Impacts of Banning Glyphosate on Agriculture Sector in Sri Lanka; A Field Evaluation

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Impacts of Banning Glyphosate on Agriculture Sector in Sri Lanka: A field evaluation

LM Abeywickrama (Professor in Agricultural Economics)
AL Sandika (Head, Department of Agricultural Economics)
Piumika Sooriyarachchi (Research Assistant)
Imalsha Vidanapathirana (Research Assistant)

Faculty of Agriculture
University of Ruhuna

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Prof. LM Abeywickrama
Team Leader

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Executive Summary:

In May of 2015, import and local use of glyphosate was banned in Sri Lanka. This ban was initiated under the supposition that its use was linked to chronic kidney disease (CKDu) with no formal scientific health assessment and at a time, when various regulatory bodies including US EPA, JMPR, German BfR, Australian PVMA, Canadian PMRA, had conducted extensive scientific assessments to support safety of glyphosate. The ban was implemented without introducing a suitable alternative for controlling invasive weeds. Moreover, additional comprehensive reviews were conducted to review the data on carcinogenicity. In the two years since the ban was issued, both the European Food Safety Authority (EFSA) and the European Chemicals Agency (ECHA), following extensive re-assessments have concluded that glyphosate is not a carcinogen. In addition, a joint meeting of FAO-WHO in 2016 concluded that glyphosate does not pose any risk of carcinogenicity. So, it has been a political debate over the past 2.5 years following the onset of the ban as to whether it should be reversed in Sri Lanka. However, to this point there had not been a comprehensive analysis of the social and economic impacts of the glyphosate ban. For this reason, the authors decided to conduct an interview-based analytical study with the following objectives:

(1) To assess the impact of the ban on Sri Lankan agricultural production;
(2) To assess the socio-economic and financial impacts of the ban on Sri Lankan agricultural communities and other Sri Lankan stakeholder groups;
(3) To ascertain the alternative agronomic practices adopted by farmers given the restriction on glyphosate.

The authors conducted interviews with the following agricultural stakeholder groups: small and large tea plantation owners and workers and owners of tea factories in the Matara, Ratnapura, and Badulla districts; maize farmers in the Monaragala and Anuradhapura districts; banana cultivators in the Hambantota district; and field crop farmers in the Anuradhapura district. Interview techniques included discussions with government officers, focus groups, direct observations, participatory appraisal techniques, and sample surveys.
The findings from the primary survey as well as the insights generated from group discussions are summarized below.

Overview of economic costs:

The ban has imposed significant economic costs on growers of all operation sizes – but smallholders have been most negatively affected. In the absence of glyphosate, corn farmers performed additional harrowing, incurring an additional cost of machinery of Rs. 12,500 /per ha. Due to increased demand for machinery, tractor availability has been limited for small holder farmers. Over 94% of smallholder corn farmers reported a reduction in family income, while over 86% farmer in corn have reported that family income has reduced and cost of production has increased. Over 40% of tea farmers reported a reduction in family income, while increased weed prevalence has reduced yields for over 40% of corn farmers.

There has been a decline of 11% in tea production during year 2016 compared with year 2015. Despite increasing tea prices, tea export earnings have been reduced from 1324 million USD in 2015 to 1252 million USD. The Planters Association of Ceylon, estimate that crop losses have costed more than Rs. 15 billion in the 18 months after the glyphosate ban. The labour costs of weed control in large plantations has increased over 3 folds at Telbedda Estate in Badulla District, Rs. 2966721 in 2016 to Rs 9874994 in 2017. The increment is about Rs. 5.50 per kilogram of green leaf.

Overview of black market prevalence:

The study revealed that banning of glyphosate and allied formulations is not effective and the objectives of banning have not been achieved as the farmers are using the similar chemical or different other unknown expensive formulations, with no safety track record. So, the ban has been ineffective and has endangered growers by enabling a black market.

About 50% of farmers are still using glyphosate procured through illegal channels. Dealers are selling unlabeled adulterated product direct to farmers in fields. The content of black market formulations is unassured both in terms of safety and effectiveness and there is no party responsible for ensuring product quality. By having to purchase glyphosate on the black market, growers have seen the price per 4-liter container increase by 300-350% from Rs 4.000 pre-ban to Rs 12.000 - 14.000 during the ban.

Overview of agronomic changes and associated higher production costs:

With decreased access to glyphosate, growers have resorted to inefficient alternate practices that have increased costs and decreased yield and crop quality. Alternative chemicals used by farmers in maize cultivation after banning glyphosate are kerosene, MSG, Diuron and illegal products with no identification of content. After banning, profit is reduced by Rs 22,500/ ha (~25%) due to increased costs of cultivation.

Almost 94% of smallholders have seen increased costs of cultivation and 60% of larger farmers have seen increased costs of cultivation. Due to higher weed pressure, growers either applied more expensive selective herbicides, incurring higher herbicide and labour cost or increased harrowing from 1x to 2x incurring higher machinery and labour costs.

On the cost front, 82% of corn growers reported increased cost of weed control, increased machinery costs by Rs 12,500/ ha and labour costs by 2500/ ha. On Yield/ Quality front, 40% of corn growers reported reduced yields; 35% of corn growers reported crop damage;36% of corn growers reported decreased quality of harvest and 24% of tea growers reported reduced yields.

Increased use of tractors in sloping lands of Monaragala and Anuradhapura districts in maize and field crop cultivation in Maha season, had led to severe soil erosion. About

80% of the farmers verified that the erosion has drastically increased with the use of tractors in the absence of suitable herbicide. Further, mechanization because of absence of glyphosate has also affected farming under drip irrigation (eg: Banana cultivation in Hambanthota) as mechanical weeding damages the irrigation pipes and system.

The study also showed that Kalanduru (*Cyprus rotundus*), a difficult weed to control in the absence of glyphosate, has become a threat in Chili fields. Due to enhanced weed pressure, in crops that need intensive care such as chili, farmers cultivate only manageable portion of their land abandoning the rest creating a suitable ecosystem for of pigs and snakes to survive and reproduce, leading to challenging public health scenarios.

Overview of impact on Sri Lankan production/food security:

Majority of the officers in research and administrative positions in agriculture sector are not in agreement with the decision of banning glyphosate and the findings of the study clearly identify the larger impact of this ban on agriculture in Sri Lanka.

Higher cultivation costs have limited Sri Lanka's ability to increase row crop production and decrease reliance on imports. Due to higher costs of cultivation, 89% of corn smallholders and 73% of larger corn farmers have reduced cultivated area, reducing Sri Lanka's domestic production.

Informal discussions held during the study with research and administrative officers in agriculture sector are not in agreement with the decision of banning glyphosate. They feel that this decision is not supported by scientific factors but was made merely due to pressure of the strong lobbies and influential groups. The current study show that this decision has resulted in adverse impact on agriculture while creating an unbalanced status in agriculture sector. Food import bill has been increased in recent years especially for legumes (234 million USD in 2016), onions (99.8 million USD), sugar (335 USD million) and soya bean meal (87.8 USD million in 2016). The import statistics show that although Sri Lanka is imposing restrictions on use of glyphosate, it continues to import food products in large extent from the countries where glyphosate is extensively used.

Based on the findings of the study, it can be concluded that the food production in agricultural areas has been negatively impacted and the income of the low-income farmers has declined because of the unavailability of glyphosate through legal channels. Therefore, food security of the rural farmers has been challenged following the banning of glyphosate. Further, the study shows that the medium scale maize growing farmers are adversely affected as they do not have machineries such as tractors for harrowing in an appropriate timeframe. Large-scale farmers who own the tractors can tackle the situation and in many areas as they are better off at the cost of resource-less farmers who now pay higher rates for machineries. Disparity of income

is widening in maize cultivation areas as the low-income farmers are more vulnerable after banning glyphosate compared to higher income farmers. Food security will be great challenge in future due to migration of rural youth from the rural areas to the urban centers as agriculture is becoming less attractive and this has already occurred.

In conclusion, decisions on modern technologies in agriculture should be based on the scientific research findings published by the scientists in the relevant field. Agriculture chemicals have played a critical role in crop production and this study has shown the impact of glyphosate ban on crop production in Sri Lanka. Following glyphosate ban, the cost of production of maize and tea has increased, the yields are impacted, the farm income has reduced, and illicit chemicals are proliferating in the market. Regulators should also develop a mechanism to ensure only agrochemicals approved for use are available and sold in the market. It is important to educate farmers on judicious use of agrochemicals, consequences of misuse and use of unapproved chemical substances. In the current circumstances, there is a potential risk of tea getting contaminated with residues of various unapproved chemicals which might result in tea getting rejected in export market if traces are detected in final product. The impact on field crops such as maize significantly impacts the food production and increase the reliance of the country on food/ feed imports.

1. Introduction and Background

In Sri Lanka, agriculture - including forestry and fishing - accounted for over 46 percent of exports, 8.5 percent of the GDP, and 32.7 percent of the employment in Sri Lanka during 2010-11(CBSL, 2016). Sri Lanka's agricultural sector is dominated by paddy, the staple food of the population and, plantation crops, such as tea, rubber and coconut. Increased demand from diverse end-user industry and feed industry maize is another field crop of importance. Export Agricultural Crops (EAC), like pepper, cinnamon, cardamom, cloves and, fruit and vegetables also occupy an important status in the domestic and export agricultural sectors. Agriculture is supposed to be the backbone of the country, which stems specifically from the sector's contribution to employment, foreign exchange earnings, and to the food security of the populace.

Since independence all governments have channeled vast amounts of investments in bringing about serious structural, technological and institutional changes in the domestic agricultural sector. The major turning point in the process of development was the 'green revolution' or seed-fertilizer revolution which took place in mid-1960's. Varieties of newly improved crops yielding a high response to chemical fertilizer were introduced, increasing the production and productivity of agriculture.

Improved crop production methodologies of nutrient management and crop protection helped farmers to transition from low productive traditional crop varieties to high yielding varieties and cash crops thus leading to profitable yields. Application of agro-chemicals emerged very strongly as a necessity in feeding the growing population in a sustainable manner as well as to reap a remunerative harvest.

According to United Nations (2017) the global population will reach 9.8 billion by year 2050 and the overall volume of food production worldwide will have to increase by nearly 70% in 2050 – in comparison with 2006 – to keep up with the needs of the rapidly swelling global population. To address this challenge, it is necessary to use all available technology, such as improved germ-plasm, biotech traits, improved nutrients, use of chemical pesticides, etc. to ensure sufficient food production to meet the growing demand, while protecting the natural environment and conserving precious natural resources. Globally up to 40% of the food production can be reduced due to weeds, pests and diseases. Studies have shown that the crop loses ranged from 26-40% in crops such as soybean, wheat and cotton, maize, rice and potatoes (Oerke, 2006). In order to realize the potential yields of crops one must employ the new innovations. Crop protection products, commonly referred to as pesticides or agrochemical products, are both naturally occurring and man-made (synthetic) chemicals that play a vital role in controlling diseases, insects and weeds that harm or destroy our food crops and threaten public health.

Glyphosate is one of the most widely used and most comprehensively evaluated active ingredients in weedicide worldwide, and all assessments have consistently concluded that

glyphosate does not pose any unacceptable risk to human health, the environment or non-target animals and plants. Glyphosate's overall low toxicity and its excellent safety profile are major benefits that have contributed to the widespread use of glyphosate-based plant protection products. Glyphosate has been an important herbicide being used in Sri Lanka for efficient weed management, and has contributed significantly to the growth of agricultural productivity.

However, driven by the demands of the pressure groups, government banned the glyphosate, carbaryl, propanil, chloriphyrophos and carbofuran in four districts (Anuradhapura, Polonnaruwa, Kurunegala, Moneragala) and three Divisional Secretariat (DS) divisions in Badulla by the gazette notice On December 22, 2014. In June 2015, the glyphosate ban was imposed for the entire country although the glyphosate and allied products have a long history of safe use in countries around the globe.

Chronic Kidney Disease of unknown etiology (CKDu) is a serious health issue in many agricultural areas of the country, especially in North-Central Province, of Sri Lanka, affecting a large number of individuals, and is a significant political issue.

There is no evidence that glyphosate contributes to chronic kidney failure in Sri Lanka or elsewhere, and indeed glyphosate is used extensively in many places where elevated rates of renal failure do not occur. The reasons for the occurrence of chronic kidney failure have been explored at length by World Health Organization and by other experts and organizations in Sri Lanka and no clear cause has emerged. There is restriction on import and use of glyphosate in Sri Lanka since June 2015, and there are emerging issues based on this policy decision of banning glyphosate in agricultural sector. In plantation sector, the planters are raising an issue about enhanced costs of production and labor shortage for timely weed management in the absence of glyphosate or other alternative weedicide. The farmers in food crop sector argue that they are adversely affected due to increased costs of production because of limitation on use of glyphosate.

The enhanced costs of production seen after banning glyphosate may result in Sri Lanka losing competitiveness in food prices in the International trade. Another point is that Sri Lanka cannot avoid food imports from the countries where glyphosate is abundantly used, if food is not sufficiently produced locally. These impacts are speculative and there are no comprehensive studies conducted to find out social and economic impact of banning glyphosate and alternatives used by the farmers instead of glyphosate in the country. Therefore, the authors were compelled to conduct a comprehensive study to find the present status of the agriculture sector and the impact of banning glyphosate.

1.1 Scope and Focus of the Study

1. To assess the impacts of banning glyphosate on tea cultivation and field crop sector at the outcome and output level.

2. To assess the impacts of banning glyphosate on economic and social aspects of the relevant communities
3. To assess the impacts of banning glyphosate in terms of the relevance, efficiency, effectiveness, equity, sustainability, shared responsibility and accountability, appropriateness and resource allocation.

Following objectives to be achieved in the present study.

i. To assess the impact of the ban on Sri Lankan agricultural production;

ii. To assess the socio-economic and financial impacts of the ban on Sri Lankan agricultural communities and other Sri Lankan stakeholder groups;

iii. To ascertain the alternative agronomic and practices adopted by farmers given the restriction on glyphosate

2. Methodology

In order to accomplish the objectives, various techniques were used to collect data in this study. As the impact of the banning of glyphosate is expected to be in both plantation sector and field crop sector, the study was designed to consider the sectors separately. Out of the plantation sector, the tea crop was selected because several media reports revealed that different groups of tea producers are demanding for reversal of the ban on glyphosate because of scarcity of labour and increasing labour costs for weed control.

To evaluate the impact of banning glyphosate on tea sector, tea growers from -small holdings as well as large plantations, tea factories and other relevant stake holders of Matara and Ratnapura districts were considered. To accomplish the objectives of the evaluation process, several techniques were adopted to collect necessary information.

1. Collection of recorded information from different stakeholders
2. Formal and informal discussions with different stakeholders
3. Direct observation and evaluation of agricultural fields by the qualified enumerators
4. Collection of secondary data from different sources such as - the Office of the Registrar of Pesticides, Sri Lanka Tea Board, Tea Small Holding Authority
5. Focus group discussions with Extension officers (EO) of Tea Small Holding Development Authority in Matara and Ratnapura Districts (40 EOs)
6. Field survey of tea small holders in Matara and Ratnapura Districts (250 farmers)
7. Field survey of large tea plantations (60 planters)
8. Interview of tea factory officers and factory owners (23 Factories)

To evaluate the impact of banning glyphosate on field crop sector, - Maize cultivation in Monaragala and Anuradhapura districts, chili cultivation in Anuradhapura district and banana

cultivation in Hambantota district were considered. Following procedures were employed to collect information in order to accomplish the objectives.

1. Collection of recorded information from different stake holders.
2. Formal and informal discussions with different stakeholders (Around 300 farmers in each district)
3. Sample surveys using questionnaires
4. Direct observation and evaluation of agricultural fields by the qualified enumerators
5. Collection of secondary data from different sources such as the Office of the Registrar of Pesticides, Socio Economic Planning Center of the Department of Agriculture, Provincial Departments of Agriculture of Anuradhapura, Monaragala and Hambantota; Deputy Director of Agriculture of Anuradhapura, Monaragala and Hambantota,
6. Discussions with Deputy Directors of Agriculture, Agricultural Officers, Subject Matter Specialists (SMS) and Extension Officers in Hambantta, Monaragala and Anuradhapura Districts
7. Field survey of Maize cultivators in Monaragala and Hambantota (421 farmers)
8. Field Survey of farmers of field crops including maize cultivators in Anuradhapura district (230 farmers)

2.1 Preliminary studies

In order to design questionnaires and guidelines for discussions, preliminary field visits were arranged after meetings with Provincial Directors of Agriculture in Monaragala, Hambantota and Anuradhapura districts. In the preliminary field visits, in addition to observations made on agricultural fields, several discussions were held with farmer groups and different stakeholders including government officers. Based on the information gathered following steps of the evaluation process were planned and executed.

2.2 Field Questionnaire Survey

Detailed questionnaires (Annex-1) were designed separately for maize, field crops, tea small holding sector, large plantations and tea factories. The questionnaire consists of demographic information of household, information on land use and agricultural activities, information on weed control, changes in practices after banning of glyphosate, impact of banning glyphosate, alternatives for glyphosate, changes in labour use and costs, perceptions, views and ideas of farmers about banning glyphosate. The questionnaires were pretested and trained. Qualified investigators were used to interview farmers using the questionnaire schedule. When the farmers were able to fill the questionnaires, they were asked to fill individually and handed over to the interviewer.

2.3 Personal Interviews and Group Discussions

To seek clarifications on some of the findings and for detailed information, discussions were carried out with different categories of stakeholders including community leaders, government officers and selected farmers.

2.4 Direct Observations

In order to evaluate the weed management practices in tea plantations and ascertain the current status of weed management, tea plantations were visited in Matara and Ratnapura districts. Similarly, field observations of maize cultivation were made in Monaragala, Hambantota and Anuradhapura district. Field visits were made in banana fields in Hambantota district and fields of chilies in Thirappane area in Anuradhapura district for detailed information. During the field visits, agronomic practices such as weeding techniques, land preparation techniques, irrigation methods were observed.

Using the data collected through secondary sources, sample surveys, field observations, participatory approaches, focus group discussions and personal interviews of selected stakeholders, the analysis was directed to evaluate the impact of banning glyphosate using the criteria of Efficiency, Effectiveness, Equity, Social acceptability, Technical feasibility, Food security and Sustainability of agriculture.

3. Results and Discussion

3.1 Recent trends of paddy and field crop production in Sri Lanka

According to the data published by the Department of Census and Statistics of Sri Lanka and Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI), cultivation area and the production of many of the field crops have reduced after the year 2015 (Annex-1, Annex-2, Annex-3, Annex-4). The maize cultivation in the country almost doubled from 2007 to 2015, by producing a significant amount of maize to substitute the imports and providing the raw-materials for the animal feed industry. However, the areas have declined in 2016 and this reduction is significant in Badulla, Ampara and Kurunegala districts. Total land extent under maize in the year 2015 (69971 ha) has reduced to 67671 ha in the calendar year 2016.

The statistics show that the cultivation of chili has declined remarkably after 2015. The reduction of the cultivated area is significant in Anuradhapura district (1858 ha in 2015 Maha season to 1663 ha in 2016 Maha season) which is the leading producer of Chili in the country.

Area under big onion cultivation has reduced from 6827 ha in the year 2014 to 3954 ha in the year 2016 (Annex-03). The area under Soybean cultivation has also reduced in many districts including Anuradhapura district with significant reduction seen in Mahaweli-H area, where the reduction is from 3952 ha in 2015 to 2181 ha in 2016 (Annex-4).

3.2 Maize cultivation in Monaragala and Hambantota Districts

Maize is one of the main ingredients used in the animal feed industry, which formulates around 500,000 metric tons of animal feed annually. The maize production of Sri Lanka has been increased in several folds for the period from 2006 (32000 ha and production of 47521 MT) to 2015 (69970 ha and production of 261115 MT, Figure 1). Due to increased local production by the year 2015, Sri Lanka could limit the imports by saving a huge amount of foreign exchange. The import volume in 2006 was 84043 MT and the value was 16.5 million USD. According to the statistics of the Finance Ministry, Sri Lanka annually needs 400,000 metric tons of maize of which about 250,000 metric tons is locally produced and the rest is imported. Monaragala was one of the main cultivating districts which produces about one third of the total maize production of the country. By the year 2013, the imports have been declined to 16681 tons which shows an achievement to the self sufficiency. (FAO)

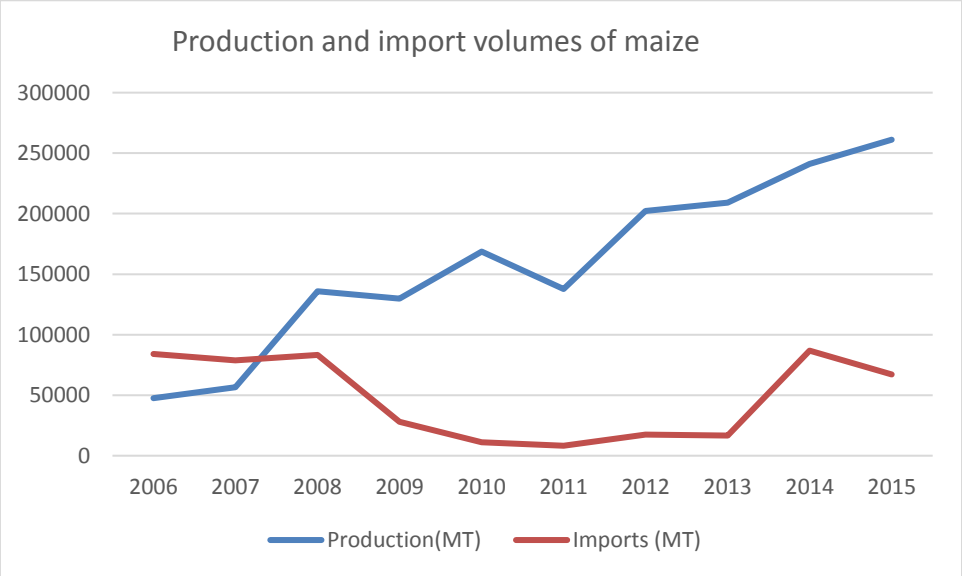

Figure 1: Maize- Production and Imports in SriLanka from 2006-2015 (Source: FAO Database)

Production of maize in Sri Lanka, both the extent of cultivation and the amount has significantly increase up to 2014/15 Maha season due to introducing new varieties, easy land preparation and weed control and also efficient purchasing mechanisms of private sector. However after 2014/15 Maha season the production has been drastically declined. Following figure (Figure 2) shows the production and area of cultivation of maize during past few years.

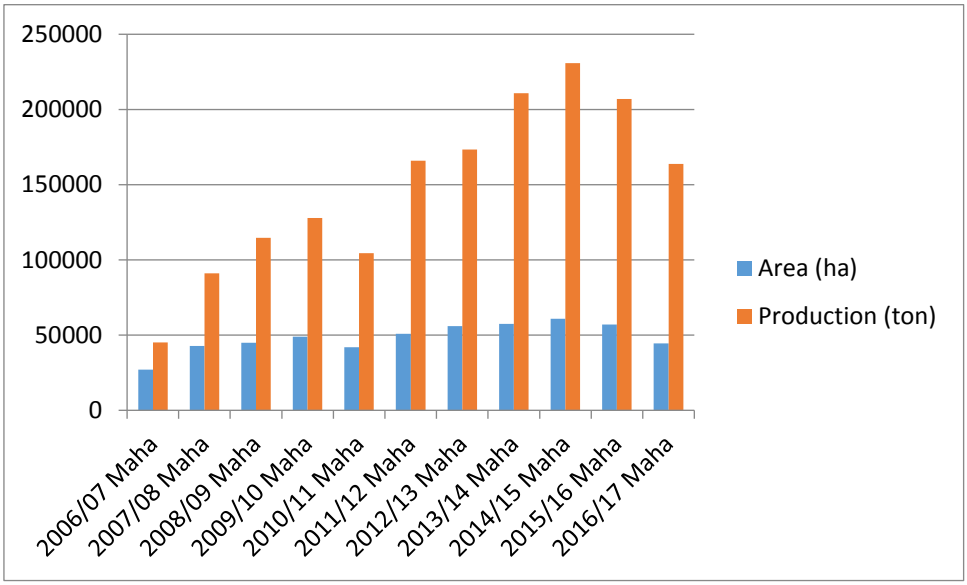

Figure 2: Area of cultivation and production of maize in Maha season from 2006 to 2016 in Sri Lanka (Source: Department of Census and Statistics, 2017)

Out of the 374, farmers interviewed in Monaragala district, 94.4% of the farmers mainly depend on agriculture. The total land area cultivated by the farmers represented in the sample has declined gradually, in spite of increasing prices of maize after 2014/15 Maha season. Area under maize cultivation was reduced by was 2.9% in 2015/16 Maha season and by 3.47% in 206/17 Maha season. About 93% of the farmers cultivate maize for commercial grains as the purchasing of the output and the price are assured compared to other field crops.

3.2.1 Costs of cultivation of Maize in Monaragala District

Average cost of cultivation of Maize per acre under rain fed condition after banning of glyphosate is given in the Table 1. Average land area per farmer in Monaragala is about 5 acres (2 ha) which is 2.5 times more than the average area of a farmer in Anuradapura district. The varieties cultivated are Jet, Pacific and Rambo.

Table 1: Costs of cultivation of maize in Monaragalaa district in the absence of weedicides

Item	Costs per acre (pre-ban on glyphosate 2014/15 Maha)	Costs per acre (post ban on glyphosate 2016/17 Maha)
First and second harrow with 4w tractors	Rs. 9053.00	Rs. 10000.00
Preparation of rows for seeding		Rs. 3000.00
Seeds (5kg packet)	Rs. 8802.00	Rs. 5000.00
Seeding (labour)		Rs. 5000.00
Fertilizer application including fertilizer cost	Rs. 5297.00	Rs. 8000.00
Manual weeding and earthling up	Rs. 5029.00	Rs. 8000.00
Harvesting (manual)		Rs. 8000.00

Processing using 4WT assembled machine	Rs.13659.00	Rs. 4000.00
Transport, storing etc		Rs. 2000.00
Total Cost	Rs.41840.00	Rs. 53000.00
Average income per acre 1500 kg x Rs 45.00	Rs.56425.00 (1850 kg @ 30.50 Rs/kg)	Rs. 67500.00 (1500 kg x Rs 45.00)
Average profit per acre (Excluding imputed cost)	Rs.27952.00	Rs. 14000.00
Average profit for five acres of cultivation (2ha)	Rs.139760.00	Rs. 70000.00

Source: Field survey 2017 / Department of Agriculture

The analysis shows that maize cultivation of five acres for a period of one season (six months) leads to a profit of about Rs. 70000.00, which is about Rs. 11600.00 per month which is little more than the below poverty line indicator Rs 8700 per month (using world bank indicator of 1.90 USD per day) and hence not a very remunerative amount. According to the inputs provided by the farmers, if a suitable weedicide is available they can save one harrow and labour units for weeding which is about Rs. 13000.00. After deducting Rs. 4000.00 as cost of weedicide farmers can still get Rs. 9000.00 additional profit per acre.

Out of the total respondents, 96.4 % of the farmers have used glyphosate to control weeds before banning it in 2015. Almost, all the farmers are aware of banning of glyphosate. The source of information about the banning of glyphosate was mass media for 76.3% of the farmers while others received the information from the officers and the neighbors. It implies that the media can play a better role in dissemination of information. Almost all respondents stated that the costs of cultivation have significantly increased due to banning of glyphosate. Increment of costs of cultivation is in different forms. In most cases, they have to harrow the land two times compared to one harrow with application of glyphosate. Therefore, costs of machinery have increased by Rs. 5000/= per acre per harrow. Also as some of the farmers are still using glyphosate from illegal markets, the prices are several folds higher (Rs. 12000.00 – 14000.00 per 4 liter can) compared to the past (Rs. 4000.00 per 4 liter can) when the glyphosate was available in normal market. Thirdly, as the rate of emergence of weeds is very high in the absence of glyphosate, farmers have to apply selective weedicides to control weeds (about 7000.00 per acre) and bear the labour costs to apply weedicides and to heap soil to the roots of the maize plants. Also, some of the weedicides they are using are not effective to control weeds according to farmers' point of view.

The average costs of cultivation per acre have increased by at least Rs. 9000 in the absence of weedicides as they have to harrow two times and additional labour costs for weed control after a month of planting. With weedicides, the farmer needed one harrow after applying weedicides and no requirement to control weeds thereafter in the middle of the crop. This is around 12% increase of the costs of cultivation leading to less profitability of maize cultivation. Also non-availability of labour during the short window of land preparation might discourage farmers growing maize.

Another serious issue faced by the farmers was the non-availability of adequate number of tractors in the area to harrow the lands within a short period. Therefore, the farmers who own the tractors and farmers who cultivate small areas using only the labour, are carrying out the operations on time while the farmers who cultivate large areas and who do not possess tractors are facing the problem. This situation has increased the hiring rates of tractors by at least two folds. The alternative measures practiced by farmers to address the challenges emerging from banning glyphosate in Monaragala district is provided in Table 2.

Table 2: Alternative practices to address the situation after banning glyphosate in 2015

Alternative	Number of farmers	%
No weedicides and only labour to control weeds	186	51.5
No weedicides and supplemented by tractors and labour	143	39.6
Use of available chemical weedicides	82	22.7
Given up the cultivation of maize	01	0.3
Minimizing weed control	55	15.2
Using **illicit** glyphosate from available sources	46	12.7*

Source: Field survey 2017; **Though 12.7% volunteered to reveal that they use illicit glyphosate, in a group discussion about 50% of the famers admitted to using illicit glyphosate to control weeds in their fields.*

The data reveals that farmers are struggling with maize cultivation. They are interested to grow Maize since the prices are stable and the market is assured, and hence are looking for solutions to address the current challenges

About 12.7% of the farmers (46) are still using glyphosate from the available sources, although it is illegal. Number of farmers who are using illicit glyphosate may be more than the number reported because of the farmers' reluctance to mention that they are using glyphosate in an illegal manner. However, group discussions revealed that about 50% of the farmers are using illicit glyphosate to control the weeds and there is a market mechanism developed for this illegal glyphosate. The people who are dealing with illicit glyphosate have conducted promotional campaign about their products to the farmers in the field prior to sale. The prices are several folds higher than the normal price of glyphosate before banning. The prices have been increased from Rs. 4000.00 to Rs. 14000.00 per four litre unit. The prices are even higher when farmers are buying in small quantities. This additional expenditure is for selling of illicit glyphosate and for bearing the risk of trading a banned weedicide. The dealers are selling them in the farmer's field without labels. Therefore, the composition and the rate of application and all other information about the weedicides are entirely dependent upon the information given by the traders. Farmers rely on traders. However, farmers believe that the content of the weedicide may be more harmful to the environment as the contents of the weedicide formulation is not assured. At this juncture, no one is responsible for the

consequences which may come up from unregistered, unlabeled, and unapproved products. In addition to high prices of so-called glyphosate, another issue is that there is no assurance of the effectiveness of the weedicides, since there is a tendency to adulterate the chemicals especially when selling in small quantities. The situation is very critical in Kotiyagala and Siyambalanduwa in Monaragala district where the plot sizes are larger (more than 10 ha). Majority of the farmers who are not using illicit glyphosate stated that the reason for not applying is the high price but not because of ban or environmental concern.

3.2.2 Analysis of consequences of banning glyphosate

In Monaragala District, it was observed that there are some farmers who cultivate more than 12 acres (Five hectares), especially in Kotiyagala and Siyambalanduwa divisions. Out of 393 farmers interviewed, 379 farmers have cultivated maize in the year 2016. Out of 379 farmers, 300 farmers were small-scale farmers who have cultivated less than five acres (79.2%) while 20 farmers (5.3%) have cultivated more than 12 acres. Table 3 represents the classified number of farmers based on land size in year 2016.

Table 3: Number of farmers belong to land categories

Area Cultivated	**Number of Farmers**	**Percentage**
Area <= 5 acres (2 ha)	300	79.2
5 ac < Area < 12 ac	59	15.6
12 ac <= Area	20	5.3

Source: Field survey 2017

Out of the 379 farmers who cultivated maize in 2016/17 Maha season, 223 farmers have used (58.9%) total weed killers before land preparation. Table 4, shows different weedicides that the farmers have used. Although they have mentioned the brands, it is not reliable as the labels were not present when they are buying.

Table 4: Different weed killers used by the farmers before banning

	Area <= 5 Acre (2 ha)		**5 < Area < 12Acre (2-5 ha)**		**12 Acre <= Area (more than 5 ha)**	
	Number of farmers	**%**	**Number of farmers**	**%**	**Number of farmers**	**%**
Farmers who used chemical weed killers	175	(58.3%)	39	66.1%	9	45%
Glyphosate	175	100.0	39	100.0	9	100.0
Weedol	1	0.6	2	5.1	0	0
Baursate	5	2.9	0	0	0	0

Source: Field survey 2017

The analysis shows that out of the farmers who used chemical weed killers before land preparation almost all have used illicit glyphosate. Farmers believe that the chemical they are buying is glyphosate or other glyphosate formulation. In large-scale cultivations, percentage of farmers who apply total weed killers are less than that of other categories. The reason behind that is the large-scale farmers are having their own tractors and other machineries. Small-scale farmers cannot hire the tractors in time and the charges for harrowing have been increased two folds (Rs.10000.00 per acre). This situation may lead to acquisition of the lands by the large-scale rich farmers while small-scale farmers abandoning their lands.

Following analysis shows the impacts of banning glyphosate on different aspects of maize crop cultivation and field properties, based on the views expressed by the farmers (Table 5). The analysis shows that the costs of weed control has been increased for about 90% of the farmers while the reduction of yield due to poor weed control was the problem for about 40% of the farmers after banning glyphosate. It is important to note that although the glyphosate is banned, farmers are still using illegal glyphosate. However, with the increased prices, the quantity they have used has been reduced. In the absence of glyphosate, some of the farmers (36%) have tried to add more fertilizer to achieve a dense crop cover in the field at the earliest possibility to avoid the growth of weed. Therefore, the crop damage and the pests and disease incidents have increased resulting in an increased requirement of fungicides and insecticides.

Table 5: Impacts of banning glyphosate on maize cultivation in different holding sizes according to the farmer's views (Number of farmers reported and percentages)

Problem		Area <= 5 (2ha>)		5 < Area < 12 (2-5 ha)		12 <= Area (5ha<)	
		Count	%	Count	%	Count	%
Cost of weed control	Number of respondents	298		59		20	
	Reduced	14	4.7	3	5.1	0	0
	No change	43	14.4	5	8.5	2	10.0
	Increased	241	80.9	51	86.5	18	90.0
Yield / production	People who answered the question	299		59		20	
	Reduced	121	40.5	24	40.5	8	40.0
	No change	161	53.8	31	52.5	12	60.0
	Increased	17	5.7	4	6.8	0	0
Fertilizer requirement	People who answered the question	298		59		20	
	Reduced	19	6.3	0	0	0	0
	No change	178	59.7	30	50.8	15	75.0

	Increased	101	33.9	29	49.2	5	25.0
Crop damage	People who answered the question	294		57		19	
	Reduced	30	10.2	8	14.0	1	5.3
	No change	160	54.4	28	49.1	12	63.2
	Increased	104	35.4	21	36.9	6	31.6
Pests and diseases	People who answered the question	292		58		20	
	Reduced	23	7.9	1	1.7	0	0
	No change	206	70.5	37	63.8	16	80.0
	Increased	63	21.6	20	34.5	4	20.0
Quality of yield	People who answered the question	292		57		20	
	Reduced	100	34.3	25	43.9	9	45.0
	No change	172	58.9	24	42.1	8	40.0
	Increased	20	6.8	8	14.0	3	15.0
Soil properties	People who answered the question	292		56		19	
	Reduced	35	11.9	12	21.5	9	47.4
	No change	165	56.5	31	55.4	6	31.6
	Increased	92	31.5	13	23.2	4	21.1

Source: Field survey 2017

Following table shows the alternative methods used by the farmers in maize cultivation after banning glyphosate in 2015 (Table 6). The analysis shows that small-scale farmers have used more labour while large-scale farmers are using more machineries since many of them own tractors. It is important to highlight that some of the small-scale farmers have given up the maize cultivation while large farmers are continuing because of sustained resources. Also, rich farmers have acquired the adjoining plots of small-scale farmers, as the small-scale farmers have given up the cultivation due to difficulties they are facing in the absence of glyphosate.

Table 6: The alternative approaches used in weed control after banning glyphosate

	Area <= 5 ac (2 ha)		5 < Area < 12 (2-5 ha)		12 <= Area (5ha<)	
	Count	%	Count	%	Count	%
People who answered the	283		52		18	

question						
Use of more labour	153	54.1	25	48.1	2	11.1
Use of machineries	102	36.0	24	46.2	11	61.1
Use of glyphosate or other chemical weed killers	92	32.5	27	52.0	7	38.9
Given up maize cultivation	2	0.7	0	0	0	0
Minimizing weed control	43	15.2	11	21.2	0	0

Source: Field survey 2017

Further it is found that many small scale farmers (50%) have given up the cultivation area of maize crop after banning glyphosate while this reduction is not apparent in farmers with large holdings as well as those having their own tractors. A large number of farmers stated that their income and consequently living standards are declining with current policies of banning glyphosate (Table 7).

Table 7: Consequences of banning glyphosate for farm families who cultivate maize

	Area <= 5 ac (2 ha)		5 < Area < 12 (2-5 ha)		12 <= Area (5ha<)	
	Count	%	Count	%	Count	%
Number of respondents	280		55		19	
Reduction of the land area	139	49.6	21	38.2	5	26.3
Increment of costs of production	222	79.3	46	83.6	17	89.5
Reduction of family income	177	63.2	35	63.6	13	68.4

Source: Field survey 2017

Field observations and discussions with the stakeholders revealed that increased soil erosion in the sloppy lands which used for maize cultivation due to extensive use of tractors for tillage compared to minimum tillage with herbicide application. The idea of the community leaders were if this situation continues, the land which used for maize cultivation will be completely eroded within a few years.

3.3 Maize and field crops in Anuradhapura District

To find the impacts of banning of glyphosate on maize cultivation and field crop sector in Anuradhapura district, 302 farmers from Horowpathana, Thirappane, Mihintale, Kahatagasdigiliya Divisional Secretariat (DS) divisions of Anuradhapura district were interviewed. Focus group discussions were conducted with farmer groups and agricultural officers in the district. Discussions were made with Provincial Director of Agriculture, Subject Matter Specialists (SMS) and other relevant officers.

3.3.1 Cost of cultivation

In Anuradhapura district the average area per farmer is about 2 acres (less than one hectare) which is less than that of in Monaragala district. Cost of cultivation per acre of maize under rain fed in Anuradhapura district in the absence of glyphosate is given in Table 8.

Table 8: Average cost of cultivation of maize in Anuradhapura district (per acre) post glyphosate ban.

Item	Pre-ban period (2014/15 Maha)	Post-ban period (2016/17 Maha)
Two plough with 4WT	Rs.5735.00	Rs. 10000.00
Preparing rows for seeding (Manual)	Rs.10422.00	Rs. 6000.00
Seeds		Rs. 5500.00
Fertilizer application including labour	Rs.11022.00	Rs. 12000.00
Weed control using selective weedicides	Rs.8790.00	Rs. 4000.00
Manual weeding and earthing up		Rs. 7000.00
Manual harvesting	Rs.9700.00	Rs. 6000.00
Threshing using machineries		Rs. 4000.00
Transporting and other costs		Rs. 2000.00
Average total cost	Rs. 45678.00	Rs. 56500.00
Total income per acre	Rs.51243.00 (1653kg@ Rs.31.00)	Rs. 72000.00 (1600kg x Rs. 45)
Gross profit per acre (Excluding imputed cost)	Rs. 22030.00	Rs. 15500.00
Gross profit per average block (2 ac)	Rs. 44060.00	Rs. 31000.00

Source: Field survey, 2017 / Department of Agriculture, 2017

Gross profit of Rs. 31000.00 for two acres over a six-month period (per season) translates to roughly Rs. 5200 per month, which is less than the below poverty line in Sri Lanka (Rs. 290 per day) and is not an attractive income for a farm family. If the farmer has the choice to use total (non-selective) weed killers at the beginning at normal price, farmer can save costs on one harrow, costs for selective weed killer and half of manual weeding cost amounting to Rs. 9500 per acre.

Out of the 290 farmers interviewed, 96% of the farmers have cultivated maize during past years at least one season. 90% are small-scale farmers who cultivate less than five acres while the rest cultivate more than five acres. Almost all the farmers in both categories, either small-scale or large-scale, have used formulations of illicit glyphosate for weed control in maize cultivation showing the importance of weedicides. Table 9 shows the number of farmers who use different brands of weedicides in maize cultivation.

Table 9: Different weedicides used by Maize of Anuradhapura farmers in weed control after glyphosate ban.

	Small scale farmers (Area <5 acres) (2ha>)		Large-scale farmers (Area >= 5 acres) (2ha=<)	
	Count	%	Count	%
Glyphosate	134	72.0	14	63.6.
Veedol	54	29.0	6	27.3
Baursate	18	9.7	0	0
Other	8	4.3	2	9.1

Source: Field survey 2017

Before banning glyphosate, they have bought glyphosate at the price of Rs.1000.00 per litre (Rs. 4000.00 per 4L unit). However, they have to spend about Rs.12000.00 –Rs.14,000.00 depending on the source per 4L of illicit glyphosate. Farmers were reluctant to reveal the source where they can buy banned glyphosate. However, it was revealed that there is a network to distribute illicit glyphosate in agricultural areas. The mechanism is well organized and the farmers know the sources. Farmers claimed that the chemicals are delivered in cans without labels of brands and instructions. In addition, it is not possible to buy in small quantities as they have to buy 4L cans. Therefore, the farmers have to share large cans after buying large cans as groups. Also, some farmers stated that the chemicals they are buying are not strong enough to kill weeds compared to the branded weed killers which they purchased before banning while another group of farmers stated that present formulations may be more harmful to the humans and the environment. All the respondents are of the opinion that the composition of the weedicides they are buying is not reliable and also there is no responsible party for stewardship as they are secretly buying unbranded products (Table 10).

Table 10: Responses of farmers on different aspects of Maize cultivation in Anuradhapura district after banning glyphosate

Problem		Area <= 5 acres (2ha>= area)		Area > 5 acres (5ha< area)	
		Count	%	Count	%
Cost of weed control	Number of respondents	260		30	
	Reduced	4	1.5	0	0
	No change	0	0	0	0
	Increased	90	34.6	11	36.7
	Extremely increased	166	63.8	19	63.3
Change of yield	Number of respondents	260		30	
	Reduced	21	8.1	2	6. 7
	No change	235	90.4	28	93.3

	Increased	4	1.5	0	0
	Extremely increased	0	0	0	0
Crop growth	Number of respondents	260		30	
	Reduced	21	8.1	2	6. 7
	No change	235	90.4	28	93.3
	Increased	4	1.5	0	0
	Extremely increased	0	0	0	0
Fertilizer requirement	Number of respondents	260		30	
	Reduced	4	1.5	0	0
	No change	235	90.4	28	93.3
	Increased	21	8.1	2	6.7
	Extremely increased	0	0	0	0
Pests and diseases	Number of respondents	260		30	
	Reduced	4	1.5	0	0
	No change	235	90.4	28	93.3
	Increased	21	8.1	2	6. 7
	Extremely increased	0	0	0	0
Quality of the product	Number of respondents	260		30	
	Reduced	21	8.1	2	6. 7
	No change	235	90.4	28	93.3
	Increased	4	1.5	0	0
	Extremely increased	0	0	0	0
Soil properties	Number of respondents	260		30	
	Reduced	21	8.1	2	6. 7
	No change	190	73.1	22	73.3
	Increased	49	18.8	6	20
	Extremely increased	0	0	0	0

Source: Field Survey, 2017

Above analysis from Table 10 very clearly shows that irrespective of the size of the holding, cost of cultivation has increased after banning glyphosate. The reason for increment of costs is increased expenditure on labour and machineries in the absence of glyphosate or higher price they are paying for illicit glyphosate available in informal channels. According to the information from the farmers, many other parameters such as the yield, growth of the crop, fertilizer requirement, pests and diseases and quality of the product have not been changed

after banning glyphosate. It was observed, and verified by the farmers' responses, the soil erosion of cultivated lands has drastically increased due to increased frequency of harrowing.

Famers have employed different alternative methods for weed management following banning of glyphosate (Table 11). Analysis shows that a significant number of small-scale farmers (59.4%) with less than five acres have tried to shift to labour and machineries while 80% of the large-scale farmers are using illicit glyphosate or other chemicals. Also, some of the small-scale farmers have given up cultivation of maize due to enhanced cost of cultivation after banning of glyphosate.

Table 11: Alternative methods to control weeds employed by Maize farmers in Anuradhapura district after glyphosate ban.

	Area <= 5 acres (area <= 2 ha)		Area > 5 acres (Area > 2ha)	
	Count	%	Count	%
Number of respondents	256		30	
Use of labour and/ or machineries	152	59.4	6	20
Using other chemicals or glyphosate	176	68.75	24	80
Given up cultivation of maize	8	3.1	2	6. 7
Minimizing weed control	48	18.8	0	0

Source: Field Survey, 2017

The impact of Glyphosate ban was measured through the response of farmers about changes in land area cultivated, changes in costs of cultivation and consequent reduction in family income following glyphosate ban. The impacts based on the responses from two categories of farmers, small-scale and large-scale is summarized in Table 12.

Table 12: Maize Farmer's response about consequences of banning glyphosate in Anurdhapura district

	Less than 5 acres (254 farmers)		More than or equal to 5 acres (30 farmers)	
	Number of farmers	%	Number of farmers	%
Reduced the land area cultivated	226	89.0	22	73.3
Increase of costs of	238	93.7	18	60.0

cultivation				
Reduction of family income	240	94.5	26	86.7

Source: Field Survey, 2017

The analysis revealed that the small-scale farmers are seriously affected as they do not possess their own tractors and also non-availability of tractors in time during the cultivation period. The large-scale farmers, generally equipped with own tractors can cultivate their lands on time compared to the small-scale poor farmers. Therefore, increment of costs of production is mainly for the small-scale farmers (94%) compared to the large-scale farmers (60%). However, a majority of both categories of farmers responded that their family income was badly affected after banning of glyphosate as consequences of reduced acreage and increased costs.

3.4 A case study in chili cultivation in Thirappane, Anuradhapura.

Green Chili cultivation is a remunerative crop compared to other crops in Thirappane area. Total costs of cultivation of chili is about Rs. 1,60,000.00 per acre. Average yield per acre is about 2500 kgs which can be sold at an average price of Rs. 200.00 per kg thus leading to an average income of about Rs. 500000.00 per acre. Therefore the profit per acre per year is about Rs. 340000.00 (Table 13)

Table 13: Average cost of cultivation of Chili in Thirappane, Anuradhapura district

Item	Amount /acre
Nursery preparation including seeds	Rs 5000.00
Land preparation using tractors and labour	Rs. 30000.00
Preparation of ridges and beds	Rs. 15000.00
Transplanting using labour	Rs. 15000.00
Fertilizer application including labour costs	Rs. 20000.00
manual weed control	Rs. 25000.00
insecticides and pesticides	Rs. 15000.00
harvesting and processing	Rs. 35000.00
Total cost	Rs 160000.00
Gross Income (Average yield per acre is about 2500 kgs x average price of Rs. 200)	Rs. 500000.00
Gross Profit per acre.	Rs. 340000.00

A large number of farmers in Thirappane, in Anuradhapura district produces green chilies for Dambulla Economic center. These farmers are the major producers of the green chilies. In addition to the green chilies, they cultivated maize, cowpea and some cucurbits in the past years using irrigation water from agro-wells. After banning glyphosate, many of these farmers have given up cultivation of maize as it is not economical. They are cultivating green chilies in a small portion of their land while the rest of the lands are abandoned. For the

cultivating chilies require large number of labour and due to higher wages and scarcity of labour, they are cultivating only a small plot out of total area of their land. As the remaining uncultivated land is converting in to grass lands and shrubs, wild life population including snakes, pigs are leading to increasing public health challenges. Farmers owing tractors are involved in cultivation, while the poor farmers are converting to agricultural labourers.

Many growers of green chilies are not following the recommendations of the Department of Agriculture. They use their own experiences for applying fertilizer, irrigation, pest and disease control and other practices hoping to maximize the profit. The farmers are applying insecticide starting from the beginning of the crop to avoid the pests and diseases. Normally the application frequency of insecticides is once in every three days. The amount of application of insecticides to the field per crop season is several folds higher than that of weedicides they used in maize cultivation.

Difficulties in controlling mana grass (*Cymbopogan* species) has resulted in reduction of area under cultivation of maize and other field crops such as chilies. Medium scale cultivators have been drastically affected due to absence of labour and machineries. Costs of hiring rate of machineries have been doubled. Difficulties of controlling other weeds such as kalanduru (*Cyprus rotundus*) in chili fields of Thirappane area is an emerging issue. The farmers claimed that use of suitable weed killer to control kalanduru is necessary at least once a year.

Farmers responded that they do not bother about the chemicals they apply as everyone is drinking purified and filtered water. Famers do not want to go back to drinking hard water, from open sources or ground water again. Farmers are spending about Rs. 1000.00 per month for drinking water. As almost all the families are using filtered drinking water in Anuradhapura District, quality of the ground water and the surface hard-water is no more valid reason to justify the banning agrochemical.

3.5 A case of banana cultivation in Hambantota district

Banana cultivation is very popular with irrigation in Hambantota district. The farmers were using glyphosate during past years to control weeds in banana fields which allowed them to apply intensive irrigation techniques such as drip irrigation and spraying thus helping them to get higher productivity with optimized use of water and land. However, the large-scale banana cultivators are now facing the problem of applying improved technologies due to absence of weedicides. Farmers complained that if they use labour to control weeds, the manual operations damage their irrigation systems and the replacing cost is very high. In order to control the weeds in the initial stages of the crop, effective chemical weedicides are vital. The banana cultivation is no more profitable and also the sophisticated new technology cannot be applied now with the government's decision of banning weedicides. Only small-scale traditional farmers can continue banana cultivation in the absence of suitable weed killer as the application of water and fertilizer will increase the growth of weeds. Therefore,

investors who are willing to invest in banana cultivation are reluctant to invest and the sector is losing the emerging market potentials.

3.6 Tea Small Holding Sector

According to the Sri Lanka Tea Board Statistics, Sri Lanka's tea exports for 2016 totaled 288.7 Million kgs compared with 306.9Million kg in 2015 showing a decrease of 18.2Million kg. This records the lowest export volume since 2002, when total exports declined to 287.2 Million kg. Overall, tea production totaled at 292.36 Million kg showing a decrease of 36.41 Million kg compared with 328.17 Million kg in the year 2015. According to the Sri Lanka Tea Board Statistics, comparison of the second quarter tea production shows that except in Kalutara district, in all other tea growing districts, the tea production has been significantly declined in 2016 compared to 2015 (Table 14). Following figure shows the reduction of production and export volume (Million kg) in the year 2016 compared to 2015.

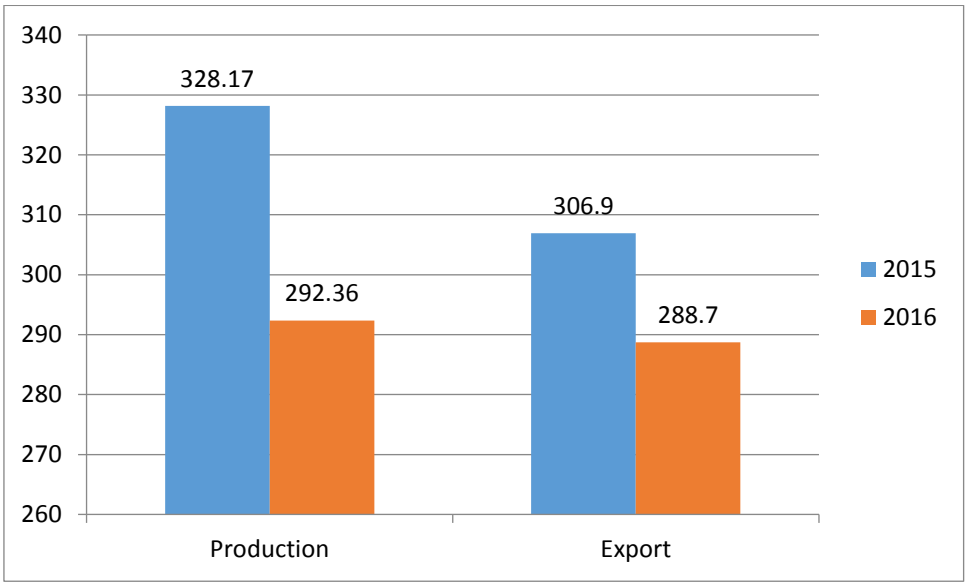

Figure 3: Production and export volume of tea (Million kg) in the year 2015 & 2016

In Sri Lanka, about 2 million of people (10% of the total population) depend on tea industry directly or indirectly. About 60% of land area under tea cultivation is in small holding sector and they contribute 75% of total production. Further, 79% of the tea small holdings are in low-grown areas and hence the contribution of the small holding sector in low-country (low altitude) areas is important. Therefore, Matara and Ratnapura district were considered for the study to impact of banning of glyphosate in tea sector.

Table 14: District-wise tea production in Sri Lanka in the second quarter of 2015 and 2016 (kgs) (As at the Month of June)

District	2015 (kg)	2016 (kg)	Change (kg)	Percentage change
Badulla	16687	14347	-2340	-14.02

Colombo	388	305	-83	-21.49
Galle	24558	21135	-3423	-13.94
Hambantota	135	107	-28	-21.06
Kalutara	8892	9154	262	2.95
Kandy	17502	17180	-322	-1.84
Kegalle	5239	4138	-1100	-21.01
Matale	1939	745	-1194	-61.57
Matara	20999	17232	-3767	-17.94
Nuwara-Eliya	39671	33448	-6223	-15.69
Ratnapura	36979	36055	-925	-2.5
Total	172989	153845	-19144	-11.07

Source: Sri Lanka Tea Board, 2017

Randomly selected 294 small holders from Kotapola, Pasgoda, Akuressa and Mulatiyana Divisions of Matara District and Rakwana, Kalawana, Kolonna and Nivithigala Divisional Secretariat Divisions of Ratnapura district were interviewed using a questionnaire in addition to focus group discussions and direct observations. Distribution of tea farmers according to their farm size is presented in Table 15.

Table 15: Distribution of Tea farmer by farm size

Land area under tea cultivation	Number of farmers	Percentage of farmers
Less than 1.25 acres (0.5 ha)	128	46 %
1.25 ac – 5 ac (0.5 ha – 2 ha)	131	47 %
More than 5 acres (2 ha)	18	7 %

Source: Field Survey, 2017

Majority of the farmers in all categories are applying weedicides to control weeds in their land despite the land size. About 73% farmers of holding size less than 1.25 acres, 76% farmers of holding size between 1.25 acres to 5 acres and 83% farmers of holding size more than 5 acres used glyphosate to control weeds (Figure 3). Use of chemical weedicides is increasing with the increasing of the holding size.

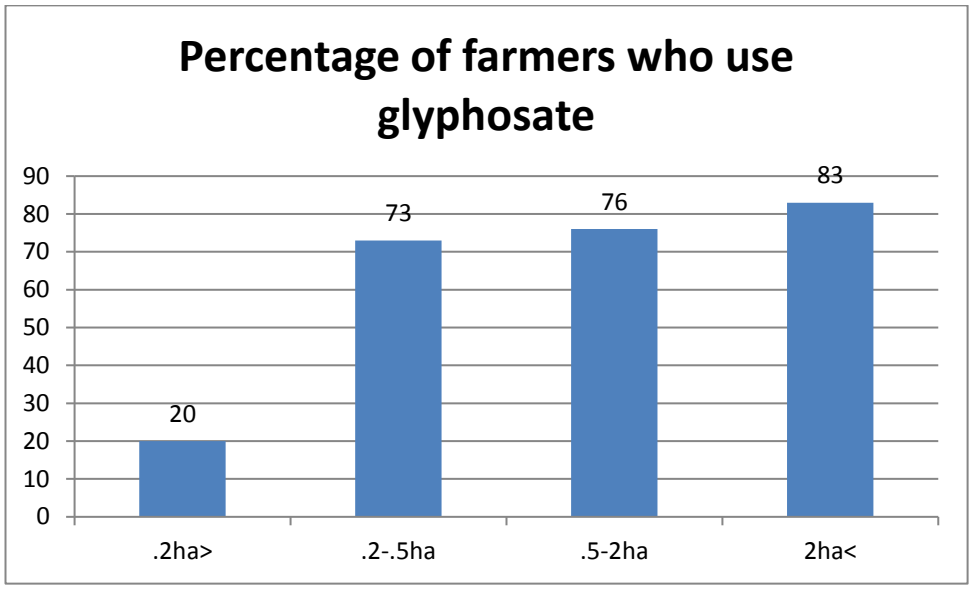

Figure 4: Percentage of farmers who use Glyphosate for weed control

Application of weedicides is more frequent in large holding sizes compared to the small holding sizes. Majority of the farmers in small holding sizes are using chemical weedicides to control weeds occasionally (55%) or once a year. Following table 16 shows the percentage of farmers in different categories, and frequency of weedicide application in their tea plantations.

Table 16: Frequency of applying weedicides in different holding size

Frequency	Percentage of farmers		
	Less than .5 ha	.5 – 2 ha	More than 2 ha
Twice a year	18 %	34 %	47 %
Once a year	25 %	15 %	20 %
Occasionally	46 %	44 %	33 %

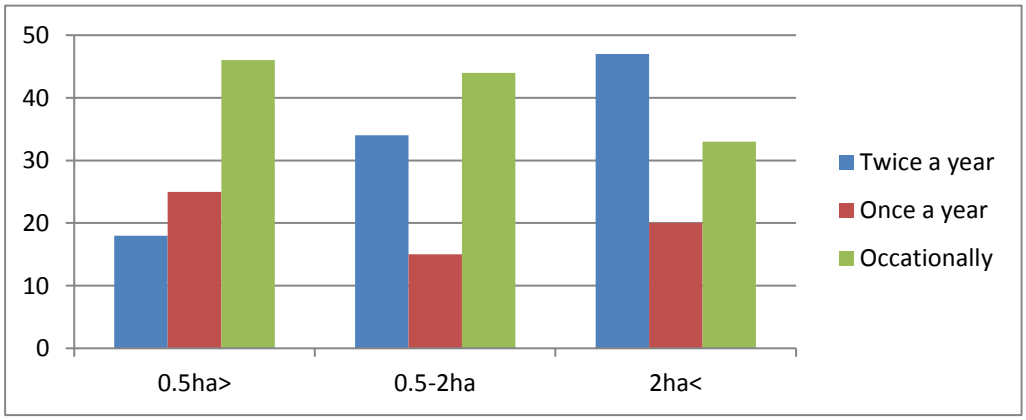

Figure 5: applying weedicides in different holding size

Source: Field Survey, 2017

The amount of application of chemical weedicide is increasing with the holding size increases because labour intensive weed control methods are increasingly difficult to execute due to labour shortage and increased wage rates. With the present situation, after banning glyphosate and allied weedicides, farmers are struggling to control the weeds. It was observed that weeds have grown in some of the tea lands where the tea cover is not dense and in the large vacant areas and along the boundaries of tea lands. Many of the farmers have reduced the amount of application of weedicide due to high prices. The price has been increased from Rs. 4000 to Rs. 15000.00 (Rs.12000.00 – Rs. 150000.00) per four liter unit which is available in emerged informal market of illicit glyphosate. Farmers stated that that the quality of the weedicides is not up to the standards and many of the dealers are in the practice of diluting the chemical composition using different methods.

Out of the farmers who are using other chemicals (14%), majority uses Diuron (1,1-dimethyl, 3-(3',4'-dichlorophenyl) urea) which is a broad-spectrum residual herbicide and algaecide used in agriculture for pre-emergent and post-emergent control of broadleaved and grass weeds. It seems that the number of farmers who are using other chemicals is much less in comparison to the number of farmers who are using illicit glyphosate. Also, farmers stated that the Diuron is not an effective weedicide compared to glyphosate.

3.6.1 Change of costs of production after banning glyphosate

Further, farmers were questioned about the change of the costs of production after banning glyphosate. Out of the respondents (264), 143 of farmers (54.14%) stated that their costs of production have significantly increased and about 21.6 % of the farmers stated that the increment of costs of production is remarkably high. The responses of farmers from different farm sizes on changes in costs of production in post glyphosate ban are given in Table 17.

Table 17: Cost of Production of tea after banning glyphosate

Land category	Change of costs of production (percentage of farmers)	
	Increased	Highly increased
Less than 0.5 ha	38.3%	19.2%
0.5ha – 2ha	32.5%	23.7%
More than 2 ha	16.7%	38.8%

Source: Field Survey, 2017

3.6.2 Farmers view on different aspects of tea plantation after banning glyphosate

In the preliminary studies, it was found that the perceptions of the people about glyphosate are different in different aspects. Therefore, the farmers were questioned about the issues on tea cultivation after banning the glyphosate. The responses are summarized according to the size of the holding sizes table 18.

Table 18: Farmers view on different aspects of tea plantation after banning of glyphosate

Issues		Less than 1.25 acres (0.5 ha)		1.25 – 5.0 acres (0.5 – 2 ha)		More than 5 acres (2ha)	
		Count	%	Count	%	Count	%
Costs of weed control	Number of farmers responded	120		114		18	
	Highly Reduced	3	2.5	3	2.6	2	11.1
	Reduced	12	10	10	8.8	1	5.6
	No change	36	30	37	32.5	5	27.8
	Increased	46	38.3	37	32.5	3	16.7
	Highly increased	23	19.2	27	23.7	7	38.9
Tea yield (Production)	Number of farmers responded	120		115		18	
	Highly Reduced	5	4.2	2	1.7	3	16.7
	Reduced	19	15.8	27	23.5	5	27.8
	No change	74	61.7	62	53.9	10	55.6
	Increased	18	15	21	18.3	0	0
	Highly increased	4	3.3	3	2.6	0	0
Growth of tea bush	Number of farmers responded	118		114		18	
	Highly Reduced	5	4.2	2	1.8	2	11.1
	Reduced	27	22.9	21	18.4	4	22.22
	No change	71	60.2	64	56.1	11	61.1
	Increased	14	11.9	23	20.2	1	5.6
	Highly increased	1	0.9	4	3.5	0	0
Requirement of fertilizer	Number of farmers responded	117		116		18	
	Highly Reduced	3	2.6	2	1.7	0	0
	Reduced	20	17.1	13	11.2	3	16.7
	No change	72	61.5	82	70.7	13	72.2
	Increased	16	13.7	17	14.7	2	11.1
	Highly increased	6	5.1	2	1.7	0	0
Crop	Number of farmers responded	120		117		18	

damages	Highly Reduced	9	7.5	17	14.5	2	11.1
	Reduced	37	30.8	31	26.5	10	55.6
	No change	51	42.5	50	42.7	5	27.8
	Increased	15	12.5	12	10.3	1	5.6
	Highly increased	8	6.7	7	5.9	0	0
Incidence of pests and diseases	Number of farmers responded	117		111		18	
	Highly Reduced	9	7.7	5	4.5	2	11.1
	Reduced	9	7.7	16	14.4	3	16.7
	No change	76	65.0	80	72.1	11	61.1
	Increased	19	16.2	9	8.1	1	5.6
	Highly increased	4	3.4	1	0.9	1	5.6
Convenience of field activities	Number of farmers responded	116		111		17	
	Highly Reduced	13	11.2	12	10.8	2	11.8
	Reduced	39	33.6	28	25.2	5	29.4
	No change	46	39.7	44	39.6	5	29.4
	Increased	12	10.3	19	17.1	4	23.5
	Highly increased	6	5.2	8	7.2	1	5.9
Quality of the yield	Number of farmers responded	119		113		17	
	Highly Reduced	2	1.7	3	2.7	1	5.9
	Reduced	22	18.5	12	10.6	0	0
	No change	58	48.7	54	47.8	8	47.12
	Increased	22	18.5	22	19.5	4	23.5
	Highly increased	15	12.6	22	19.5	4	23.5
Soil properties	Number of farmers responded	118		114		18	
	Highly Reduced	2	1.7	5	4.4	1	5.6
	Reduced	19	16.1	12	10.5	2	11.1
	No change	43	36.4	51	44.7	7	38.9
	Increased	34	28.8	27	23.7	4	22.2

	Highly increased	20	16.9	19	16.7	4	22.2

Source: Field Survey, 2017

The results revealed that, irrespective to the size of the holdings, the costs of weed control have increased. About 40% of the farmers who have larger holding sizes (greater than two hectares), stated that the increment of costs of production in the absence of suitable herbicide is a serious issue. The reduction of the yield was significant in larger holding sizes (45% of the farmers) compared to the small holding sizes. It was reported that some of the farmers have given up harvesting of marginal lands as the plucking (harvesting of green leaves) is not economical after controlling the weeds using labourers. However, only 20% of farmers among the very small holding sizes (less than 0.5 hectare) recorded lower production as they are able to maintain the production by efficient weed control using family labourers. Among the other aspects, farmers with large holding sizes responded that the growth of the tea bush is adversely affected due to poor weed control after banning glyphosate and it will reduce the harvest.

Table 19 summarizes the responses of farmers on alternative methods employed to control weeds in tea lands after banning glyphosate in 2015. It shows that most of the farmers with very small holding sizes are using more labour while in large holding sizes only about 50% of the farmers are using more labour while a significant number of farmers minimize the weed control in order to reduce the costs of weed control thus impacting the yield. Some of the farmers in all categories (about 10%) have tried to use small machineries such as bush cutters, although it is very difficult to use in tea lands.

Table 19: Alternative methods to control weeds in tea plantations after banning glyphosate

	Area <= 1.25ac (.5ha>)		1.25ac < Area < 5ac (.5 - 2ha)		5ac<= Area (2ha<)	
	Count	%	Count	%	Count	%
Number of respondents	125		126		18	
Try to increase labour	88	70.4%	93	73.8%	9	50%
Try to use machineries	16	12.8%	10	7.9%	3	16. 7%
Use of other weedicides / glyphosate	26	20.8%	25	19.8%	3	22.1%
Given up the entire cultivation	0	0%	1	0.8%	0	0%
Minimizing weed control	18	14.4%	20	15.9%	5	27.8%

Source: Field Survey, 2017

Above analysis reveals that after banning of glyphosate, farmers in tea small holding sector have made efforts to divert the strategies to control weeds in tea lands. Majority of the small-scale farmers (less than 2 hectares) have tried to use more labour although the approach is

difficult and expensive according to the information. About 20% of the farmers have used other weedicides.

Further the farmers were questioned about the impacts of banning glyphosate on different aspects on tea cultivation (Table 20)

Table 20:Impact of glyphosate banning on different aspects of tea cultivation

	Area <= 1.25ac (.5ha>)		1.25ac < Area < 5 ac (.5 - 2ha)		5ac<= Area (2ha<)	
	Count	%	Count	%	Count	%
Reduction of area of harvesting	12	10%	24	19.5%	5	29.4%
Increased costs of production of green leaf	64	54.2%	54	45%	12	66.7%
Reduction of family income	46	39.7%	49	40.5%	8	44.4%

Source: Field Survey, 2017

The findings show that some farmers in all categories have reduced the area under cultivation due to difficulties in weed management. Only 10% of farmers of holding size less than 1.25 acres reduced the area of harvesting, while 29.4% of farmers of holding size more than 5 acres reduced their area of harvesting. According to the findings, the majority in all categories stated that the costs of cultivation have increased due to banning of glyphosate. Also, more than 40% of the farmers in all categories reported that the family income reduced due to reduced production and increased costs of cultivation.

It was observed that some areas are getting covered with dense weed growth, in the absence of weed management while in other areas there is an increased tendency of soil erosion because of mechanical weed control methods in tea lands of the small holding sector. If this situation continues, tea production in the small holding sector will be further reduced in future, thus impacting the total tea production in the country in a significant manner. Also, increased population of snakes and other wild animals due to growing shrubs in adjacent areas is threatening to the life of the labours in tea sector.

3.7 Large plantation sector

Twenty large tea plantations were investigated for the impact of banning glyphosate on large tea plantation sector. The study revealed that almost all the planters were using glyphosate to control weeds in boundaries and road sides before banning. Except three planters, others have used glyphosate to control weeds when the labour is not sufficient. Normally many planters were applying weedicides twice a year while some are using occasionally (only when needed). After banning of glyphosate, the planters are facing a critical problem due to

absence of labour. The labour requirement increased by about 30% as a consequence of banning glyphosate. During field visits, it was observed that boundaries and roads are full of grasses in some of the plantations. Planters have neglected controlling weeds in boundaries and vacant areas as it is expensive and non-remunerative. Labourers of the plantations claimed that due to growth of shrubs in plantation boundaries, population of poisonous reptiles (snakes) has increased thus threatening the life of the labourers. Soil erosion of the sloppy tea lands has increased due to use of mechanical equipment for weed control. The study revealed a trend in reduction of tea production in large plantation. However, large plantation owners can manage by dropping marginal areas of tea lands and focus on the remaining area, which is still sufficiently remunerative.

In addition to the tea sector, it was observed that weed management has become very difficult after glyphosate ban in coconut, rubber and cinnamon plantations due to scarcity of labour and difficulties of using machineries in uneven and sloppy lands in many of these plantations.

Following statistics are given the impact of banning of glyphosate in two large plantations in Badulla District – Telbedda Estate and Uri Estate.

Cost of weed control in estate sector is showing an increasing trend while giving up some of the areas. Costs of manual weed control at Telbedda Estate, Badulla in the years 2016, and 2017 is given in the following table. By the end of the year 2016, they were not able to find suitable weedicides.

Table 21: Costs of weed control at Telbedda Estate, Badulla

Month	**Costs for 2016(Rs)**	**Costs for 2017(Rs)**
January	1,00,888.78	5,64,295.18
February	1,35,281.24	10,24,975.00
March	3,43,747.45	83,656.18
April	5,26,109.41	7,20,255.92
May	3,68,966.95	9,90,727.99
June	45,096.33	13,43,716.83
July	1,66,177.98	11,37,014.23
August	6,36,947.31	7,50,220.89
September	3,78,468.38	16,13,624.50
October	2,65,037.50	16,46,508.04
Total	Rs.2,966,721.33	Rs.9,874,994.76

Source: Records of the estate

The data reveals that the increment of costs of weed control for the year 2007 over the year 2006 is Rs.69,08,274.00 which is about three folds. It is about Rs.11,813.00 per hectare. As the average yield of low producing tea lands is about 2160 kg of green leaves per hectare per year, average increment of cost of production per kilogram of green leaves is about Rs.5.47 due to absence of proper weed control mechanism. The same situation was observed in Uri Estate in Badulla.

In Uri Estate in Badulla District the costs of manual weed control in the absence of weedicides are given in the following table and it shows a remarkable increase of costs of weed control . According to the records, the costs of weed control have been increased by four folds.

Table 22: Costs of manual weed control at Telbedda Estate, Badulla

Month	**Costs for 2016(Rs)**	**Costs for 2017(Rs)**
January	1,24,690	6,09,656
February	1,12,269	14,80,514
March	1,02,921	9,88,895
April	16,973	5,84,368
May	62,808	9,73,415
June	5,22,422	13,90,488
July	2,24,768	9,09,313
August	1,93,044	7,38,538
September	5,88,844	6,30,741
Total	Rs.1,948,739	Rs.8,305,928

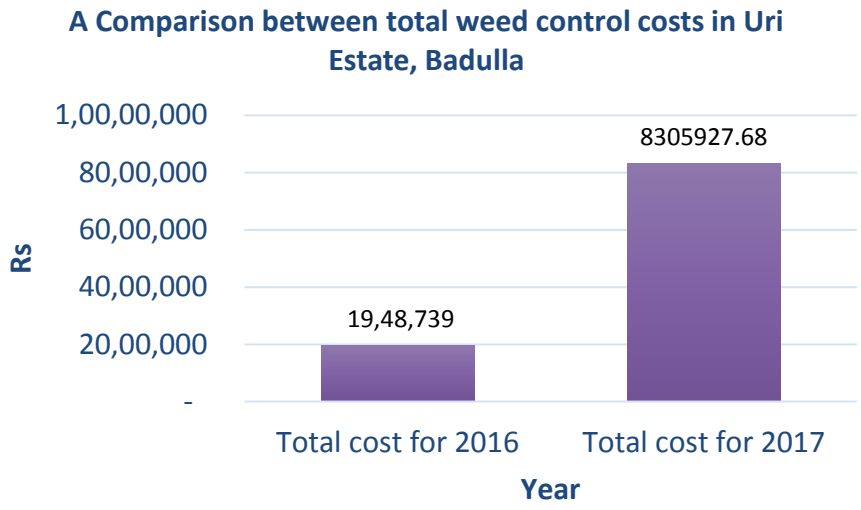

Figure 6: A comparison between total weed control costs in Uri Estate

4. Impact of banning glyphosate and the efficiency of agriculture

Agriculture sector of the country is not growing at the rate compared to the industrial sector and service sector. Agriculture contributed 8.5%, service contributed 60.6% and industry contributed 30.9% to GDP in 2016. Latest report released by Department of Census and Statistics, Sri Lanka's economy grew by 4 percent in the second quarter of 2017, up from 3.8 percent in the earlier quarter. The industrial and the services activities recorded higher growth rates of 5.2 percent and 4.5 percent respectively. Agricultural activities reported a negative growth rate of 2.9 percent, the sector was affected by bad weather for the past 18 months.

Informal discussions held during the study with research and administrative officers in agriculture sector revealed that they are not in agreement with the decision of banning glyphosate. According to these learned and experienced professionals in the sector, the decision of banning glyphosate is not supported by scientific factors but was made merely due to pressure of the strong lobbies and influential groups. The study very clearly shows that this decision has resulted in adverse impacts on agriculture while creating an unbalanced status in agriculture sector. Food import bill has been increased in recent years especially for legumes (234 million USD in 2016), onions (99.8 million USD), sugar (335 USD million) and soya bean meal (87.8 USD million in 2016). The import statistics show that although Sri Lanka is imposing restrictions on use of glyphosate, it continues to import food products in large extent from the countries where glyphosate is extensively used.

The productivity of the land and labour is very low in agriculture sector due to increased labour costs during last two decades and people, especially the young generation, are moving away from the agriculture as it becomes less remunerative. It is obvious that labour-replacing technologies are essential to increase the productivity of land for agriculture to be efficient and remunerative. In field crops and plantation crops, farmers were using total weed killers in order to reduce the labour cost of controlling weeds during last two decades effectively.

However, due to banning of glyphosate there are major impacts on different aspects of crop production. As the current study reveals, the costs of production of maize cultivation has increased by about 12% after banning glyphosate due to increased prices of illicit glyphosate in the black market and or increased labour and machinery costs. In tea sector, it is reported that there is about 30% increment of the labour cost after banning glyphosate. Farmers are struggling with increasing costs and are trying to minimize the costs of production as otherwise they cannot compete with low priced imports. With limited access to agricultural technologies such as glyphosate, Sri Lankan farmers have experienced the increasing costs of production and decreasing efficiency of agriculture, eroding Sri Lanka's competitiveness of agricultural sector. Although the government is making efforts to increase the food production, it will be tough task without using efficient new technologies. The study revealed that the efficiency of the production of maize and tea has significantly reduced making these crops less competitive. Different elements of the impact of glyphosate ban are discussed in the following sections.

4.1 Effectiveness of banning glyphosate

First, the results revealed that the decision of banning glyphosate is not effective as the farmers are still searching and using illicit glyphosate from informal markets at higher prices demonstrating the dire requirement of such weed killers in order to continue farming. The illicit glyphosate available in market are sold with no labels, and hence not assuring any safety, efficacy or performance. In Monaragala district 20% of the farmers are using glyphosate in Maize cultivation while it is 65% in Anuradapura district. In tea small holding sector the percentage of farmers who are still using glyphosate from informal sources is more than 20%. The real figures may be larger than above many of the farmers are reluctant to reveal about the use of glyphosate as use of glyphosate is illegal. As many of the farmers are using illicit glyphosate or other weedicides to control weeds, the objective of banning glyphosate has not been achieved. Also, since the farmers are buying weedicides from the illegal and informal sources, composition of such weedicides is not assured. Some of the farmers are preparing their own chemical formulations using kerosene, monosodium glutamate (MSG) and different other chemicals causing unknown environmental issues and health risks to human. Increased soil erosion due to increased use of tractors in maize cultivation and increased mechanical weed control in tea plantations in the absence of herbicides may cause more damages to the environment. These findings highlight that farmers are moving to use more unsafe and unsustainable options for weed management in the absence of legitimate glyphosate.

With the reduction of local production of the food crops including maize, imports of food crops have to be increased from the countries where all modern technologies including agrochemicals are abundantly used. Increased demand for Soya products (imports of Mt 101 in 2012 and Mt 1122 in 2013) such as soya meal, supplementary foods, and other formulations is a good example to show that while the country is trying to reduce usage of agro-chemicals, it actually continues to import food products from the countries where agrochemicals are routinely and frequently used for crop production.

4.2 Equity

Agricultural sector of the country is one of the least remunerative sectors. Further, due to the restrictions imposed on cost reduction technology and consequent increment of the costs, the sector is becoming non-remunerative. Therefore, poor farmers are giving up agriculture while the rich and better equipped farmers are still sustaining in Monaragala district. It was observed that small-scale farmers are facing problems as they do not have their own tractors to use on time. The hiring charges of tractors have been increased due to increased demand, thus making it a very costly proposition. Therefore, small-scale farmers cannot cultivate their land in time while large-scale farmers are cultivating their land. This has resulted in large-scale farmers acquiring the lands from small-scale farmers. As the maize cultivation is less remunerative, younger generation who involved in maize cultivation in Monaragala district is giving up maize cultivation and migrating to cities searching off farm jobs. Therefore, in many rural areas, only women are continuing maize farming as there are no alternatives. In Anuradapura district also, the most vulnerable group was the resource less poor farmers. In tea sector also, small holders who are having less than 1.25 acres are adversely affected compared to the large holders as the small farmers cannot afford high prices for weedicides or the machines for weeding thus showing the disparity.

Other aspect was the food crop cultivators in Sri Lanka has to compete with the low priced imports from foreign countries where all cost reducing modern technologies including weedicides are used. Therefore, under current scenarios, farming will not be a remunerative enterprise in Sri Lanka.

4.3 Social acceptability

It was observed that many non-government organizations were conducting campaigns against use of agrochemicals including in Anuradhapura, Polonnaruwa, Habantota and other district where field crops are cultivated. Through these campaigns, farmers have been informed that there is a role of agrochemicals in contaminating the drinking water which leads to different health issues including CKDu. It is noted that the cost of production has increased, the production suffers and many farmers continue to access illicit glyphosate, whose quality and safety are not known. As almost all farming families are using filtered and purified drinking water, they have no concern about contamination of drinking water with agrochemicals including glyphosate. Farmers stated that they have to pay about Rs. 750.00 to Rs 1000.00 for drinking water per month as open well /tube well water is too hard and not potable. In this context banning of glyphosate in CKDu affected areas has only created an additional loss to family income of farmers

4.4 Technical feasibility

It was observed that the implementation of the policy of banning glyphosate to achieve the expected outcomes is not technically feasible as the demand for such technology is a matter of livelihood for many farmers. Therefore, the mechanisms developed in rural areas to distribute weedicides in the name of glyphosate could not be controlled. The ultimate outcome is the use of chemical formulations which are perhaps more harmful to the environment and to the users directly and indirectly while increasing the costs of cultivation of crops. Present situation is more damaging because the farmers are using different unknown formulations of weedicides which are more expensive and whose composition is not known. As a substitute for the glyphosate, a majority of tea small holders are using **diuron (**3-(3,4-Dichlorophenyl)-1,1-dimethyl urea) which is a pre-emergence weedicide recommended for sugarcane cultivation and this substitute is neither cost effective nor effective for controlling weeds compared to glyphosate.

4.5 Food security

The food production is impacted in the country since modern technology tools employed in other developing countries are either not available or restricted to use. Sri Lanka has to increase the imports to cover the deficits in food production. This trend was observed in many of the field crops, especially in maize during last two years. In addition, migration of farmers from farming and declining profitability will reduce the purchasing power of rural poor. Further, if high prices for the green leaf of tea cannot be maintained in future, tea cultivation will no longer be profitable as cost of production is already high.

4.6 Sustainability

It was observed that the soil erosion has drastically increased due increased use of tractors in sloppy lands of Monaragala and Anuradhapura districts where maize and other field crops are cultivated in Maha season. About 80% of the farmers verified that the erosion has drastically increased with the use of tractors in the absence of suitable herbicide. This situation will reduce the suitable land area for agriculture in near future due to marginalization of agricultural lands due to heavy soil erosion. The possible erosion can be reduced by minimum tillage after using a suitable weed killer. In tea lands this situation is very critical as the majority of tea lands are steeply inclined lands and more vulnerable for soil erosion as the tea lands are situated in areas with heavy rainfall. Manual and mechanical weeding has increased the soil erosion compared to controlling the weeds using herbicides. Therefore, the sustainability of land use is also under the threat in the absence of suitable herbicides which reduces the soil erosion.

4.7 Economic Impacts

Use of modern technologies is an essential element to minimize the costs of production. More labor-intensive technologies will increase the costs of production discouraging the farmers. The results of the current study revealed that field crops and tea are no more remunerative if the labour saving technologies are not available to reduce the costs of production. At the same time, the food crops which are imported are low priced as the producing countries use all available labour saving modern technology including weedicides. After banning glyphosate, the profit per acre has reduced by an average of Rs. 9000.00 per acre in maize cultivation. Extrapolating this to all maize acres (75,000 acres), and assuming 100% use of glyphosate for weed management, this amounts to profit of ~675 Million LKR.

As the agriculture is becoming difficult and non-attractive to the young generation, rural youths are migrating to the urban areas for off-farm jobs. Therefore, only the elderly farmers and women are engaged in agricultural activities which impede the use of modern technology. Also, as the farming is less remunerative, the income of the rural areas will not be sufficient to cater to the demand for other commodities. Moving away of the young generation and able people from rural areas, the rural areas will not be developed and, disparity of income between the poor and the rich may be widened in the rural agricultural areas as the poor resource less farmers cannot continue in agriculture without owing tractors. Ultimately the poor farmers will become labourers in the fields owned by rich farmers. Food security of the country will be at a great risk in future making it dependent upon imports mainly if younger generation is not attracted towards farming.

5. Conclusion

With limitations on use of glyphosate, in field crop sector, the farmers are facing difficulties in controlling some of the weeds such as *mana grass* (*Cymbopogan glyciria*) and *kalanduru* (*Cyprus rotundus*). Rain-fed agriculture is becoming more difficult due to difficulties of controlling weeds and therefore, the cultivated area of field crops is declining gradually. The medium scale farmers are adversely affected as they do not have machineries such as tractors for harrowing on time. Large-scale farmers who own tractors can address the situation better than poor farmers who now pay higher rates while hiring machineries such as tractors. This disparity of income is pronounced in rural agricultural areas in Monaragala and Anuradhapura districts. Some lands, especially rocky and uneven lands where tractors cannot be used, are completely abandoned in Monaragala and Anuradapura districts because these lands cannot be cultivated without weed killers. Soil erosion has also increased in steeply inclined lands due to increased harrowing and this can further impact the yields in plantation sector.

The study also showed that many of the agricultural lands are converted into shrubs and forests as farmers are not cultivating these lands because of enhanced costs and labour shortages. It was reported that the wild animal populations which damage the crops have

significantly increased. Also, mana grasses are invading rural roads creating difficulties for rural life in many areas. This situation has also increased the threat of wild animals and reptiles to the humans, livestock and crops.

The findings of the study revealed that banning of glyphosate and allied formulations is not effective and the objectives of banning has not been achieved as the farmers are using a similar chemical of unknown formulation or an alternative formulation at higher prices.

Development of black markets for weedicides and use of potentially harmful and ad-hoc chemical formulations for weed control are other issues in the agricultural sector. Applying formulations such as MSG (Ajinomoto), kerosene, in order to control weeds in agriculture is more harmful to the soil, biodiversity and human health. Not only the main crops considered in the study (tea and maize), but also almost all crop sectors including plantation crops (rubber, coconut), export crops such as banana, pepper and cinnamon and field crops are all impacted and farmers are struggling to sustain due to increasing costs and labour scarcity in the absence of proper, cost effective weed control mechanism.

Huge investments were recently incurred by private companies to construct two large storage facilities for maize (16,000 MT each) at Monaragala and Anuradhapura expecting increased production of maize in two districts. However, due to declining production of maize, at present the facilities are underutilized and this has impacted the future investments.

Based on the findings of the study, it can be concluded that the food production in agricultural areas has reduced and the income of the farmers with limited resources has also reduced. Therefore, food security of the rural farmers has been challenged. Also, the disparity of the income between resouorce-rich and resource-poor farmers has widened. Rich farmers have the capacity to face the consequences of the banning glyphosate since they have tractors while the poor farmers have to face the increased rate of hiring charges of tractors and increased prices of available illicit herbicides. Migration of rural youth from the rural areas to the urban centers due to increased costs of cultivation has created labour scarcity in agricultural areas which leads to negligence of productive lands.

As the agriculture sector is the least remunerative, especially in rain-fed food crop sector, the banning glyphosate which was a low-cost weed management tool used by the farmer has pulled the food crop sector in to a catastrophe. If low cost alternatives are not presented to the farmers at the earliest possibility, the food crop production will further suffer thus creating a problem of food security making Sri Lanka to depend on food imports from other countries.

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Annex-01: Extent of maize cultivation by major growing districts in Sri Lanka 2007 – 2016 (ha)

District	Season	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average (2007-2016)	%
A'pura	Maha	10,276	16,212	20,170	20,753	15,507	20,630	21,577	21,752	21,182	21,066	18,913	
	Yala	1,097	589	395	502	393	1,918	1,026	531	452	4,042	1,095	**34**
	Total	11,373	16,801	20,565	21,255	15,900	22,548	22,603	22,283	21,634	25,108	19,440	
Monaragala	Maha	6,169	8,704	9,888	13,477	14,760	17,140	19,578	20,870	21,885	22,551	15,502	
	Yala	539	578	204	445	445	405	514	514	505	629	478	**27**
	Total	6,708	9,282	10,092	13,922	15,205	17,545	20,092	21,384	22,390	23,180	15,180	
Badulla	Maha	4,053	5,131	4,120	4,508	4,731	4,041	5,217	5,739	6,414	3,601	4,756	
	Yala	2,201	3,682	2,305	4,283	4,274	4,163	5,403	5,403	4,873	2,527	3,911	**16**
	Total	6,254	8,813	6,425	8,791	9,005	8,204	10,620	11,142	11,287	6,128	8,949	
Ampara	Maha	2,766	6,485	4,693	4,114	2,982	2,972	3,120	3,276	5,325	4,525	4,026	
	Yala	458	372	74	244	154	222	572	572	526	548	374	**8**
	Total	3,224	6,857	4,767	4,358	3,136	3,194	3,692	3,848	5,851	5,073	4,325	
Kurunegala	Maha	727	940	931	1,243	893	940	1,804	1,426	1,330	1,150	1,138	
	Yala	521	410	448	392	369	245	843	368	306	217	412	**3**
	Total	1,248	1,350	1,379	1,635	1,262	1,185	2,647	1,794	1,636	1,367	1,571	
Other	Maha	3,104	5,391	4,982	4,792	3,033	5,158	4,597	4,464	4,818	4,201	4,496	
	Yala	2,273	3,112	2,643	2,867	3,050	1,697	3,472	2,305	2,356	2,573	2,743	**12**
	Total	5,377	8,503	7,625	7,659	6,083	6,855	8,069	6,769	7,174	6,774	7,239	
Sri Lanka	Maha	27,095	42,864	44,786	48,887	41,906	50,881	55,892	57,525	60,954	57,094	48,788	
	%	**79**	**83**	**88**	**85**	**83**	**85**	**83**	**86**	**87**	**84**	**86**	
	Yala	7,089	8,744	6,071	8,731	8,685	8,648	11,830	9,694	9,017	10,536	8,905	
	%	**21**	**17**	**12**	**15**	**17**	**15**	**17**	**14**	**13**	**16**	**14**	**100**
	Total	34,184	51,608	50,857	57,618	50,591	59,529	67,722	67,219	69,971	67,630	56,589	
	%	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	

Source: Department of Census and Statistics and Data Bank of HARTI

Annex -02: Extent of chili cultivation by major growing districts in Sri Lanka (ha)

District	Season	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	AVERAGE (2007-2016)	%
Anuradhapura	**Maha**	2779	2844	3183	2394	2130	3053	2416	2180	1858	1663	2450	**21**
	Yala	428	342	284	441	410	474	558	298	441	501	418	
	Total	3207	3186	3467	2835	2540	3527	2974	2478	2299	2164	2946	
Puttalam	**Maha**	741	974	829	790	648	797	848	933	596	633	779	**10**
	Yala	766	666	569	613	738	722	684	684	447	578	647	
	Total	1507	1640	1398	1403	1386	1519	1532	1617	1043	1211	1449	
Kurunegala	**Maha**	569	737	761	724	652	592	671	537	393	388	602	**7**
	Yala	651	543	607	481	487	378	240	249	586	401	462	
	Total	1220	1280	1368	1205	1139	970	911	786	979	789	1095	
Monaragala	**Maha**	716	847	833	875	736	895	1015	922	873	927	864	**7**
	Yala	203	236	137	178	178	202	271	271	243	232	215	
	Total	919	1083	970	1053	914	1097	1286	1193	1116	1159	1070	
Hambantota	**Maha**	678	711	613	683	615	554	582	742	604	592	637	**6**
	Yala	344	275	270	314	327	303	384	300	250	248	302	
	Total	1022	986	883	997	942	857	966	1042	854	840	950	
Other	**Maha**	3565	3770	3261	3399	3451	4098	3761	4164	4040	4015	3866	**49**
	Yala	2642	2860	2209	2370	2971	2661	3006	2698	2697	5089	2954	
	Total	6207	6630	5470	5769	6422	6759	6767	6862	6737	9104	6820	
	%	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	

Source: Department of Census and Statistics and Data Bank of HARTI

Annex- 03: Extent of big onion cultivation by major growing districts in Sri Lanka (ha)

District	*Season*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*AVERAGE (2007-2016)*	*%*
Matale	**Maha**	113	37	43	6	12	24	21	20	0	0	35	
	Yala	3283	1790	2838	1890	1611	2801	1863	2392	2400	1445	2231	**45**
	Total	3396	1827	2881	1896	1623	2825	1884	2412	2400	1445	2349	
Anuradhapura	**Maha**	45	17	18	122	13	10	20	17	16	381	66	
	Yala	1119	1101	1284	1197	916	1294	1094	1921	1213	718	1186	**24**
	Total	1164	1118	1302	1319	929	1304	1114	1938	1229	1099	1269	
Mahaweli - H	**Maha**	0	0	0	0	10	16	75	6	3	7	20	
	Yala	1887	605	492	582	443	669	567	1706	1246	721	892	**18**
	Total	1887	605	492	582	453	685	642	1712	1249	728	923	
Kurunegala	**Maha**	27	47	40	29	29	22	13	19	26	2	25	
	Yala	210	187	175	148	137	145	135	94	69	20	132	**3**
	Total	237	234	215	177	166	167	148	113	95	22	172	
Jafna	**Maha**	9	81	52	74	108	74	64	107	446	200	122	
	Yala	0	0	28	19	56	59	83	112	98	97	69	**3**
	Total	9	81	80	93	164	133	147	219	544	297	163	
Other	**Maha**	56	38	29	12	36	46	68	172	121	97	106	
	Yala	239	188	81	79	113	229	221	259	237	294	220	**7**
	Total	295	226	110	91	149	275	289	431	358	391	326	
Sri Lanka	**Maha**	250	220	182	243	207	191	260	342	612	689	320	
	%	**4**	**5**	**4**	**6**	**6**	**4**	**6**	**5**	**10**	**17**	**6**	
	Yala	6738	3871	4899	3915	3276	5195	3963	6485	5263	3295	4690	
	%	**96**	**95**	**96**	**94**	**94**	**96**	**94**	**95**	**90**	**83**	**92**	**100**
	Total	6988	4091	5081	4158	3483	5386	4223	6827	5875	3984	5124	
	%	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	

Source: Department of Census and Statistics and Data Bank of HARTI

Annex - 04: Extent of Soya Bean by Major Growing Districts (2007-2016) (ha)

District	Season	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	AVERAGE (2007-2016)	%
Mahaweli - H	**Maha**	131	55	188	576	104	72	710	829	186	129	298	**65**
	Yala	2156	945	897	3179	1965	0	4802	2445	3766	2052	2467	
	Total	2287	1000	1085	3755	2069	72	5512	3274	3952	2181	2765	
Anuradhapura	**Maha**	118	68	155	88	36	48	210	225	55	24	103	**19**
	Yala	275	27	213	484	166	1330	1858	319	446	1826	694	
	Total	393	95	368	572	202	1378	2068	544	501	1850	797	
Ampara	**Maha**	2	9	5	0	0	0	0	0	1	3	4	**11**
	Yala	3	2	10	1	0	3	54	54	1725	2157	445	
	Total	5	11	15	1	0	3	54	54	1726	2160	449	
Matale	**Maha**	8	19	2	12	11	18	5	15	1	5	10	**2**
	Yala	119	16	69	101	101	13	74	72	31	28	62	
	Total	127	35	71	113	112	31	79	87	32	33	72	
Kurunegala	**Maha**	4	38	32	2	50	0	63	56	1	0	31	**1**
	Yala	6	4	11	13	14	0	0	10	48	9	14	
	Total	10	42	43	15	64	0	63	66	49	9	45	
Other	**Maha**	26	29	43	78	22	29	55	60	73	44	56	**3**
	Yala	9	14	28	13	14	6	100	27	49	22	51	
	Total	35	43	71	91	36	35	155	87	122	66	107	
Sri Lanka	**Maha**	289	219	425	709	223	166	1042	1185	318	207	478	**100**
	%	**10**	**18**	**26**	**16**	**9**	**11**	**13**	**29**	**5**	**3**	**12**	
	Yala	2568	1007	1229	3791	2260	1351	6887	2927	6065	6094	3418	
	%	**90**	**82**	**74**	**84**	**91**	**89**	**87**	**71**	**95**	**97**	**88**	
	Total	2857	1226	1654	4500	2483	1517	7929	4112	6383	6301	3896	
	%	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	

Source: Department of Census and Statistics and Data Bank of HARTI