

## **SPATIAL VARIATION OF PLASTIC WASTE GENERATION IN PRESENT SRI LANKA**

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### **Abstract**

An understanding of the spatial variations of solid waste generation helps in many ways to design waste management policies particularly at micro-regional levels. Many of the studies have focused different factors behind the post-consumer plastic waste generation as the determinants, but few of them focused on the spatial variation in finding durable solutions. In this study, quantitative and qualitative techniques were used to identify the spatial variation of plastic waste generation in Sri Lanka. Research results reveals that the per capita generation of plastic waste has a significant variation among provinces, districts and LGAs. The per capita plastic waste at national level is 0.11 kg per week and 5.72 kg per year. This finding coincides approximately with the Sri Lanka custom data of annual plastic import for consumption (5kg per head in 2014). The most prominently used plastic items are lunch sheets, polythene bags, shopping bags and wrappers of food items. It is revealed that the spatial variation of plastic waste generation is very dynamic among the districts and LGAs. Despite the western province, the second highest generation of plastic waste is recorded in the Eastern province. The study concludes that those significant findings could provide quick, useful and low-cost decision support to find durable solutions for emerging issues of post consumer plastic waste generation.

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### **Keywords:**

Plastic waste generation,  
Spatial variation,  
Plastic types,  
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## 1. Introduction

The use of plastic production in the world has been increasing compare to the other manufactured materials. It is assumed that global plastic waste generation will be increased 12 billion tons in 2050. Approximately 8.3 billion metric tons already been produced and over 60 percent has ended up with garbage dumping. The human population generate vast quantities of waste materials including macro ( $1 > \text{mm}$ ) and micro fragments of plastic debris (Brown *et al.*, 2010). It has been encouraged by rapid increase in population, expansion of urban areas and improvement of technology (Ajadi and Tunde, 2010). The extensive use of plastic for diverse purposes has become a severe socio-economic and environmental issue in Sri Lanka. Due to the factors such as population growth, urbanization, changing lifestyle and modern food packaging system, this issue has intensified during the last few decades and is likely to be one of the greatest pressing issues of the country in the future. Therefore, the use of plastic and the disposal of its waste should be a focal point of concern when formulating the national strategies for sustainable development. In 2012 Central Environmental Authority of Sri Lanka (CEA) presented the results of their survey carried out for updating information on solid waste generation and pointed out that Local Government Authorities (LGAs) collect 3424 metric tons of solid waste daily. The solid waste generated in Sri Lanka mostly include polythene/plastic wastes/shopping bags, short term bio-degradable wastes, Long-term biodegradable wastes, Metal wastes, Wooden wastes, Glass waste, paper wastes, Building wastes, Slaughter house wastes, cloth/garment wastes, hazardous waste and other wastes. Polythene and plastic waste is the second largest solid waste which comprises 10.5% of total waste generation of the country (CEA 2012). In fact, several attempts have already been made by the Ministry of Environment and by the CEA to solve this problem by initiating several projects.

The current national plastic waste management strategy in Sri Lanka is based on the 3R approach that focuses on Reducing, Reusing and Recycling the plastic waste. The 3R system calls for intensifying the recycling process of plastic waste, reusing of plastic materials and reducing the use of plastic by individuals as well as by institutions. Focusing on implementing the aforementioned 3R strategies, the CEA has started a project in 2007 called the “National Post Consumer Plastic Waste Management” (NPCPWM). This project has been running for nearly 8 years with the aim of expanding its capacity in the future. However, in order to facilitate its

expansion, it is essential to evaluate the progress of the activities already implemented by the project. Moreover, it is also essential to identify the present status of plastic consumption in Sri Lanka. In addition, it is necessary to investigate the response of the general public to the 3R approach implemented by the CEA. With this importance, the research carried out covering of all provinces in Sri Lanka. Although there were ample research available for waste management in Sri Lanka, limited research have been undertaken on post consumer waste management at household level. With these limitations, the present study was focused to analyze the present situation of plastic waste generation in Sri Lanka and find out the spatial pattern with respect to the province, District and Local Government Authority (LGA) levels.

## **2. Research Method**

Collection of data and information was undertaken by using Multi-stage Stratified Random Sampling Method (MSRS). The sample is representative of the entire country and 3 levels of sampling was conducted at Local Government Authorities (LGAs), Grama Niladhari Divisions (GND) and households. In stage 1, the LGAs were selected from Municipal Council (MCs), Urban Council (UCs) and Pradeshiya Sabha (PSBs) of all districts. Accordingly, depending on the existence, one MC and one UC were randomly selected from each district. Twenty per cent of PSBs were selected from each district in a completely random manner. The Colombo Municipal Council (CMC) was selected in addition to the above LGAs since it collects 700,000 kg per day out of which 23.5% is non-degradable plastic (CEA, 2012). The final sample included 89 LGAs which consisted of 16 MCs, 19 UCs and 54 PSBs. In stage 2, Five GNDs were selected from all the selected LGAs using the method of simple random sampling. The ultimate sampling unit of this study was households. Accordingly, twelve households were randomly chosen from each selected GND. The final sample duly comprised of 5340 households (89 LGAs x 5 GNDs x 12 Households).

The total plastic consumption per week was measured for each family in the sample. In addition, a questionnaire was used to obtain data related to the background of the family; their awareness about, knowledge of and attitudes towards plastic consumption and waste disposal. Statistical analysis was employed to quantify and identify the spatial distribution aspect of the island wide plastic waste generation. The three following estimates on per head plastic waste generation were

calculated for each district based on the per head plastic waste generation per week measured for each household in the sample.

$X_1 = S_1/n_1$ - per head plastic waste generation for MCs

$X_2 = S_2/n_2$ - per head plastic waste generation for UCs

$X_3 = S_3/n_3$ - per head plastic waste generation for PSBs

S1, S2, S3 denote the total plastic waste generation of the households selected for the sample from each MC, UC and PSB. n1, n2, n3 denote the total number of members in the households selected for the sample from each MC, UC and PSB.

Total plastic waste generation for each district (TPGD) was calculated based on the above three estimates.  $TPGD = P_1X_1 + P_2X_2 + P_3X_3$ , where P1, P2 and P3 correspond to the respective populations in MC, UC and PSB. Then the total waste generation of the country (T) was the sum of TPGD values of all districts. The per capita plastic waste generation per week (x) was calculated as  $x = T/P$  where P is the total population of the country. SPSS was used to analyze the data gathered using the questionnaire; and the results were discussed and presented using frequency and cross-tabulated tables, and charts on the nature of plastic waste generation and its spatial distribution.

### 3. Results and Analysis

#### 3.1. Spatial Variation of Per Capita Plastic Waste Generation

There is a considerable amount of post consumer plastic waste generation in many areas of the country. Island wide per capita plastic consumption (denoted by weight) is about 0.11 kg per week, 0.44 kg per month and 5.72 kg per year. However, Island wide per capita plastic waste generation varies among provinces, districts and types of LGA's as indicated in Table 1.

As shown in figure 1, a significant per capita plastic waste generation is recorded at provincial level. Eastern province has the second highest plastic waste generation followed by the Western province (0.14kg) while the lowest value is recoded in the North Central province (0.05 kg). Contrary to the general belief that provinces with a majority of rural population do not generate a lot of plastic, the Eastern province, which has a higher rural population, indicates a high generation of plastic waste. This should be a point of interest for further study.

In addition to the remarkable provincial level variations, significant variations of per capita plastic waste generation were also found in the district level as depicted in Figure 2. According to Figure 2, it is apparent that in Colombo and Vauniya districts, the per capita plastic waste generation is higher while it is considerably lower in Moneragala, Kegalle and Anuradhapura districts. In the Northern Province, Vavuniya district has the highest value (0.16kg) while Kilinochchi and Mulative records the lowest (0.07kg). Enentthough there is no significant disparities among the said districts in terms of urban development, population density and lifestyle of the residents etc. Vauniya district shows the second highest per capita plastic generation ion the Country.

**Table 1:** Island Wide Per Capita Plastic Waste Generation Among the Provinces, Districts and LGAs

Province	District	Per week per household/kg				Per week per person/kg			
		MC	UC	PS	Overall	MC	UC	PS	Overall
Western	Colombo	1.07	0.75	0.86	0.95	0.25	0.15	0.24	0.22
	Gampaha	0.32	0.88	0.4	0.45	0.07	0.3	0.2	0.15
	Kaluthara	-	0.46	0.39	0.43	-	0.11	0.08	0.09
	Overall	0.77	0.57	0.45	0.55	0.16	0.14	0.11	0.14
North Western	Kurunegala	0.45	0.25	0.32	0.35	0.13	0.06	0.08	0.09
	Puttalam	-	0.4	0.27	0.33	-	0.09	0.06	0.07
	Overall	0.45	0.36	0.31	0.34	0.13	0.07	0.08	0.08
Central	Kandy	0.34	0.34	0.47	0.43	0.09	0.09	0.10	0.10
	Matale	0.13	-	0.34	0.27	0.03	-	0.08	0.07
	Nuwara Eliya	0.38	0.31	0.29	0.32	0.08	0.06	0.07	0.07
	Overall	0.28	0.32	0.41	0.35	0.06	0.06	0.09	0.08
Uva	Badulla	0.29	0.41	0.28	0.37	0.06	0.10	0.70	0.08
	Monaragala	-	0.23	0.26	0.24	-	0.06	0.50	0.05
	Overall	0.29	0.38	0.27	0.29	0.06	0.10	0.07	0.07
Southern	Galle	0.49	0.32	0.36	0.40	0.14	0.12	0.13	0.13
	Matara	0.38	0.47	0.36	0.40	0.10	0.13	0.11	0.11
	Hambantota	0.28	0.31	0.16	0.22	0.07	0.08	0.05	0.06
	Overall	0.38	0.38	0.31	0.34	0.10	0.11	0.10	0.10
Sabaragamuwa	Kegalle	-	0.26	0.17	0.18	-	0.06	0.05	0.05
	Rathnapura	0.22	0.23	0.32	0.27	0.05	0.07	0.07	0.06
	Overall	0.22	0.26	0.25	0.24	0.05	0.06	0.06	0.06
North Central	Anuradhapura	-	0.31	0.18	0.19	-	0.08	0.05	0.05
	Polonnaruwa	-	-	0.30	0.30	-	-	0.07	0.07

	Overall	-	0.31	0.19	0.20	-	0.08	0.05	0.05
Northern	Jaffna	0.504	0.33	0.32	0.37	0.10	0.08	0.08	0.08
	Vavunya	-	0.72	0.72	0.72	-	0.15	0.17	0.16
	Mannar	-	0.33	0.60	0.46	-	0.08	0.13	0.10
	Mulativ	-	-	0.33	0.33	-	-	0.07	0.07
	Kilinochchi	0.485	0.53	0.5425	0.52	0.29	-	0.07	0.07
	Overall	0.50	0.42	0.37	0.39	0.10	0.09	0.09	0.09
Eastern	Ampara	0.48	0.58	0.52	0.52	0.12	0.12	0.12	0.12
	Batticaloa	0.49	0.67	0.48	0.52	0.13	0.14	0.12	0.12
	Trincomalee	-	0.45	0.61	0.56	-	0.12	0.16	0.14
	Overall	0.49	0.54	0.53	0.52	0.12	0.13	0.12	0.12

Source: Field Survey, 2016

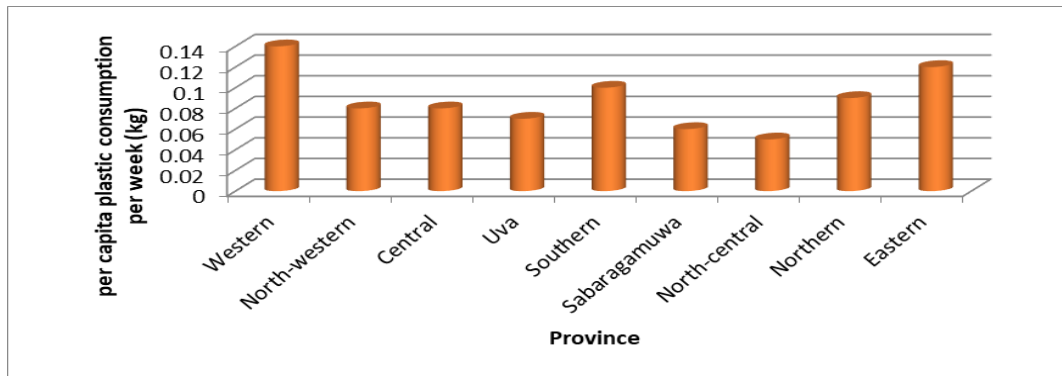


Figure 1: Weekly Per Capita Plastic Waste Generation at Provincial level

Source: Field Survey, 2016

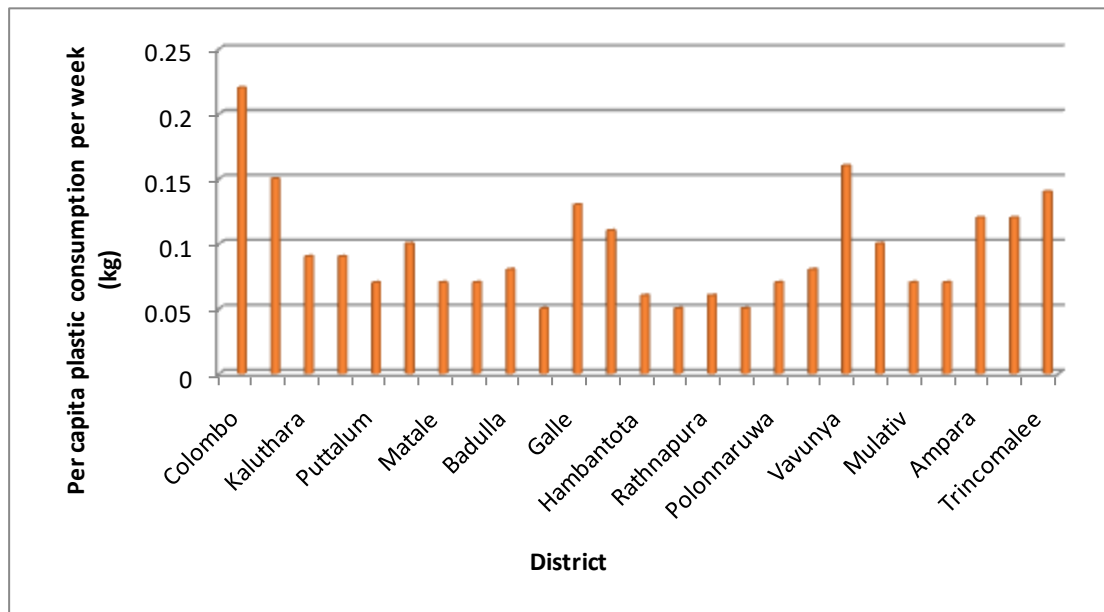


Figure 2: Weekly Per Capita Plastic Waste Generation at district level

Source: Field Survey, 2016

The Figure 3 shows the spatial distribution of per capita plastic waste generation by districts per week.

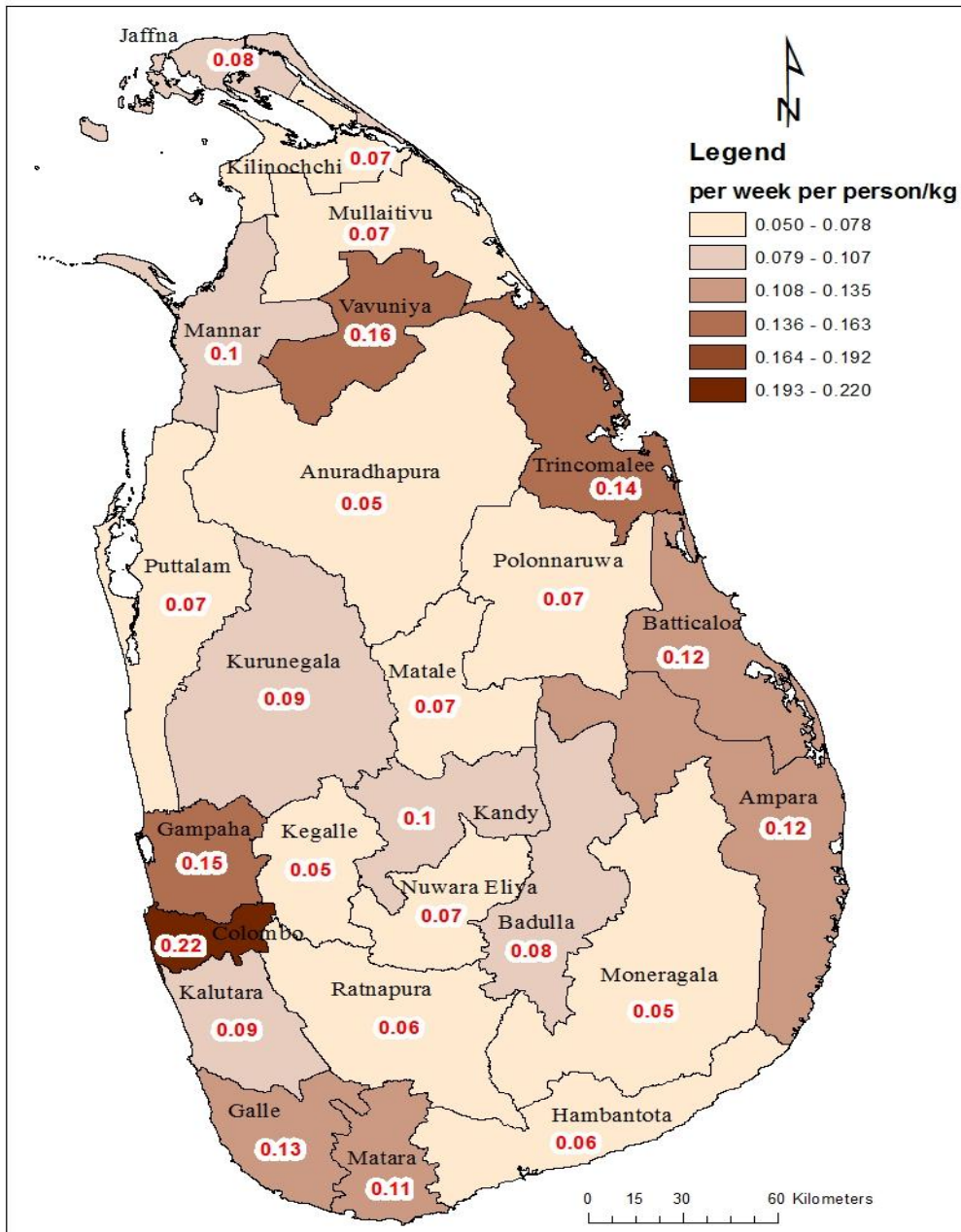
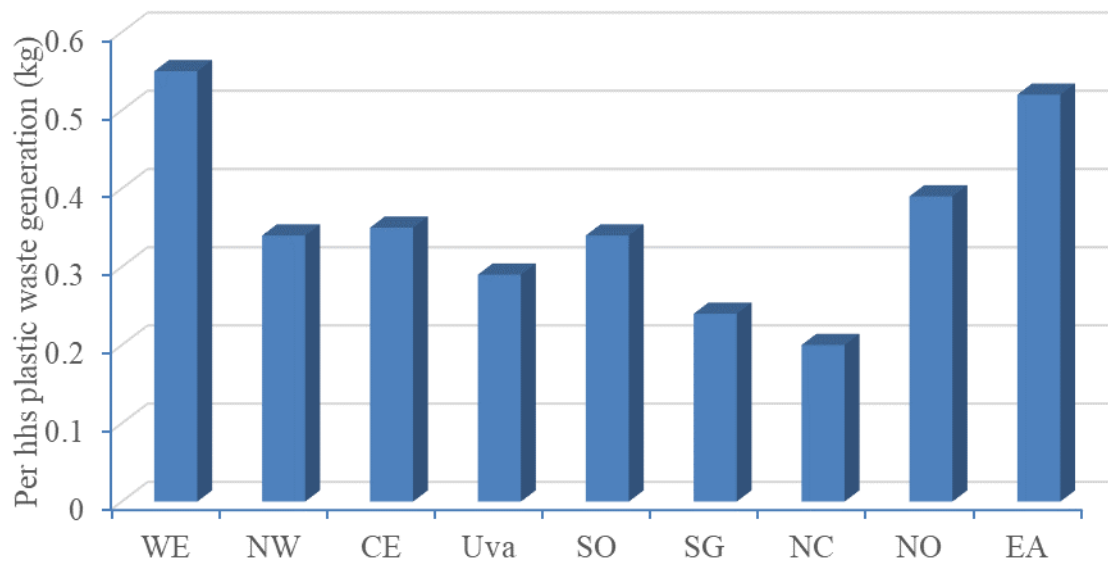


Figure 03: Spatial Distribution of Per Capita Plastic Waste Generation by District. Source: Field Survey, 2016



### 3.2 Spatial Variation of Per Households Plastic Waste Generation

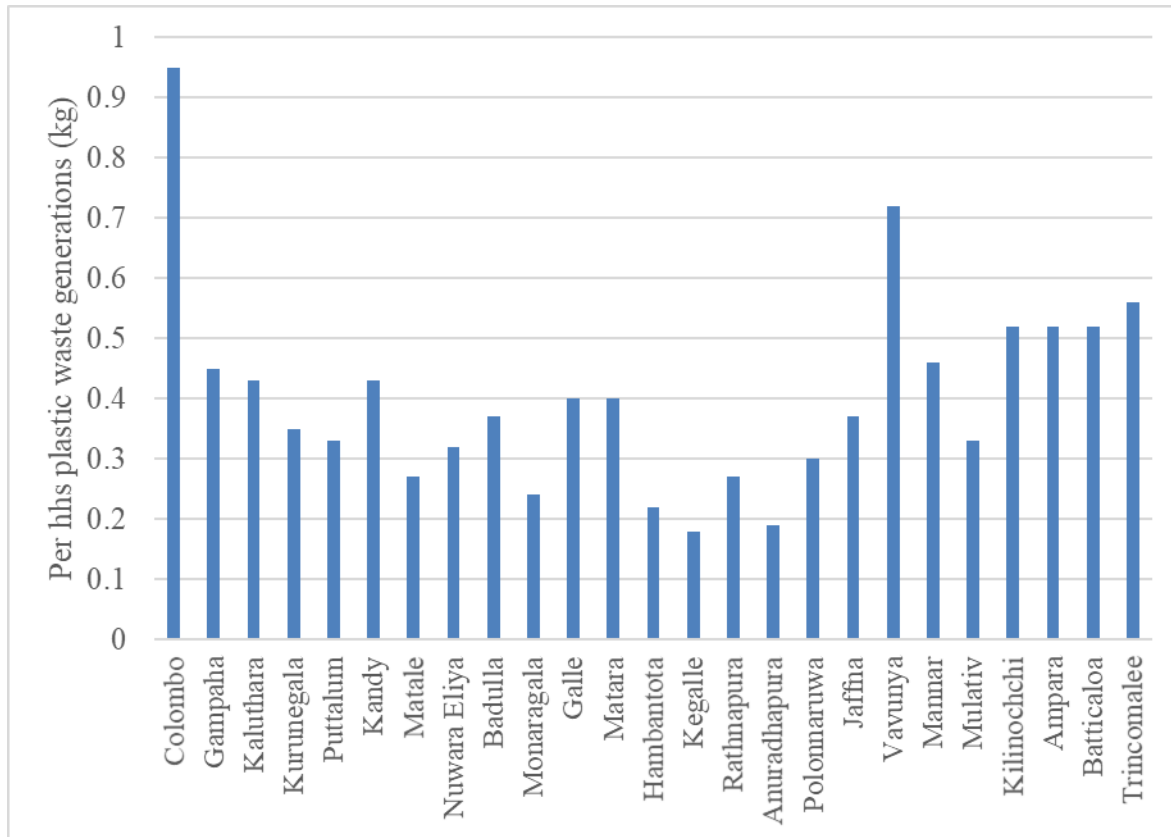
It is evident that the provincial level status of per household plastic waste generation varies significantly as shown in Figure 4. As depicted in Figure 4, similar to the pattern of per capita plastic waste generation, the Western province has the highest per household plastic waste generation (0.55kg). The second highest household plastic waste generation is recorded in the Eastern province (0.52kg) while the lowest value is recorded in the North Central province (0.20 kg).



**Figure 4:** Spatial Distribution of Per Household (hhs) Plastic Waste Generation Among the Provinces of WE (Western), NW (NorthWestern), CE (Central), Uva, SO (Southern), SG (Sabaragamuwa), NC (NorthCentral), NO (Northern) and EA (Eastern).Source: Field Survey, 2016

The present status of per household plastic waste generation varies significantly among the districts and it is presented in Figure 5. Accordingly, per capita plastic waste generation is higher in Colombo (0.95kg) and Vauniya (0.72kg) districts while it is considerably lower in Kegalle (0.18kg) and Anuradhapura districts (0.19kg).





**Figure 5:** Spatial Distribution of Per Household (hhs) Plastic Waste Generation at District Level.

Source: Field Survey, 2016

### 3.3 Types of Plastic Waste Generation and Its Spatial Variation

This study also attempted to find the types of plastic waste that are mostly generated by people. It was discovered that lunch sheets, shopping bags, various kinds of plastic food wrappers are the types of plastic waste that are most often generated. The percentage of the most frequently generated type of plastic waste by household is tabulated in Table 02. According to Table 2, it is noticeable that the items such as lunch sheets, shopping bags and wrappers are the most often used types of plastic.

It is also evident that there is a significant spatial variation of types of plastic waste generation in Sri Lanka at province, district levels as indicated in Table 2 and Annexure1. In all provinces, except in the Uva and North Central provinces, more than 60% of the households use lunch sheets. In addition, except in the North Central province (73%), more than 80% of the households use shopping bags. The usage of polythene bags is highest in the Northern and

Eastern Provinces (91%) while it is lowest in the Sabaragamuwa province (47%). More than 70% of the households in all provinces use plastic wrappers. The North Central province has the lowest usage of plastic wrappers (38%). The spatial distribution of the most often generated types of plastic waste by province is depicted in Figure 6.

Table 02: Percentage of Households Generating Different Types of Plastic Waste by Province

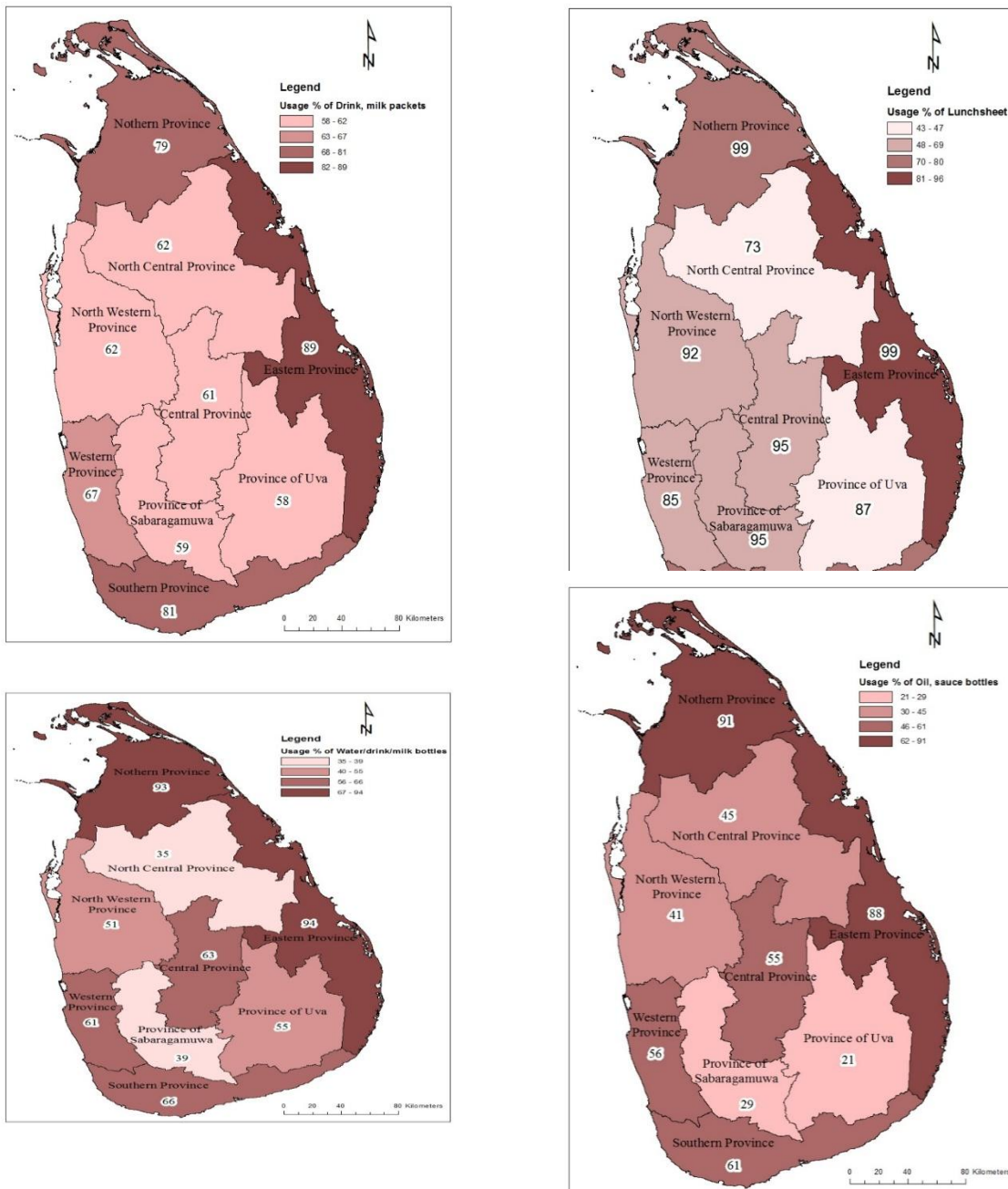
Type of Plastic	Percentage of major type of plastic waste generate in households by Province								
	Western	North Western	Central	Uva	Southern	Sabaragamuwa	North central	Northern	Eastern
Lunch sheets	69	68	63	43	80	60	47	76	96
Shopping bags	85*	92	95	87	99	95	73	99	99
Polythene bags	72	75	86	67	96	47	52	91	91
Other bags	56	36	54	37	59	16	49	71	8
Water/drink/milk bottles	61	51	63	55	66	39	35	93	94
Oil, sauce bottles	56	41	55	21	61	29	45	91	88
Plates, cups and cans	55	30	36	30	49	13	61	58	25
Butter, ice-cream boxes	71	63	72	44	78	48	88	79	83
Drink, milk packets	67	62	61	58	81	59	62	79	89
wrappers of biscuits, toffees	81	75	88	78	91	91	38	97	97
Tooth paste, brushes, combs, soap boxes	64	78	68	68	56	64	75	94	96
Tubes	69	42	16	29	90	20	78	88	8
packets used for food items	79	66	92	81	77	67	87	88	97

**Note:** <sup>1</sup>This 85% refers to the households who responded 'Yes' to the use of shopping bags. What is denoted by the remaining 15% is the percentage of households that indicated no response to this question.

Source: Field Survey, 2016

Shampoo bottles	75	66	81	58	85	70	48	96	99
Yought, ice-cream cups	80	69	76	57	70	82	26	80	84
Pen clips, rulers	64	48	49	32	35	37	62	78	82
Buttons	46	33	30	13	76	9	42	65	22
Other	54	47	47	25	37	18	14	67	19

The spatial distribution of the prominent types of plastic waste generation (% of households) by province is shown in Figure 06.



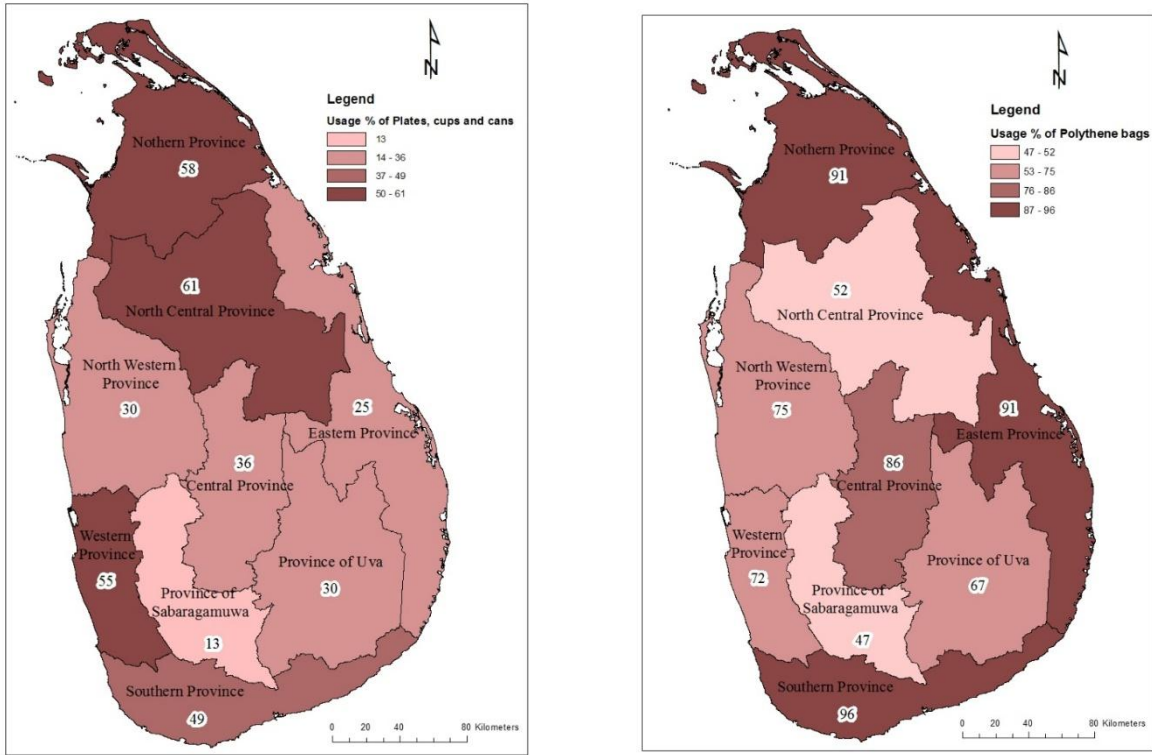
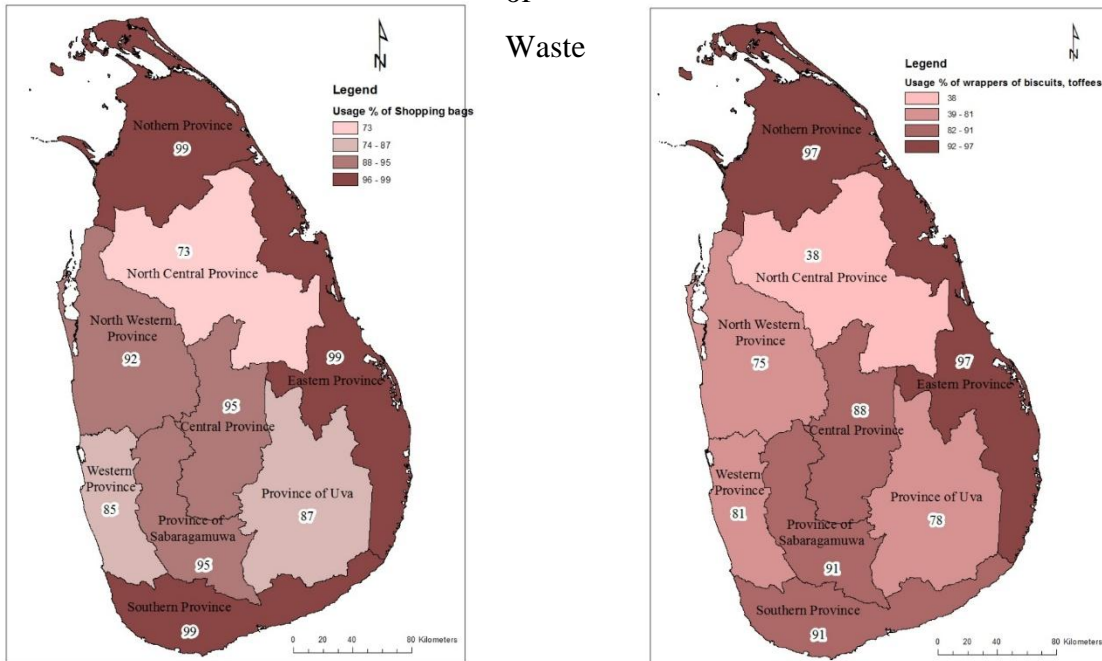


Figure. 6: Spatial Distribution of Prominent Types

of Waste Plastic



Generation (% of households) by Province

In addition, spatial variation of the types of plastic waste generation can be seen among the districts as noticed from the Appendix 1. With regard to the question of the quantity of plastic waste generation per month per household, the highest waste of lunch sheet generation per household is recorded in Colombo district (60 lunch sheets per month) whereas the lowest is recorded in Jaffna (10 lunch sheets per month). A remarkably high usage of shopping bags is seen in the Vauniya district (100 bags per month per household). The usage of shopping bags is also quite high in Batticloa (70), Mannar and Mulative (50) districts. The consumption of shopping bags is very low in Matara and Anuradhapura Districts (Appendix 1).

### ***3.4 Relationship Between the Occupation of the Head of the Household and Plastic Waste Generation***

The relationship between the occupation of the head of the household and the plastic waste generation was also studied in this research. According to Figure 7, the plastic waste generation was highest in households where the head of the household was employed in the Fisheries sector and was lowest when employed in the Private sector. The second lowest usage was recorded in households where the head of the household was employed in the Government sector.

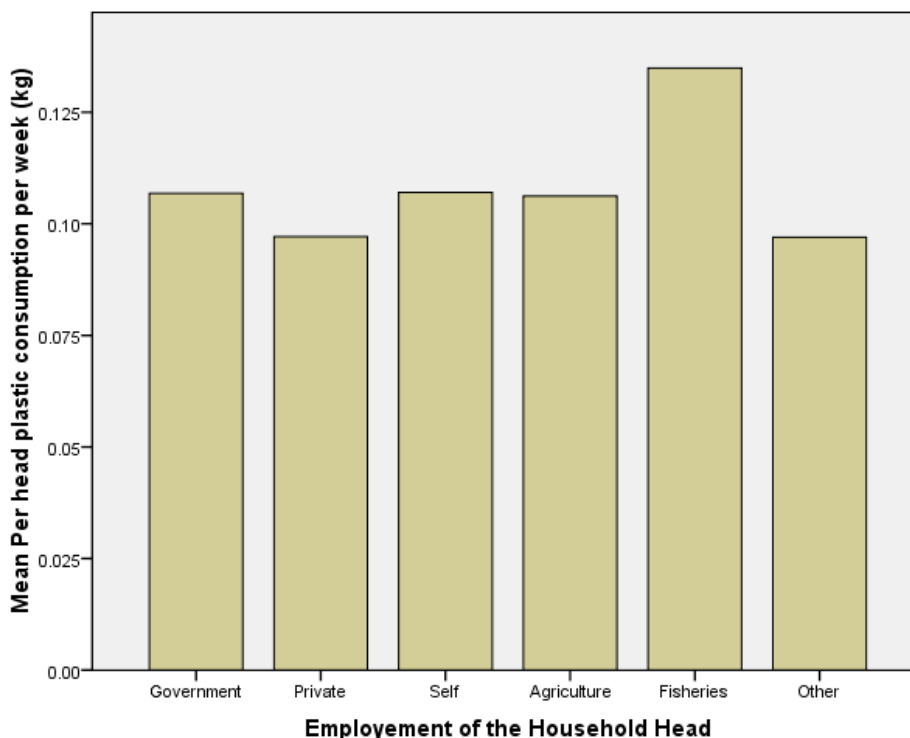


Figure 7: The Occupation of the Head of the Household and the Mean Per Capita Per Week Plastic Waste Generation. Source: Field Survey, 2016.

### ***3.5 Relationship Between the Standard of House and Plastic Waste Generation***

The relationship between the standard of house and the plastic waste generation per week was studied by this research. As depicted in Figure 8, the per capita plastic waste generation per week was highest in the Very High Standard houses and was lowest in the Moderate Standard houses. Moreover, plastic waste generation in the Low and the Very Low standard houses was higher than the Moderate standard houses.

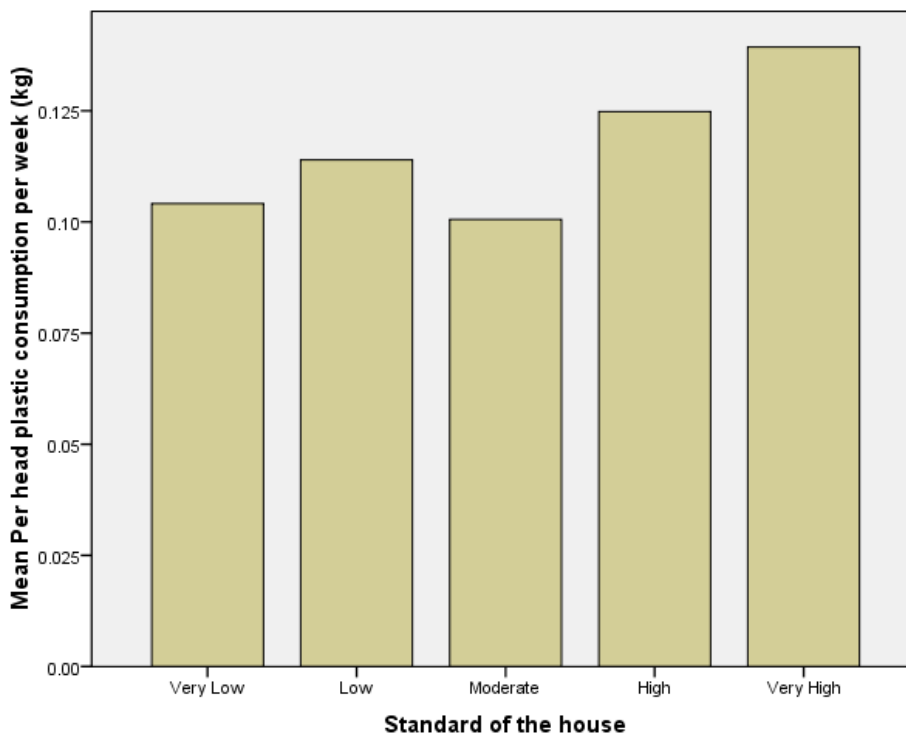


Figure 2: Relationship Between the Standard of House and the Mean Per Head Plastic Consumption Per Week. Source: Field Survey, 2016.

#### **4. Conclusion**

The conclusion of this study discusses the trends of plastic waste generation, most prominent types of plastic waste, its spatial variation and the relationship among the occupation of the head of the household, standard of house and the mean per capita per week plastic waste generation. Since several geographical factors are directly related to this issue, the spatial variation of plastic waste needs to be clearly identified by a national survey. As revealed by this study, the per capita generation of plastic waste has a significant variation among provinces and districts as well as among LGAs. Thus, it is evident that the present situation of plastic waste generation in the country exhibits many significant issues that need to be taken into account when planning national plastic waste management in Sri Lanka. Per capita plastic waste at national level is 0.11 kg per week and 5.72 kg per year. This finding coincides approximately with the Sri Lanka custom data of annual plastic import for consumption (5kg per head in 2014). The most prominently used plastic items are lunch sheets, polythene bags, shopping bags and wrappers of food items. The spatial variation of plastic waste generation is higher among the districts and LGAs. In the Western province, per capita and per household plastic waste generation is higher than that of the other provinces. The second highest generation of plastic waste is recorded in the Eastern province. In the Northern Province, Vavuniya district has the highest value of per capita plastic waste generation and Kilinochchi records the lowest. Generally MCs and UCs have higher consumption of plastic than PSs but in the case of some provinces, namely in the Northern, North Central and Sabaragamuwa provinces, the higher consumption is recorded in PSs. Further, there is a significant relationship among the variable of occupation of the head of the household, standard of house and the mean per capita per week plastic waste generation.

#### **Acknowledgments**

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