field crops. However, still there has been a negative trend in OFC sector with wide fluctuations and extensive instability in regional level. Thus, the government has to depend on imports to meet the increasing domestic demand. This is mainly attributed to low growth in the agricultural sector and vulnerable for food security. Hence this study was undertaken to answer the question of what the nature and extent of growth and instability in area, production and average yield of selected other field crops has been. The national and district level production and cultivation extent figures of black gram, green gram, cowpea and kurakkan were used for the analysis. Compound growth rate and Co-efficient of variation was used to measure the long term growth trend and instability. Based on the different levels of compound growth rates and instability indexes, a matrix was prepared to identify the most vulnerable regions. The results of this study reveal that, Yala season is highly susceptible to fluctuations of production and extent of cultivation. Cultivation of cowpea is more stable though it follows a negative trend. It was also revealed that increasing of the land area under cowpea cultivation in Hambantota district and Mahaweli H is suitable. Kurakkan cultivation is unstable and also pursues a negative trend. However, the prospects of kurakkan cultivation in Northern and Eastern Provinces are high. Black gram and green gram cultivation in the dry zone dose not entail production risk. With immense population pressure and urbanization, land area for crop cultivation in the wet zone would further decline. Proper irrigation support for intermediate zone, crop diversification in dry zone, developing new high yielding varieties and promoting cultivation in North and Eastern provinces would be timely.

1. Introduction

Other Field Crops (OFC) in Sri Lanka mostly include condiments (chili, big onion, red onion), coarse grain (maize and kurakkan), pulses (green gram, cowpea, soybean, black gram) and oil crops (groundnuts and gingerly). Average monthly consumption of OFC s is given below.

Table 1: Average Monthly Consumption of OFC

Crop	Average monthly consumption per person (grams)
Green gram	50.40
Cowpea	24.36
Kurakkan flour	21.39
Black gram	5.78
Maize	12
Soybean	9.08
Other pulses	16.09

Source: Household Income and Expenditure Survey, 2009/2010

Consumption of pulses and legumes enhances the level of protein intake and plays a significant role in Sri Lankans' dietary requirement. In Sri Lanka, the expansion of the production of pulses such as green gram, cowpea, soybean and groundnut has to be considered to supplement protein requirements (Jayawardena, ND).

Currently, OFCs are cultivated in 73,721 hectares in *Maha* season and about 35,448 hectares in *Yala* season in Sri Lanka. Around 63 percent of the total cultivation extent of OFC comes from dry zone areas with irrigation facilities, while 30 percent and 7 percent of the area is distributed in intermediate and wet zone respectively. With the development of *Mahaweli* scheme, irrigated land became right of way in dry zone area and more desirable new varieties of OFC were introduced for cultivation.

However, the level of production of these crops does not fulfil the domestic requirement. As a consequence, the country depends heavily on imports, to fulfill the short fall of domestic production of OFCs. Chili (dry) of which the annual import is around 82 percent of the total availability and big onion, green gram and black gram, the annual imports are around 65%, 50%, and 55% of the total availability respectively (External trade Statistics, 2011). These figures make clear that there is a production deficit of the necessary food commodities and Sri

Lanka is mainly dependent on the imports of several field crops, irrespective of their feasibility for cultivation in the island.

In order to increase the production of agricultural crops, the Sri Lankan government initiated various production-oriented programmes from time to time, which have exaggerated the level of production of domestic crop sector especially paddy and OFCs. However, agricultural growth and its stability have been subjected to much distress when formulating strategies for agricultural development in the country in recent years. In the last two decades, a decreasing trend in production and cultivation extent of OFCs could be observed. These are alleged to be accompanied by considerable annual fluctuations and instability in production, cultivation extent and average yield. These fluctuations in output continued to be a matter of concern. This leads to serious implications in terms of aggregate supply management, price shocks and farm income. Consequently, it destabilizes the viability of OFC sector and lessens its potential to contribute to economic growth as well as food and nutritional security.

Further, the climate of the island has undergone a change that the expected rainfall does not come at the correct time, severely handicapping farmers during the growing season. Water scarcity and excess water have become recurrent problems faced by the crop production in Sri Lanka. Meanwhile, the increasing ambient temperature has also caused several direct and indirect negative impacts on crop growth (Punyawardena, 2012). This has also been accompanied with wide regional variations and cyclical effects of the production fluctuation.

Thus, this study was undertaken to answer the question of what the nature and extent of growth and instability in area, production and average yield of selected OFCs in national level over and above districts level has been. Such information will help decision makers and policy planners for formulating a suitable action plan towards manipulating the area, production and yield of these crops in Sri Lanka.

2. Objectives

To address the above concern, this paper aims to estimate the seasonal and year-round instability and growth rates in area, production and average yield with respect to national level, major agro climatic zones and district level for the selected OFCs. The specific objectives of this study were (i) To review the trend of area, production and average yield during the period of 1979 to 2011, (ii) To estimate the instability in area, production and average yield, (iii) To estimate the growth rates for area, production and average yield based on the Logistic

Growth Model, (iv) Identify the relationship between growth rate and instability and (v) Identify the most vulnerable regions of cultivating of these crops and to provide necessary information and recommendation to policy makers.

This paper is split into five sections. The first section presents the data used in the study and methodology which has been applied to analyze the data. The section analyzes the time series trend with respect to production, area and average yield concerning seasonal, annual and regional variability of selected OFCs. Next, instability in area, production and average yield for considered crops will be estimated. Estimated growth rates for above disciplines and developed matrix for instability and growth rates in each district is given in section four. The final section provides conclusion and recommendations.

3. Material and Methods

The analysis covers the time series secondary data pertaining to production, extent and average yield with respect to district and national level as well as three different agro climatic zones for the period of 1979 to 2011. Mainly, data were compiled from Department of Census and Statistics and import data were gathered from Sri Lanka Custom.

This analysis is limited to four OFCs. Three crops i.e. green gram, black gram and cowpea from pulses were selected concerning vulnerability for higher variation and high import bill. Kurakkan was selected from the coarse grain category due to rapid increase in consumption and dramatic production decline over the past three decades as well as owing high indigenous value among Sri Lankans.

To have an overview of the production, cultivation extent and average yield of these crops, the graphical analysis was employed and examined the change in production patterns over the years. Further, to observe the dynamics of OFC production and extent of cultivation, district and agro climatic zone wise analysis was undertaken. Districts which represent Dry Zone (DZ) are Puttalam, Anuradhapura, Ampara, Hambantota, Udawalawe, Mahaweli 'H'area, Jaffna, Vavuniya, Mulaitivu, Mannar, Trincomalee, Batticaloa and Kilinochchi, Kurunegala, Matale, Badulla and Monaragala represent Intermediate Zone (IZ) and Colombo, Kalutara, Gampaha, Galle, Matara, Ratnapura, Kegalle, Kandy and Nuwara Eliya represent Wet Zone (WZ).

Studies of instability and growth rate related to OFC sector in Sri Lanka are rare. A study carried out by Fernando *et al* (2009) has examined the instability and growth rates of paddy in different agro climatic zones. They have used

coefficient of variation and production risk of cultivation index to estimate instability. Based on the log linear function, growth rates have been estimated. Their results reveal that the highest production stability recorded in wet zone while higher risk in production of paddy involved in intermediate zone. However, some studies carried out in India have used different measurements to find out the instability and growth performance in food grain sector in India.

Sharma and Dhakre (2009) have used semi log exponential function to compute compound growth rates. The coefficient of variation index has been used to study the instability in ginger production in North- East region in India. In order to measure the percentage contribution of area, productivity and their interaction, the technique of decomposition has been adopted.

Growth and instability of major oilseeds in India (Kachroo *et al*, 2010) was estimated using Logistic and Coppock's model for computing close approximation of the average year percent variation adjusted for trend. Prasad *et. al* (2009) has used exponential function to derive the compound growth rate and also coefficient of variation was used to measure the magnitude of instability in area, production and productivity of different crops. Singh and Kaviarasan (2010) have employed exponential function for analyzing growth in area, production and productivity of flowers and they have applied Cuddy – Della Value Index (adjusted coefficient of variation) to assess the instability of time series economic variable affects on flower production.

In this study growth rates are computed by using log linear functions (Gujarati and Sangeetha, 2009). Time series data on production, area and yield with respect to these crops in regional level as well as for the country were used. The equation fitted to analyze the growth rate is semi log exponential form.

$$Y_t = Y_0 (1+r)^t \dots\dots\dots(i)$$

Where; Y_t is extent/production/average yield of selected OFCs in t^{th} time period and r is the compound rate of growth of Y , Y_0 is intercept and t = time in years.

$$\text{Compound Growth Rate (CGR) (\%)} = \{\text{Antilog} (\log \beta_2) - 1\} * 100 \text{ (Gujarati, 2009)} \dots\dots(ii)$$

The growth performance in production, extent cultivation and average yield is carried out for the period of 1979 to 2011 on the selected crops and this estimation was carried out at national level and districts level, under different agro climatic zones representing seasonal variations.

Co-efficient of variation (CV) was used to measure the magnitude of instability in extent, production and average yield of selected four OFCs. In general, the CV measures the amount of variation of the response variable. The index is as follows;

$$CV = (\text{Standard deviation}/\text{Mean}) * 100 \dots\dots\dots (iii)$$

Where; X_t = extent/production/average yield in the year t and \bar{X} = mean of extent/production/average yield.

Further, for better understanding of district level growth and instability scenario based on the different levels of compound growth rates and instability indexes, a matrix was prepared for extent/production /average yield.

Thus, four levels of growth i.e. high, moderate, low and negative and three levels of instability: low, moderate and high instability were considered for the preparation of the matrix. The levels were derived by taking the mean and standard deviation as a measure of check. The grouping ranges as follows;

Category
High > ($\bar{X} + \frac{1}{2}$ SD)
Moderate = ($\bar{X} \pm \frac{1}{2}$ SD)
Low < ($\bar{X} - \frac{1}{2}$ SD)

Where; \bar{X} - mean and SD – Standard deviation

Source: Krishnamurthy & Veerabhadraiah, (1999)

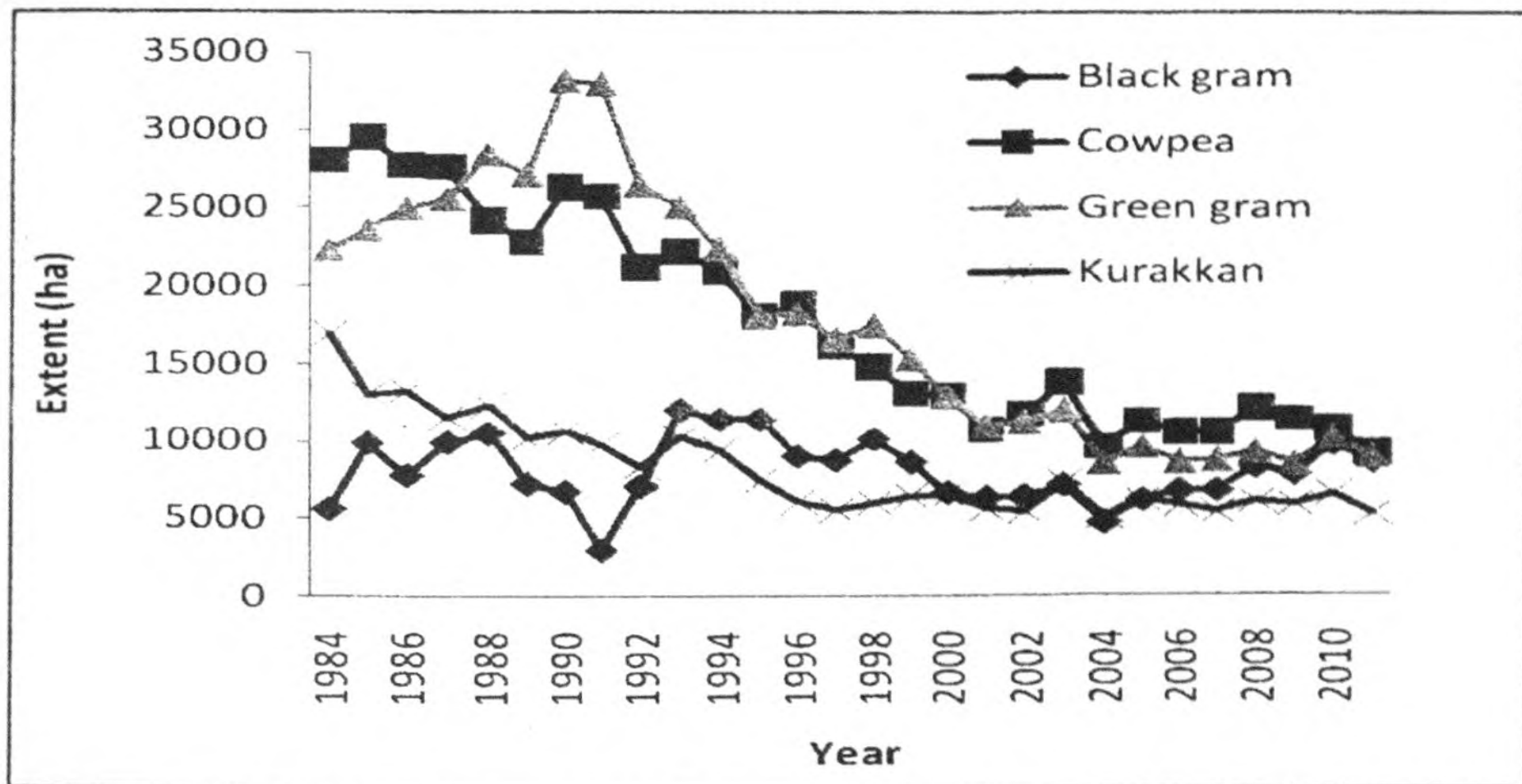
4. Results and Discussion

4.1 Trend Analysis in Production, Extent and Average Yield (black gram, green gram, cowpea and kurakkan)

4.1.2 Graphical Analysis

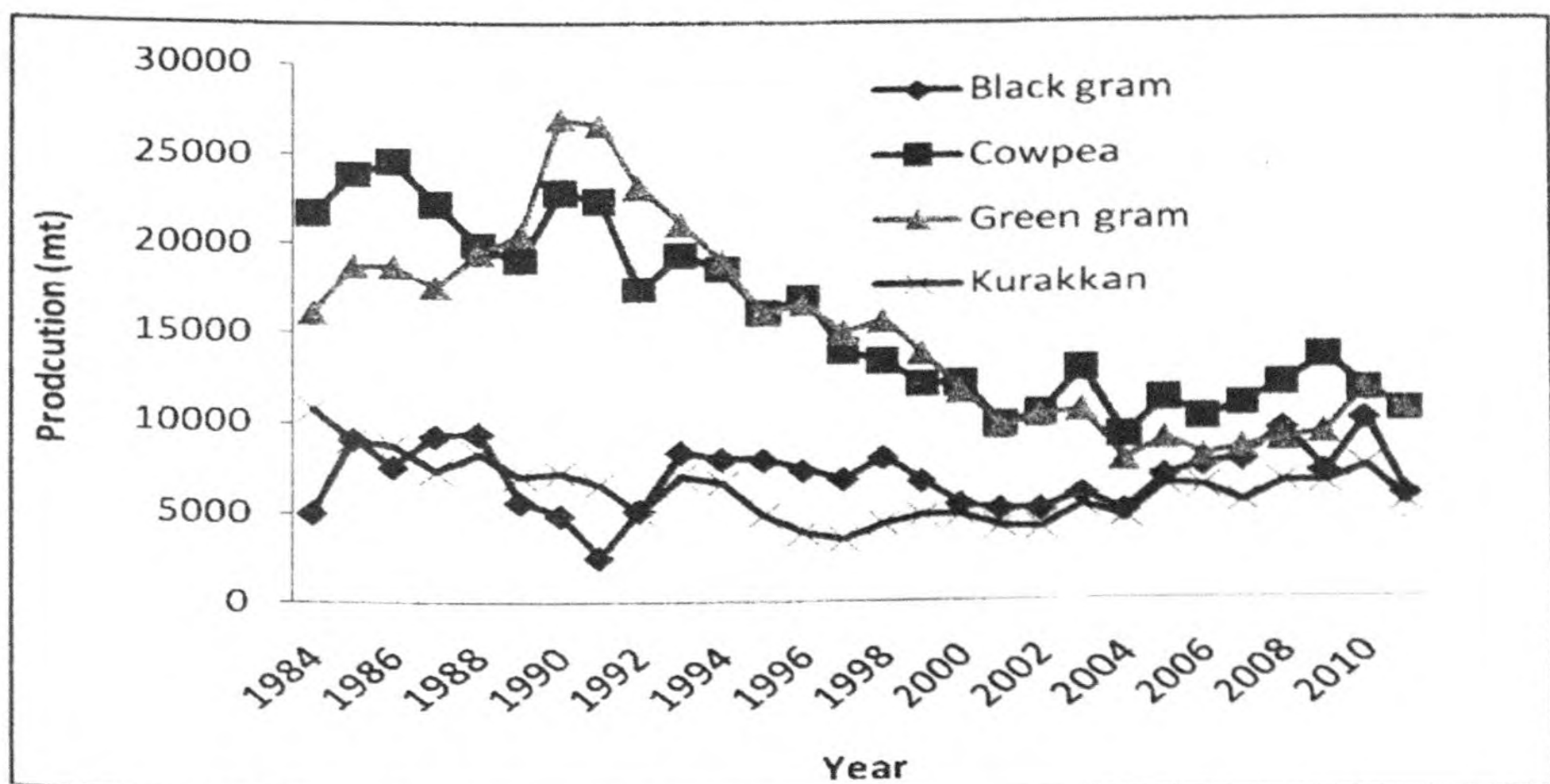
Production and cultivation extent of these crops followed a volatile and drastically declining trend in the last two decades (Figure 1 and 2). During the period of 1985 to 2011, production has dropped by 37%, 56%, 44% and 40% while there was a 13%, 69%, 62% and 60% decline in cultivation extent in black gram, Cowpea, green gram and kurakkan respectively (Figure 1 and 2). Comparably percentage change in production was slightly smaller than the percentage change in extent cultivation due to slight yield improvement except black gram where 33 percent yield drop could be observed (Figure 3, 4, 5 and 6).

Figure 1: Cultivation Extent of Black gram, Green gram, Cowpea and Kurakkan



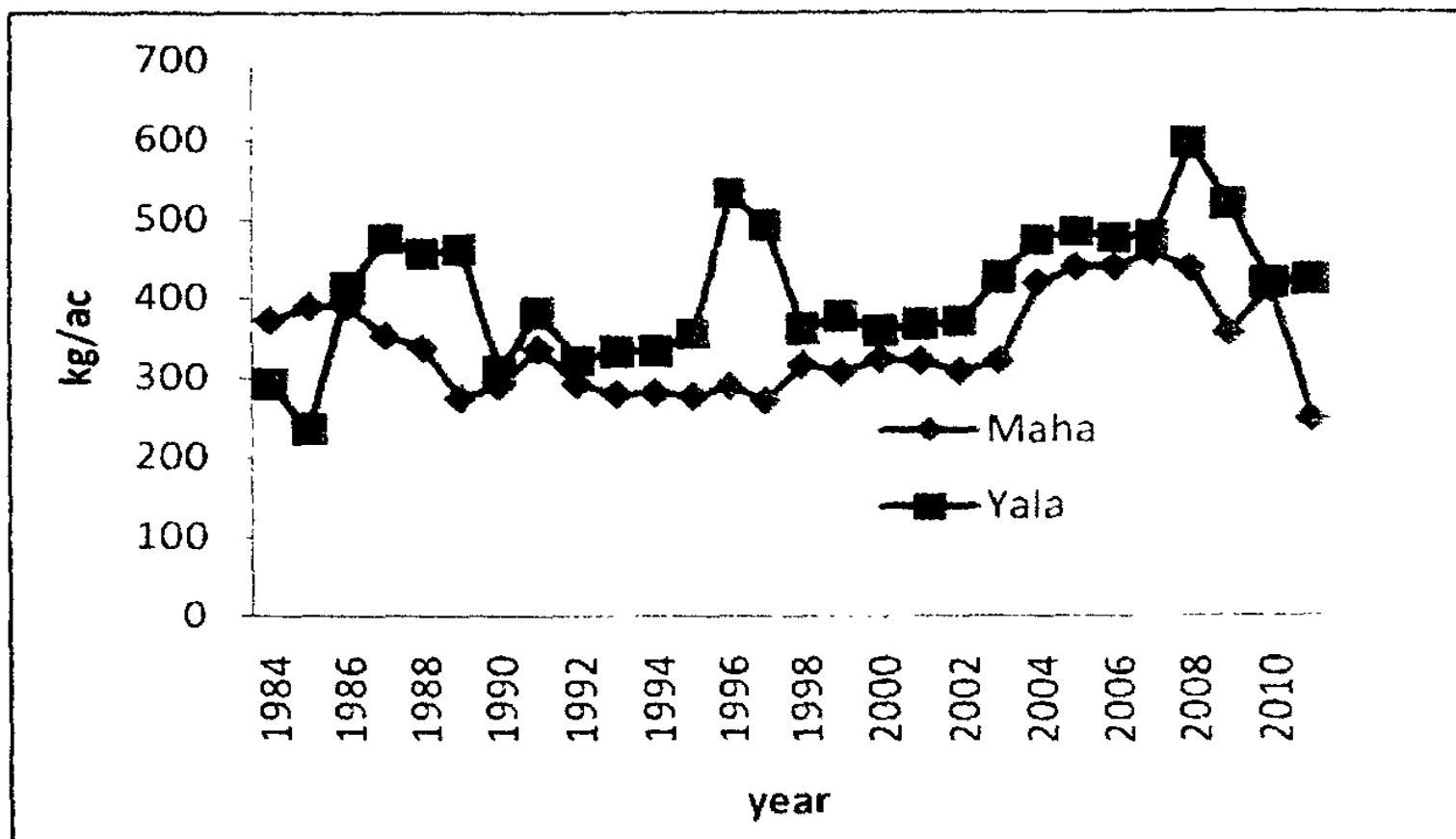
Source: Department of Census and Statistics

Figure 2: Long Term Trend in Production of Black gram, Green gram, Cowpea and Kurakkan



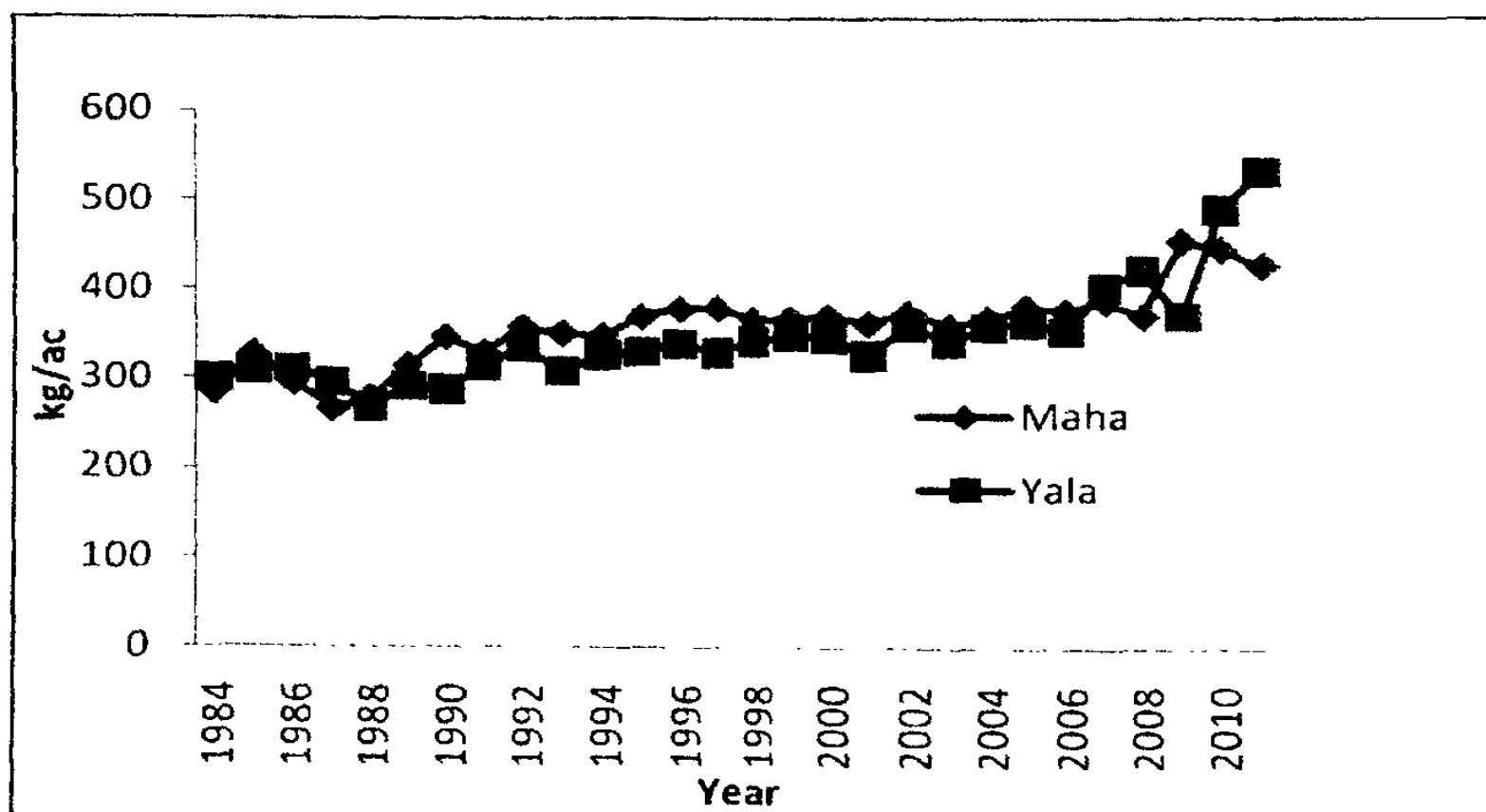
Source: Department of Census and Statistics

Figure 3: Average Yield of Black gram



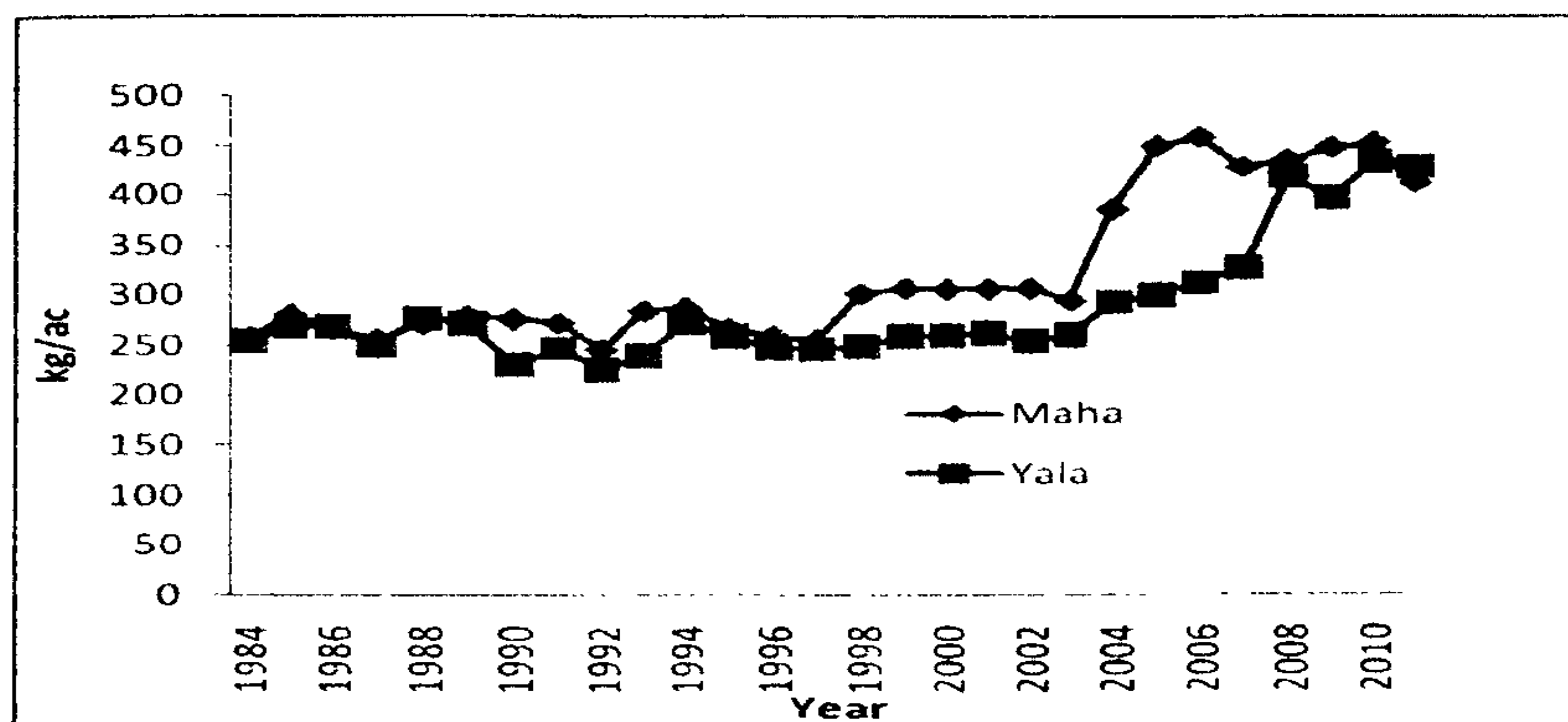
Source: Department of Census and Statistics

Figure 4: Average Yield of Green gram



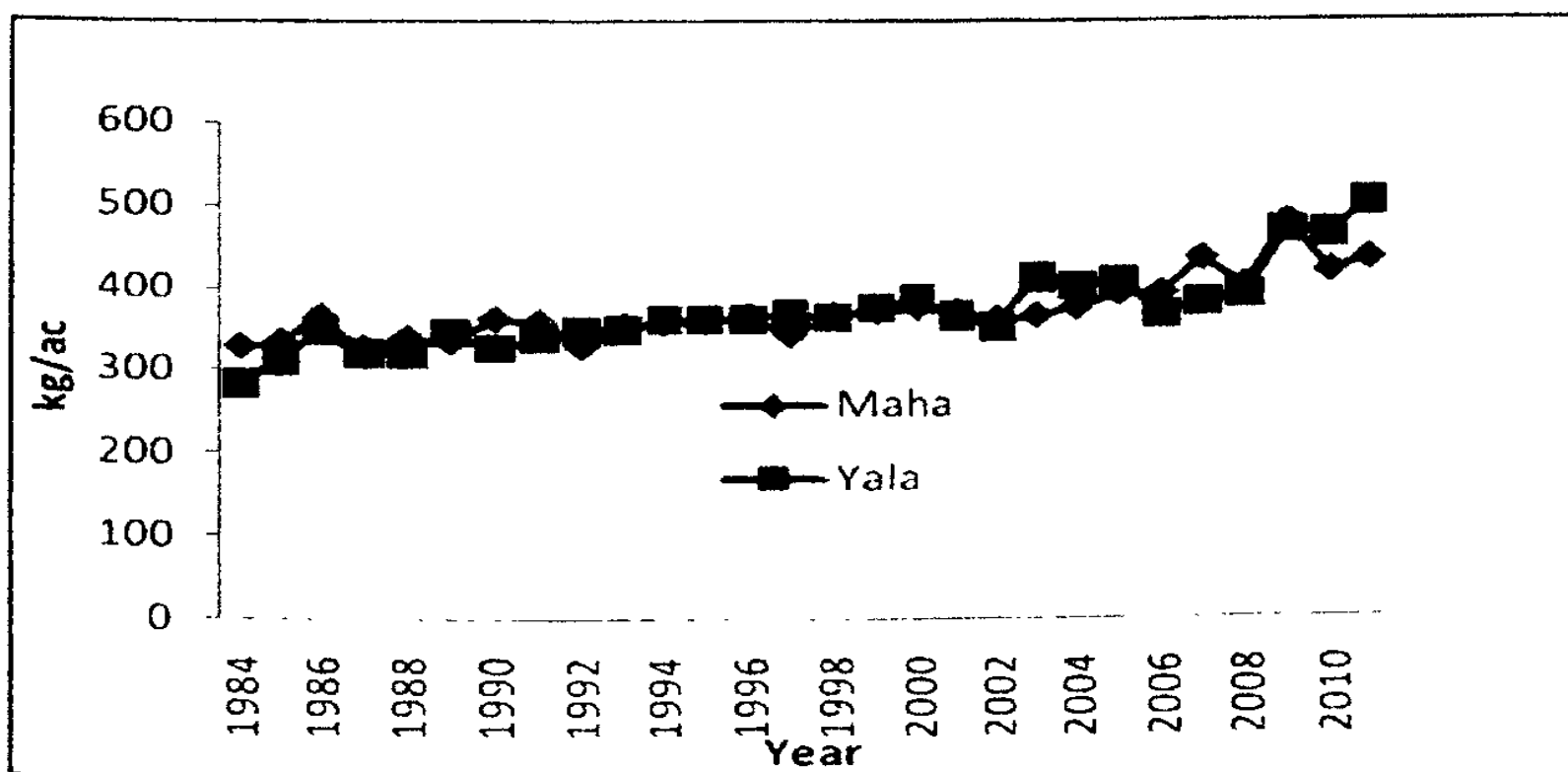
Source: Department of Census and Statistics

Figure 5: Average Yield of Kurakkan



Source: Department of Census and Statistics

Figure 6: Average Yield of Cowpea



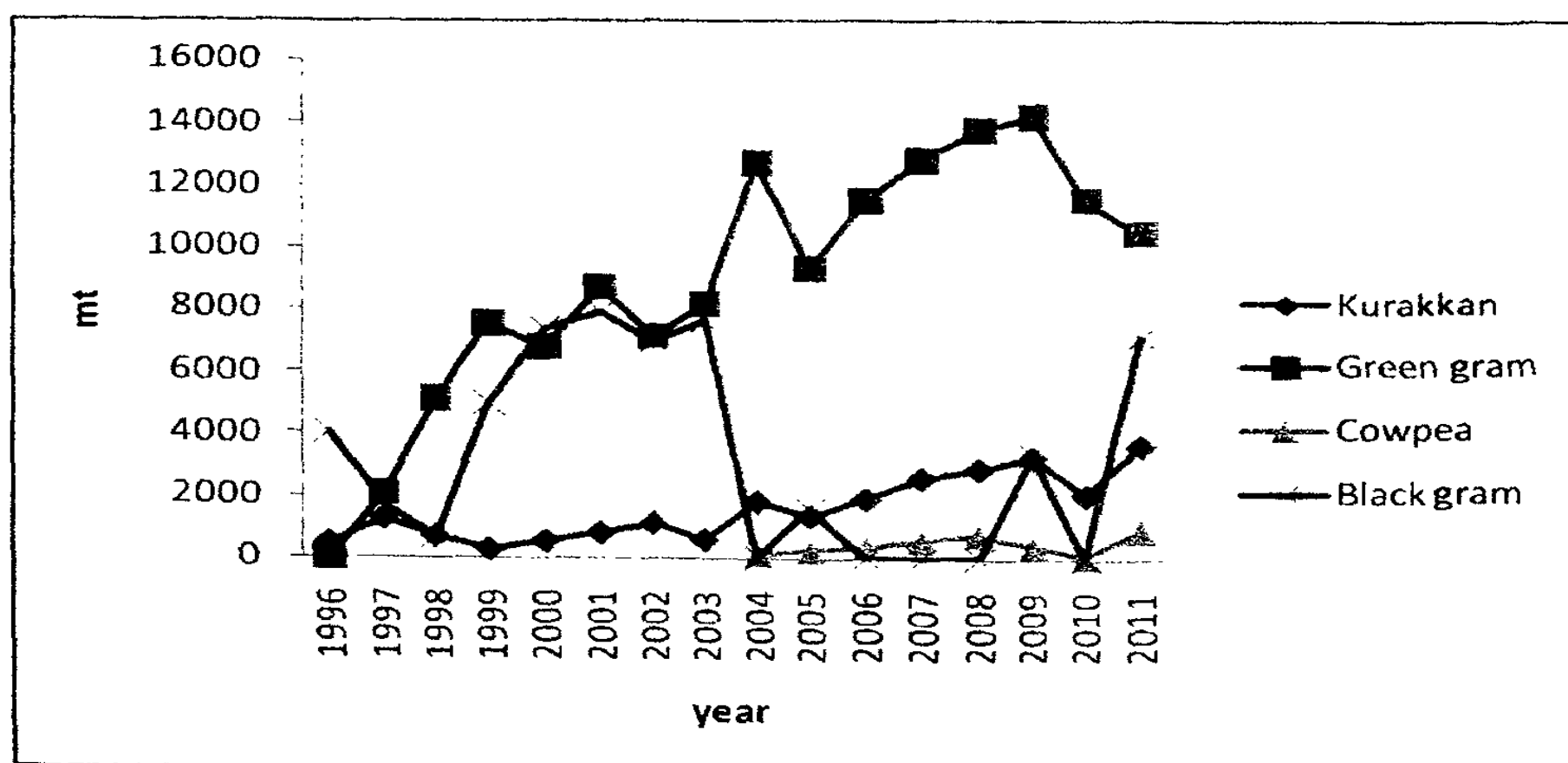
Source: Department of Census and Statistics

The dramatic shift in extent cultivation of these crops into paddy cultivation in dry zone areas after implementation of Mahaweli project, primarily contributed to this production decline. Another reason was the much bigger focus of policies and support measures on self-sufficiency in rice and the neglecting of the OFC generally (Karunagoda, et al, ND)

Further, irregularities in rainfall also caused fluctuation of production over the years. However, it is observed that such a sharp fall in subsidiary food production

was not due to drought and rainfall irregularities but to the free trade policies pursued by the government under which cheap/subsidized imports of subsidiary foods undermined domestic agriculture.

Figure 7: Annual Import Quantity of Kurakkan, Green gram, Cowpea and Black gram after 1996



Source: Sri Lanka Custom

Following the implementation of the WTO agricultural agreement in 1995, a major policy change took place in 1996 and the external trade was more liberalized with the replacement of quantitative import restrictions into *ad valorem* tariff system. Hence, imports of OFCs tend to increase after 1996 (Figure 7). Local farmers could not compete with the imported food as they were comparatively cheaper partly owing to higher productivity resulting from advanced technology and partly due to subsidies in the supplying countries (Kelegama, 2002).

4.1.3 Compound Growth Rate and Instability in Extent, Production and Average Yield

Growth rates are extensively used in the agricultural field as they have important policy implications. Hence, this study is focused on evaluating the long term growth performance and the instability during the overall period in case of selected OFCs with regard to extent, production and average yield in *Yala, Maha* and annual, separately using compound growth rate and co-efficient of

variation (CV). The results were presented in Table 1. According to that, the overall growth trend for extent, production decreased significantly while average yield shows a positive growth in both *Yala* and *Maha* seasons in all considered crops except black gram which compounds growth rates which were not significant (Table 1).

Table 2: Instability Index (CV) and Compound Growth Rates in Selected Other Field Crops

Extent	Blackgram		Cowpea		Greengram		Kurakkan	
	GR	CV	GR	CV	GR	CV	GR	CV
<i>Annual</i>	-0.1NS (0.014)	26.39	-3.54* (0.004)	39.20	-3.05* (0.006)	42.75	-2.47* (0.006)	57.42
<i>Maha</i>	-0.3NS (0.014)	29.96	-3.34* (0.004)	37.64	-2.47* (0.006)	41.67	-4.40* (0.008)	50.08
<i>Yala</i>	-0.1 NS (0.014)	52.80	-3.92* (0.004)	46.83	-4.30* (0.006)	52.68	-4.40* (0.008)	73.00
Production								
<i>Annual</i>	0.3 NS (0.007)	26.00	-2.57* (0.004)	33.35	-1.69** (0.006)	37.67	-2.57* (0.005)	39.56
<i>Maha</i>	0.3 NS (0.007)	28.18	-2.47* (0.004)	34.49	- 1.19*** (0.007)	39.11	-3.25** (0.010)	37.29
<i>Yala</i>	1.21 NS (0.016)	65.14	-2.57* (0.004)	35.54	-2.86* (0.007)	45.37	-2.47* (0.006)	66.70
Average Yield								
<i>Annual</i>	0.6 NS (0.004)	16.52	1.11* (0.001)	11.88	1.41* (0.001)	15.03	1.92* (0.002)	22.26
<i>Maha</i>	0.5 NS (0.004)	17.89	0.90* (0.001)	11.51	1.31* (0.013)	14.00	2.02* (0.002)	23.49
<i>Yala</i>	1.31 NS (0.004)	19.90	1.41* (0.001)	15.32	1.51* (0.015)	18.15	0.003* (0.003)	20.07

Note: This is based on the author's estimations

Figures in parentheses indicated the standard error for their respective coefficients,

* Denote coefficients are significant at 1 % level

** Denote coefficients are significant at 5 % level

*** Denote coefficients are significant at 10 % level

NS – Denote not significant

The results of CV show that relatively higher instability in extent, production and average yield recorded in *Yala* season in each crop (Table 2). It further illustrates the range of differences in degree in instability among production, extent and average yield.

In case of cowpea, the instability index was low compared to other three crops ranging from 48 percent in extent cultivation in *Yala* season to 11 percent in average yield in *Maha* season, though a high negative growth trend was implied. It reveals that even though cultivation extent and production of cowpea is stable compared to other crops with the other factors like cheap imports, high labour cost and farmer motivation for paddy cultivation with government subsidies possibly forced farmers to shift away from the cowpea cultivation. On the other hand, the highest instability in cultivation extent and production of kurakkan was observed with 73 percent in cultivation extent and 66 percent in production variation in *Yala* season. Kurakkan production has been declining by 3.2 percent in *Maha* and 2.5 percent in *Yala* season (Table 2). The data further indicated that yield instability index was below 20 percent for all crops except kurakkan which ranges around 23 percent in *Yala* and *Maha* season. This implied that much risk was not involved in average yield variable, yet area variability has more influence on production fluctuations and poor growth performance.

4.2 Instability and Growth Rates under Three Major Agro Climatic Zones

More than 85 percent of total extent of black gram cultivation reported in *Maha* season and low instability accounted in this season compared to *Yala* accompanied high production risk. Production instability varies around 125 percent in wet zone, 84 percent in intermediate zone and 68 percent in dry zone in *Yala* season and each agro ecological zones performs a negative growth trend (Table 3). This would be due to uneven rainfall and inadequate irrigation.

However, dry zone is more stable for black gram cultivation and instability varies around 30 percent in area and production and nearly 12 percent in yield in *Maha* season. Yet, intermediate and wet zone engage high risk for cultivating black gram. In *Yala* season, wet zone cultivation extent and production is decreasing in low rate compared to *Maha*. On the other hand, in intermediate zone, both extent and production decrease in low rate in *Maha* compared to *Yala*.

At present, around 95 percent of the black gram cultivation extent is distributed within dry zone region, hence, it reveals that there is no risk in cultivation of this crop. However, if needed to increase the area cultivation of black gram, *Maha* season in intermediate zone with strong irrigation support and *Yala* season in

wet zone can be utilized to minimize the risk of cultivation and to achieve comparably high growth. Growth rates of yield are high in intermediate zone than in dry zone. Therefore, further yield improvement in dry zone would be successful because cultivation is more stable in dry zone.

Table 3: Instability Index (CV) and Compound Growth Rates of Blackgram in Major Agro Climatic Zones

Blackgram	Wet Zone		Intermediate Zone			Dry Zone
	GR	CV	GR	CV	GR	CV
Extent						
Annual	-9.43* (0.018)	96.91	-4.69* (0.001)	74.64	-0.10 NS (0.007)	26.92
Maha	-8.24* (0.020)	98.62	-4.30* (0.013)	72.19	0.00 NS (0.008)	30.70
Yala	-6.29* (0.013)	150.98	-5.82* (0.016)	88.99	0.90 (0.015)	55.17
Production						
Annual	-7.04* (0.016)	79.72	-3.82* (0.014)	72.81	0.50 NS (0.008)	27.79
Maha	-5.92* (0.018)	81.29	-3.54** (0.015)	74.06	0.40 NS (0.007)	28.48
Yala	-2.37** (0.009)	124.58	-4.97** (0.016)	83.67	2.02 NS (0.017)	68.41
Average Yield						
Annual	1.01 NS (0.044)	38.91	1.21* (0.003)	17.31	0.60* (0.002)	9.40
Maha	-1.00 NS (0.053)	33.93	1.11* (0.003)	17.75	0.80* (0.002)	12.05
Yala	- 11.66*** (0.065)	30.79	1.82* (0.004)	24.24	0.70** (0.003)	12.33

Note: This is based on the author's estimations

Figures in parentheses indicated the standard error for their respective coefficients,

* Denote coefficients are significant at 1 % level

** Denote coefficients are significant at 5 % level

*** Denote coefficients are significant at 10 % level

NS – Denote not significant

Green gram cultivation is mainly carried out in *Maha* season (60 percent). According to the results presented in Table 4, green gram cultivation in *Yala* season in intermediate zone is highly vulnerable to production risk due to high fluctuation in extent cultivation. Instability index for extent cultivation is around 73 percent and production instability around 71 percent in intermediate zone.

However, nearly one percent positive growth rate in yield can be observed in both intermediate and dry zone. On the other hand, it shows a negative trend in production and extent cultivation. Data further reveals that dry zone is more stable for green gram cultivation. Further, expanding extent cultivation of green gram in dry zone could be effective. Due to relative positive growth in yield performance, intermediate zone also can be utilized. However, proper irrigation should be developed. Immense population pressure and urbanization would further decline the land area for green gram in wet zone.

Table 4: Instability Index (CV) and Compound Growth Rates of Green gram in Major Agro Climatic Zones

Green gram	Wet Zone		Intermediate Zone		Dry Zone	
	GR	CV	GR	CV	GR	CV
Extent						
Annual	-4.4* (0.018)	52.29	-4.01* (0.013)	55.35	-1.68NS (0.007)	28.26
Maha	-4.69* (0.02)	50.45	-3.15* (0.044)	58.76	-1.39 NS (0.008)	31.13
Yala	-4.4* (0.013)	52.33	-5.73* (0.016)	73.46	-2.76 NS (0.015)	35.44
Production						
Annual	-4.01* (0.016)	53.96	-2.66* (0.014)	55.63	1.5 NS (0.044)	29.16
Maha	-4.3* (0.018)	55.02	-1.78* (0.005)	55.62	0 NS (0.007)	27.07
Yala	-3.82* (0.009)	59.31	-4.49* (0.016)	71.03	1.9** (0.065)	38.59
Average Yield						
Annual	1.5 NS (0.044)	29.16	1.3* (0.003)	16.44	1.00* (0.002)	13.36
Maha	1.1NS (0.053)	27.07	1.2* (0.003)	16.80	0.9* (0.002)	12.20
Yala	1.9** (0.065)	38.59	1.4* (0.004)	17.21	1.00** (0.003)	15.28

Note: This is based on the author's estimations

Figures in parentheses indicated the standard error for their respective coefficients,

* Denote coefficients are significant at 1 % level

** Denote coefficients are significant at 5 % level

NS – Denote not significant

Extent cultivation and production of cowpea is falling significantly in all three regions (table 5) and higher instability also could be observed in wet and intermediate zones. Dry zone is comparably stable in production of cowpea and average yield performs positively, with an upward trend in each region. This reveals that the negative trend in production is due to sharp drop in cultivation extent over the years and yield improvement could not conquer this. Instability in yield is comparable in both dry and intermediate zones. It demonstrates around 10 percent variation (Table 5). Therefore, strategies should be developed to prevent the sharp decline in cowpea cultivation in intermediate zone in order to increase the domestic production.

Table 5: Instability Index (CV) and Compound Growth Rates of Cowpea in Major Agro Climatic Zones

Cowpea	Wet Zone		Intermediate Zone		Dry Zone	
	GR	CV	GR	CV	GR	CV
Extent						
Annual	-5.07* (0.004)	52.24	-7.78* (0.008)	55.35	-1.98* (0.006)	30.91
Maha	-4.97* (0.006)	55.59	-4.97* (0.006)	49.06	-1.98* (0.007)	33.04
Yala	-5.07* (0.006)	59.10	-7.78* (0.008)	55.35	-1.98* (0.007)	30.91
Production						
Annual	-3.44* (0.004)	52.01	-4.30* (0.006)	52.23	-1.09** (0.005)	25.67
Maha	-4.02* (0.005)	59.14	-3.63* (0.005)	46.74	-1.49* (0.005)	31.13
Yala	-2.57* (0.006)	54.35	-5.64* (0.007)	66.70	-0.30NS (0.005)	25.06
Average Yield						
Annual	1.41* (0.004)	24.12	0.60* (0.002)	9.51	0.60* (0.001)	8.86
Maha	0.70 NS (0.005)	30.01	0.60* (0.002)	10.94	0.70* (0.001)	9.67
Yala	2.02* (0.002)	28.20	0.60*** (0.003)	8.26	0.60*** (0.003)	8.86

Note: This is based on the author's estimations

Figures in parentheses indicated the standard error for their respective coefficients,

* Denote coefficients are significant at 1 % level

** Denote coefficients are significant at 5 % level

*** Denote coefficients are significant at 10 % level

NS – Denote not significant

Dry zone is more susceptible to production risk of kurakkan in *Maha* compared to wet and intermediate zones (Table 6). However, extent cultivation is somewhat stabilized in dry zone and higher production instability is due to high instability in yield. Results presented in Table 6 further reveals that in intermediate zone, the kurakkan extent is decreasing by around 6 percent annually though production is declining by around 2 percent in *Maha* season owing to positive yield growth rates. Comparably all three regions show significantly a negative trend over the years and a positive trend in average yield could be examined. Yield improvement in *Maha* season both in dry and intermediate zones is vital and remedies should be taken to expand the land area for cultivating kurakkan in wet zone.

Table 6: Instability Index (CV) and Compound Growth Rates of Kurakkan in Major Agro Climatic Zones

Kurakkan	Wet Zone		Intermediate Zone		Dry Zone	
	GR	CV	GR	CV	GR	CV
Extent						
Annual	-4.97* (0.004)	60.67	-4.01* (0.013)	55.35	-1.68 NS (0.007)	28.26
<i>Maha</i>	-4.97* (0.04)	55.63	-5.82* (0.004)	64.23	-1.39 NS (0.008)	31.13
<i>Yala</i>	-4.59* (0.009)	89.98	-2.66** (0.014)	138.02	-2.76 NS (0.015)	35.44
Production						
Annual	-4.01* (0.016)	53.96	-2.66* (0.014)	55.63	-4.7* (0.004)	60.67
<i>Maha</i>	-4.3* (0.018)	55.02	-1.78* (0.005)	55.62	-5.63* (0.004)	67.04
<i>Yala</i>	-3.82* (0.009)	59.31	-4.49* (0.016)	71.03	-2.95* (0.04)	35.96
Average Yield						
Annual	1.00* (0.003)	18.99	0.7** (0.003)	20.54	1.9* (0.004)	30.26
<i>Maha</i>	2.12* (0.004)	31.72	1.71* (0.004)	31.20	2.8* (0.003)	32.46
<i>Yala</i>	2.9* (0.003)	34.05	2.32* (0.003)	32.15	0.9* (0.003)	17.08

Note: This is based on the author's estimations

Figures in parentheses indicated the standard error for their respective coefficients,

* Denote coefficients are significant at 1 % level

** Denote coefficients are significant at 5 % level

NS – Denote not significant

4.3 District Level Dynamics

To examine the dynamics of growth and instability, compound growth rates and coefficient of variations were computed for each district in Sri Lanka, considering available regular time series data. Therefore, a few districts were avoided due to not having regular time series data. In addition to that, a few districts were dropped due to insignificant compound growth rates.

4.3.1 Growth Rates and Instability Index for Cowpea Cultivation

The major cowpea cultivation districts are Ampara (29%), Monaragala (21%), Kurunegala (13%), Anuradhapura (8%), Badulla (4%) and Ratnapura (4%). Ampara district recorded a positive growth where extent cultivation is increased by 4 percent in *Maha* and 6 percent in *Yala* while production is increased by 5 percent in *Maha* and 7 percent in *Yala* due to slight improvement in yield though extent and production is unstable over the years. Other five districts recorded a negative growth. Instability in extent ranges from a lower rate of 37 percent in Monaragala district to a higher rate of 73 percent in Kurunegala, in *Maha* and 50 percent to 88 percent in *Yala* season respectively.

Table 7: Growth and Instability Matrix for Cowpea Cultivation

Instability	Extent - <i>Maha</i>			Average yield		
	High	Moderate	Low	High	Moderate	Low
Growth rate						
High	Kilinochchi	xx	xx	xx	Kilinochchi Mahaweli H	Hambantota
Moderate	xx	xx	Ampara	Batticaloa Ampara	Xx	xx
Low	xx	xx	xx	xx	Badulla Polonnaruwa	Matale Mannar Anuradhapura
Negative	Kegalle, Puttlam Matale, Kurunegala Batticaloa Jaffna Ratnapura	xx	Badulla Anuradhapura Nuwara Eliya Polonnaruwa	Puttlam, Ratnapura	Xx	Kurunegala

Instability Growth rate	Extent - <i>Yala</i>			Average yield		
	High	Moderate	Low	High	Moderate	Low
High	xx	xx	Mahaweli H Killinochchi	xx	Thrincom- alee kilinochchi	Mahaweli H
Moderate	Mulathiv	xx	Ampara	Puttlam	Nuwara-eliya Anuradha- pura	xx
Low	xx	Thrincom- alee	Badulla	Kandy	Ampara Matale	Kurunegala Ratnapura
Negative	Kegalle Puttalam Vavuniya Mannar	Kurunegala Batticaloa Hamban- tota Jaffna Anuradha- pura	Pollonn- aruwa Ratnapura Monaragala	xx	Batticaloa	

Based on the author's estimation

XX - denote district(s) not related to the cell

According to the instability matrix presented in Table 7, the Hamabantota district in *Maha* season and in Mahaweli H area in *Yala* season shows high growth trend in yield. It is more stable for cowpea cultivation. However, at present, cultivating cowpea in these two districts are not much popularized and contributes to around 5 percent in total production in each district. Thus, further increasing of land area for cowpea cultivation in Hambantota district and Mahaweli H area would be successful. Ampara, which is the major cowpea cultivating district, is having a moderate long term growth trend with massive variation in extent cultivation (Table 7). Kurunegala and Ratnapura districts are more vulnerable for production of cowpea due to the declining trend and high instability. Monaragala and Pollonnaruwa districts in *Yala* season are more stable, however, continuous declining trend is recorded.

4.3.2 Growth Rates and Instability Index for Black gram Cultivation

Around 60 percent of the land area of black gram cultivation is in Anuradhapura district. The other main black gram cultivating districts are Vavuniya (12 %), Kilinochchi (9%) and Mahaweli H area (7%). Monaragala district performs a high growth rate i.e. extent has been increased by 15 percent while production has been increased by 17 percent.

Table 8: Growth and Instability Matrix for Black gram Cultivation

Instability	Extent - <i>Yala</i>			Average yield - <i>Yala</i>		
	High	Moderate	Low	High	Moderate	Low
Growth rate						
High	Vavuniya	xx	xx	xx	Badulla	Vavuniya
Moderate	Muathiw	Mahaweli H	xx	xx	Monaragala	Xx
Low	xx	xx	Monaragala	xx	Puttlam	Xx
Negative	xx	Puttlam, Killinochchi Kurunegala	Nuwara Eliya Jaffna	xx	Kilinochchi	Nuwara- Eliya Badulla
Instability	Extent - <i>Maha</i>			Average yield - <i>Maha</i>		
	High	Moderate	Low	High	Moderate	Low
Growth rate						
High	Monaragala	xx	xx	Puttlam	xx	xx
Moderate	xx	xx	xx	xx	xx	xx
Low	xx	Kilinochchi	xx	xx	xx	Matale
Negative	xx	Puttlam, Kurunegala Mannar	Nuwara Eliya Mahaweli H	Nuwara- Eliya	Batticaloa	Kilino- chchi

Based on the author's estimation

XX - denote district(s) not related to the cell

Production is increased by higher rate than extent cultivation in both seasons due to yield improvement over the years. However, in the Monaragala district, cultivation of black gram fluctuates over time, hence, the production is susceptible for high instability. Some districts in the Northern Province and Polonnaruwa district also show a positive trend in production and area cultivating. On the other hand, in Mahaweli H area, black gram cultivation extent, production and average yield is declining in *Maha* season and in *Yala* season around a 5 percent growth rate could be observed. However, around 54 percent of the total cultivation extent of black gram is in *Yala* season, in Mahaweli H area. According to the matrix presented in Table 8, in *Maha* season no district performs low instability and high growth rate. Mahaweli H area recorded low instability though it has a negative trend over time in *Maha* season, and *Yala* season is having a moderate growth and moderate instability. In order to promote further black gram cultivation in *Yala* season, yield improvement should take place. Paddy cultivation in *Maha* season in this area is the main reason for poor performance in black gram cultivation.

4.3.3 Growth Rates and Instability Index for Green gram Cultivation

Green gram is mainly cultivated in the Hambantota district with around 43 percent in *Yala* and 19 percent in *Maha*. Though there are negative growth rates in terms of extent and production, comparatively high instability also occurs in each season. Instability in extent cultivation is mainly attributed to the production risk and yield growth rate shows a positive movement and an increase of around one percent annually.

However, extent cultivation and production is declining over time around 5 percent in *Yala* and 7 percent in *Maha*. Around 19 percent of the total cultivated land area of green gram is in the Monaragala district in *Maha* season. It shows 1.3 percent in extent and 2.4 percent in production growth in *Maha*. However, in *Yala* season green gram is cultivated in around 4 percent of the total land area and it shows a declining trend. It reveals that *Yala* season is more vulnerable for green gram cultivation in this area due to lack of rainfall.

According to Table 9, Kilinochchi district in *Maha* season and Mahaweli H area in *Yala* season are evidence for competent districts for green gram cultivation. With this positive growth trend in extent cultivation and yield, further promotion of green gram would be vital. Poor irrigation facilities in Kurunegala and Puttlam districts and farmers shifting into Maize and Soybean cultivation in the Anuradhapura district would be the foremost reasons for the decreasing trend in green gram cultivation and high variability (Table 9).

Table 9: Growth and Instability Matrix for Green Gram Cultivation

Instability	Extent - <i>Maha</i>			Average yield - <i>Maha</i>		
	High	Moderate	Low	High	Moderate	Low
Growth rate						
High	xx	Kilinochchi	xx	xx	Mahaweli H	xx
Moderate	xx	xx	xx	Batticaloa Hambantota	Anuradhapura	Pollonnaruwa Kilinochchi
Low	xx	xx	Batticaloa	Jaffna	Monaragala	Kegalle Nuwara Eliya Badulla
Negative	Matara Mathale Badulla	Puttlam Kurunegala Kegalle Ratnapura Kandy Nuwara Eliya	Jaffna Vavuniya Anuradhapura Pollonnaruwa	Matara	xx	Puttlam
Instability	Extent - <i>Yala</i>			Average yield - <i>Yala</i>		
	High	Moderate	Low	High	Moderate	Low
Growth rate						
High	xx	Mahaweli H	xx	xx	Kilinochchi Mahaweli H	xx
Moderate	xx	xx	xx	Puttlam Kandy	Matale Polonnaruwa	Trincomalee
Low	xx	xx	Kilinochchi	xx	Anuradhapura Ampara	Badulla Monaragala Hambantota
Negative	Matara Ratnapura Puttlam Kurunegala Anuradhapura	Matale Ampara Kegalle	Kandy, Monragala Polonnaruwa Hambantota	xx	xx	xx

Based on the author's estimation

XX - denote district(s) not related to the cell

4.3.4 Growth Rates and Instability Index for Kurakkan Cultivation

According to the Annex IV, in *Maha* season, the kurakkan cultivation extent is decreasing during the last three decades in all districts except Badulla, Kilinochchi and Mahaweli H area where recorded a positive growth of 8 percent, 5 percent and 4 percent recorded respectively.

Table 10: Growth and Instability Matrix for Kurakkan Cultivation

Instability	Extent - Maha			Average yield - Maha		
	High	Moderate	Low	High	Moderate	Low
Growth rate						
High	Mahaweli H	xx	xx	Matara Puttlam Badulla Mahaweli H	xx	xx
Moderate	xx	xx	Kilinochchi	Matale Anuradhapura	Kandy Pollonnaruwa	Monaragala
Low	xx	Hambantota	xx	xx	Hambantota	Ratnapura Jaffna Batticaloa Ampara
Negative	Matara Puttlam Matale Badulla Monaragala Vavuniya	Kurunegala Ratnapura Kandy Nuwara Eliya Anuradhapura Pollonnaruwa	Jaffna Mannar Trincomalee Batticaloa Ampara	xx	xx	xx
Instability	Extent - Yala			Average yield - Yala		
	High	Moderate	Low	High	Moderate	Low
Growth rate						
High	xx	xx	Kilinochchi	Mahaweli H	Pollonnaru- wa Ampara Hambantota	Trincomalee Batticaloa
Moderate	xx	xx	xx	Monaragala Anuradha- pura	xx	Xx
Low	xx	Moderate	xx	Nuwara Eliya	Kandy Matale Badulla	Kurunegala Ratnapura
Negative	Kandy Anuradha- pura Monaragala	Matara Badulla Ratnapura Moderate Kurunegala Trincomalee Nuwara Eliya Puttlam	Pollonnaruwa Batticaloa Vavuniya Jaffna Hambantota Ampara	Xx	xx	Puttlam

Based on the author,s estimation

XX - denote district(s) not related to the cell

In *Yala* season, high instability was recorded with negative growth except in Kilinochchi (5 percent increasing trend) and Mahaweli H area (4 percent positive growth). However, in some districts, production is not declining as area cultivation, due to yield improvement. In *Maha* season, Anuradhapura, Pollonnaruwa, Batticaloa and Ampara show improvement in level of production with high yield. That is, 8%, 5%, 8%, and 9% respectively. New improved varieties, and continuous irrigation supply and increasing domestic demand would be the main reasons. In *Yala* season, high instability in extent cultivation and production were recorded than other OFCs. Table 10 illustrated that Trincomalee and Batticaloa in *Yala* season and Kilinochchi in *Maha* season are more stable for kurakkan cultivation. This reveals that encouraging of the kurakkan cultivation in Northern and Eastern Provinces is essential.

Conclusion and Policy Implications

OFCs production has been declining overtime, accompanied with year to year fluctuations with wide regional variations due to change in climate as well as other economic and social phenomena. This mainly vulnerable food security. After 1985, there was a drastic decline in extent cultivation of these crops and imports have been increasing to cater to the domestic demand. The results of this study reveal that, *Yala* season is highly susceptible for production fluctuation and instability in area cultivation. The results further indicate that high risk was not involved in average yield. Instability in extent cultivation affects production fluctuations and growth performance.

Black gram and green gram cultivation in dry zone does not entail production risk. According to the derived results, if black gram production further increases, yield improvement and expanding land area with strong irrigation support in *Maha* season in intermediate zone would be decisive. Further expanding extent cultivation of green gram in intermediate zone also can be utilized, however, proper irrigation should be developed. Extent of cultivation and production of cowpea is falling significantly in all three regions. However, results reveal that further increase of land area of the cowpea cultivation in Hambantota in *Maha* season and Mahaweli H in *Yala* season would be key to promote cowpea cultivation to prevent the sharp declining trend.

The Monaragala district has a potential to promote black gram cultivation. Further, in *Yala* season, promoting black gram cultivation in the Pollonnaruwa district and the Northern Province can be vital. However, extension should be given for yield improvement. The Monaragala district is more vulnerable for green gram cultivation in *Yala* season. The Kilinochchi district in *Maha* season

and Mahaweli H area in *Yala* season are evidence for prospective districts for green gram cultivation. According to the results, encouraging of the kurakkan cultivation in Northern and Eastern provinces is essential.

To mitigate high instability, proper water management methods should be adopted. Popularizing micro irrigation systems such as drip irrigation and sprinklers, rainwater harvesting and reconstructing small tanks and canals especially in intermediate zone is important for the maximum utilization of lands for OFCs. Encouraging crop diversification in dry zone and developing new high yielding varieties which are more tolerant to drought is timely. Farmers need to be educated on crop cultivation based on different agro climatic zones. Promoting of cultivation in the North and Eastern provinces also would be timely.

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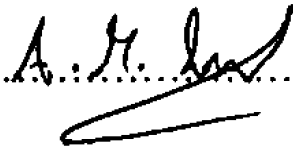
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