



APEC 2016 Expert Consultation on
Food Loss and Waste in the Retail and Consumer Sectors

Policy Impacts and Determinants of Food Loss and Waste in Korea

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Introduction

- ✓ As the sustainable development has become an important issue, food chains has gotten public attention to meet the demand of efficient resource use and reducing environmental costs.
- ✓ The economic aspect of food loss and waste means a wasted investment, thus resulting in inefficient use of resources. In addition, food losses have negative impact on the income of farmers and consumers.(Gustavsson J. et al., 2011)



Introduction

- Environmentally, food waste causes the unnecessary greenhouse gas emissions and inefficiently used water and land.
 - ✓ According to FAO (2013) about food wastage footprint and climate change, if global food wastage were a country, it is the third largest methane emitter after China and U.S., by causing 3.3 Gigatonnes of CO₂ equivalent methane.
 - ✓ Thus, there is a need for reducing food waste due to its impacts on global greenhouse.



Introduction

- Demands of public and private partnerships
 - ✓ Since food loss and waste have a various impact in terms of supply, nutrition, environment, and economy, it is required to understand how much is lost or wasted along the food supply chain.
 - ✓ Food loss and waste should be considered along the whole food supply chain in the context of sustainability.
 - ✓ It calls for the policy level intervention, public framework, and the public-private partnership.



Introduction

- Food loss throughout the food chain
 - ✓ Farm level: Post-harvest losses may occur due to unexpected weather condition, disease, handling, and machinery.
 - Weather is the main cause of food loss during harvest season.
 - If climate change is getting worse, post-harvest losses would also increase.
 - ✓ Processing and wholesale level: Transportation condition, packaging and storage may also cause substantial food loss.
 - Inedible parts such as bones or bruised fruits are not suitable for marketing and safety reasons.



Introduction

■ Food loss throughout the food chain

✓ Retail level:

- Food expired, spilled and damaged before consumer purchase.
- Some food are also discarded due to low quality because they do not satisfy consumers.

✓ Consumer level: Losses in household, restaurant, and food service also account large portion of food loss due to overconsumption and mistreatment.

✓ .



Introduction

■ Definition

✓ FAO uses food loss as the decrease in mass or nutritional value of food throughout the supply chain that was intended for human consumption. In particular, this focuses on the edible parts of foods produced for consumption but not ultimately consumed by people. (Segrè et al., 2014)

✓ UNEP and World Resource Institute (WRI) refers to food loss as a decrease in mass, caloric, and nutritional value of edible foods at any stage of food value chain, because they spill, spoil, and are abnormal reduction in quality. (Lipinski et al., 2013)



Introduction

■ Definition

- ✓ Food loss and waste are usually related with country-specific conditions, the research purpose, and cultural background.
 - Major causes of loss is technical limitations in harvesting, storage, transportation, and processing in developing countries.
 - Food waste (a part of food loss) refers to the discard of edible foods mostly at retail and consumer levels (FAO, 2015).
 - Much of food waste occurs in developed countries.
- ✓ This study considers food loss before final consumers and food waste which is loss occurring at the end of the food chain.



Literature Review

- Miura (2006), Hwang et al. (2008), and Park et al. (2011)
 - ✓ These studies measure or re-estimate the food losses in Korea.
 - ✓ Attempt to establish basic elements that are necessary to build statistics on food loss and waste, and suggests the foundation for systematic statistics through interviews and questionnaire.
 - ✓ The problem suggested is that there is no clear reason for the amount of food loss in Food Balance Sheet. (i.e., which components are included to calculate the amount of losses)

- Buzby et al. (2012), Kummu et al. (2012) estimated total value of food loss and found how much of produced food is lost along supply chain.



Literature Review

- Venkat (2011) examined the economic and environmental impacts of food waste in U.S.
 - ✓ Avoidable food waste is 55 million metric tons per year which cause greenhouse gas emissions about 113 million metric tons of CO_2 per year (\$ 198 billion of cost).

- Secondi et al. (2015), Visschers et al. (2016)
 - ✓ Investigated main determinants of food waste at consumer level.
 - ✓ Policy interventions are needed depending on the extent of urbanization.
 - ✓ Education level and attitudes are related to food waste behavior.



Implication of Literature Review

- Overall, reducing food loss and waste was important.
- Attempts have been made to estimate the total amount and value of food waste.
- Some studies developed methodological frameworks for reliable food loss data because data is important to evaluate the impacts of food loss on economic and environmental aspects.
- However, the impact of policy intervention on food loss and waste are not well-known.



Trend and Determinants of Food Loss

Food Balance Sheet 2013

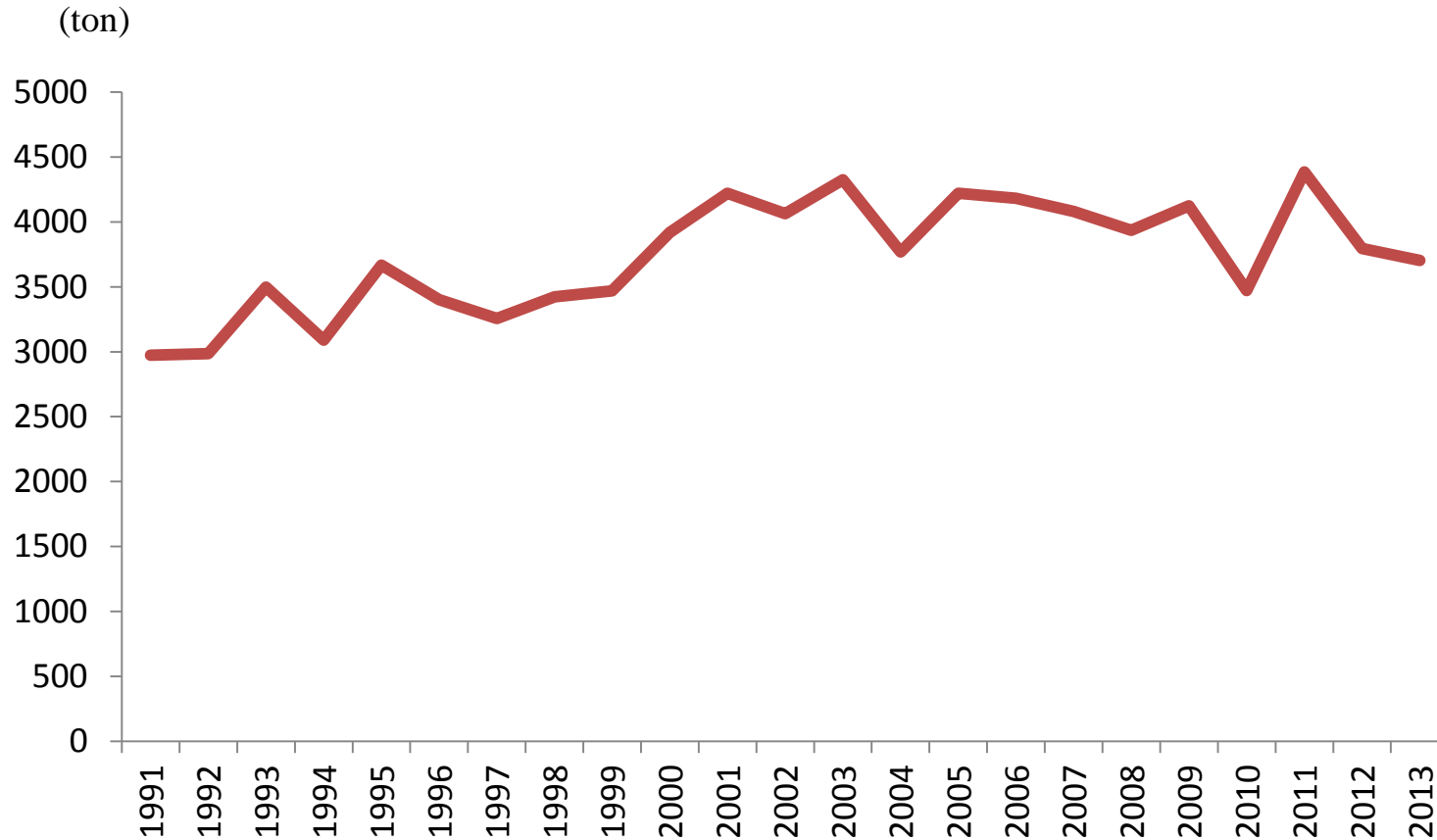
(1,000 ton, %)

Commodity	Total Supply (A)	Loss (B)	Proportion of losses among total amount	(B/A)
Cereals	19,905	542	(15%)	3
Starchy Roots	1,138	109	(3%)	10
Sweeteners	1,542	12	(0%)	1
Pulses	1,443	8	(0%)	1
Tree Nuts	144	3	(0%)	2
Oil Crops	156	1	(0%)	1
Vegetables	10,668	2,397	(65%)	22
Fruit	3,240	320	(9%)	10
Meat	2,867	54	(1%)	2
Eggs	607	12	(0%)	2
Milk	3,751	31	(1%)	1
Oils and Fats	1,131	11	(0%)	1
Fishes and shellfishes	4,356	158	(4%)	4
Seaweeds	1,176	46	(1%)	4
Alcoholic Beverages	5,365	9	(0%)	0
Total	52,121	3704	(100%)	7



Trend and Determinants of Food Loss

The total amount of food loss

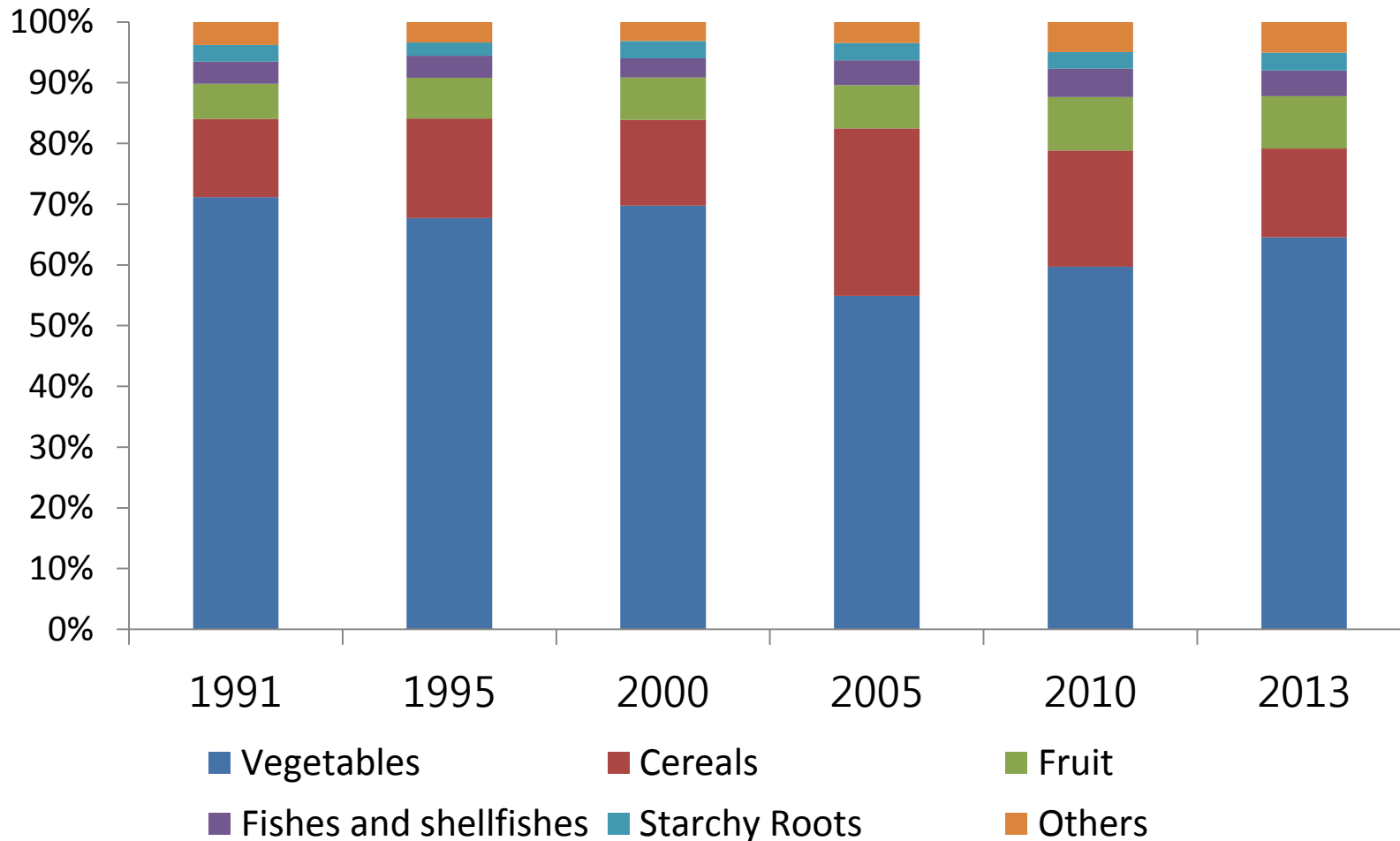


- ‘Food Balance Sheet’ provides a comprehensive patterns of food demand and supply.
- There are some missing data in food loss before 1991, so we considered the period from 1991 to 2013.
- Even though there are some fluctuations , food loss shows upward trend during 1997 ~ 2002.



Trend and Determinants of Food Loss

The proportion of food loss by each product group

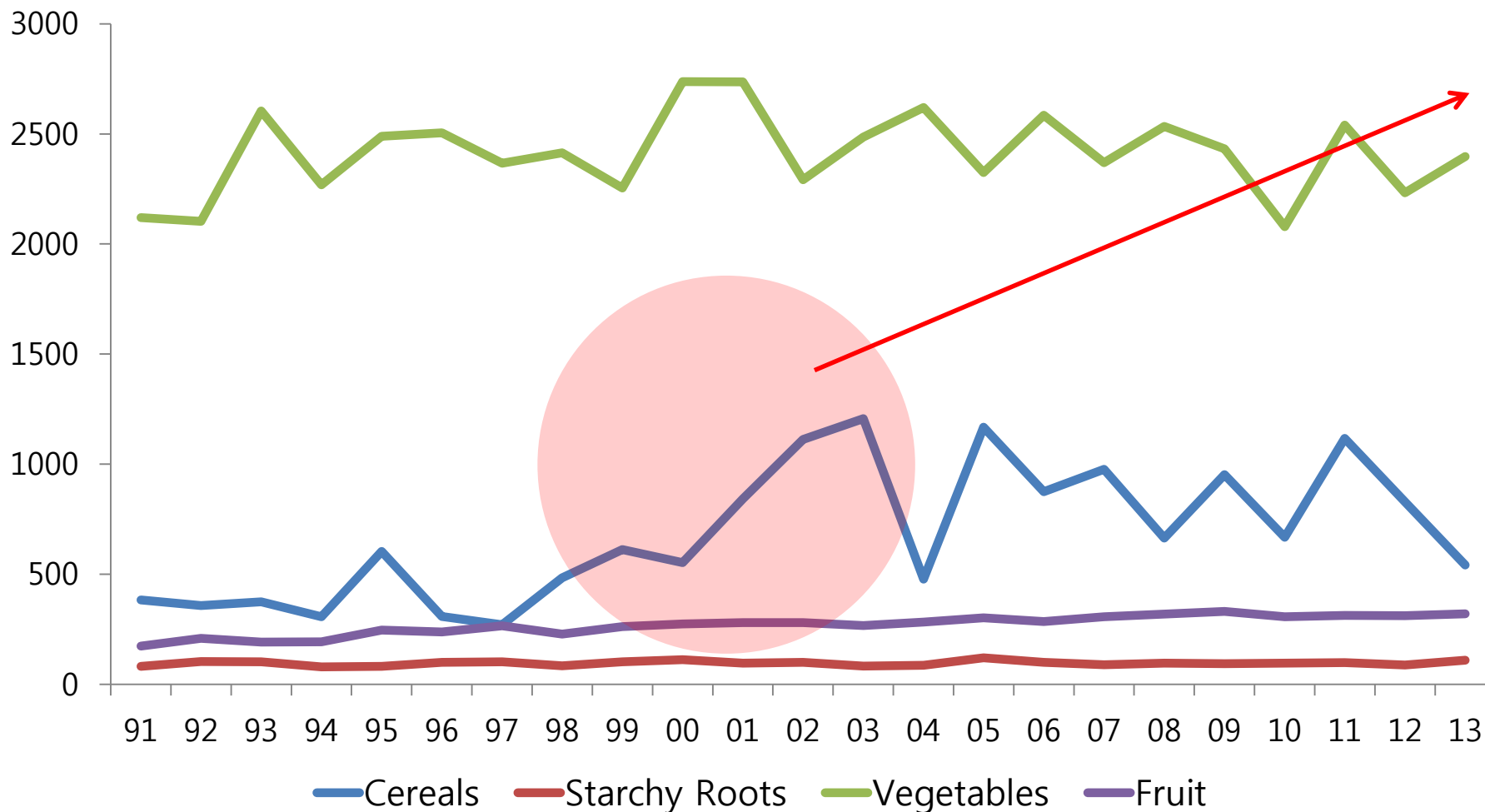


- Vegetables and cereals account for large portion of total losses (around 80%).



Trend and Determinants of Food Loss

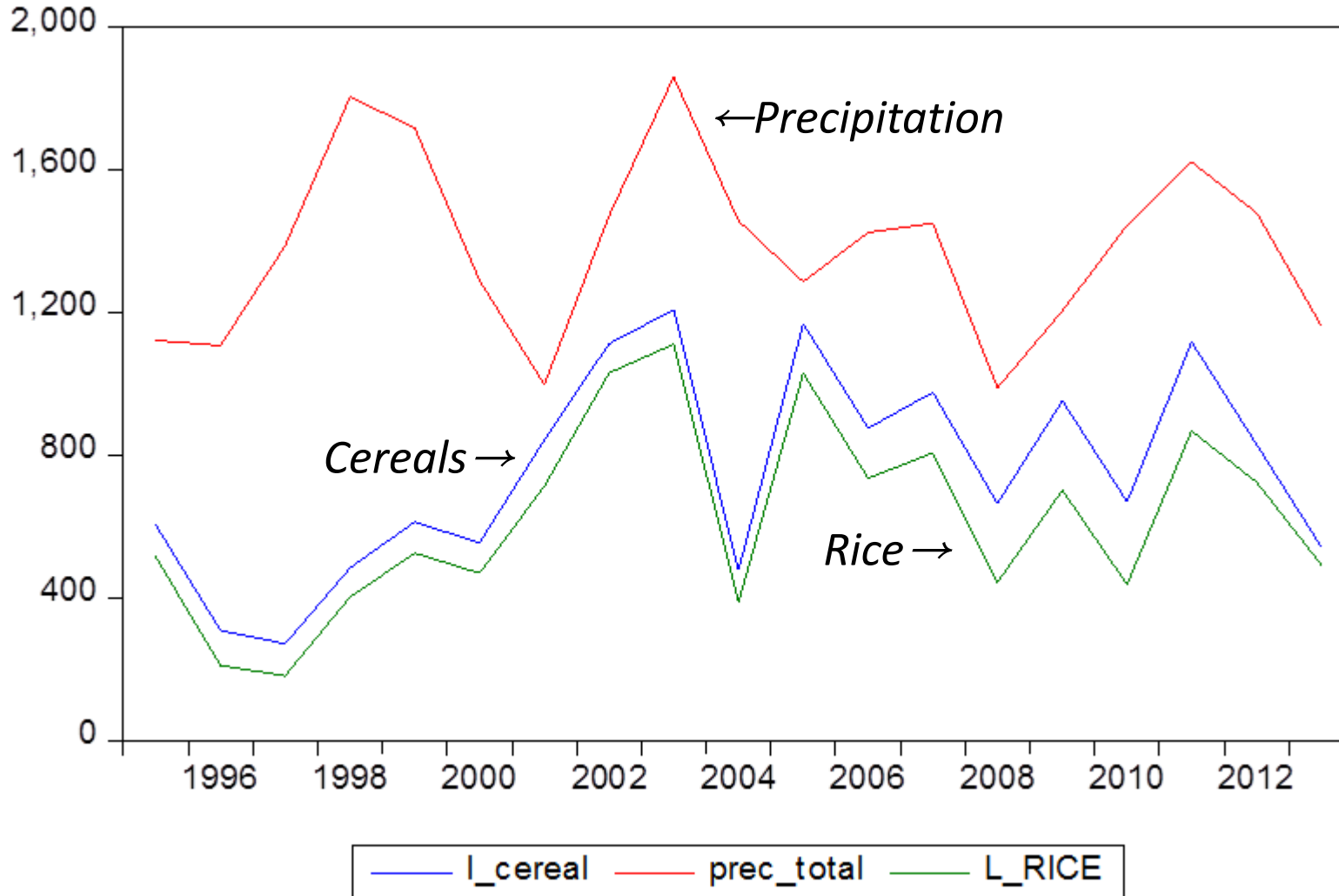
The amount of food loss by each product group



- Typhoons in 1998~2000, 2002, and 2003 which are officially ranked on the top 10 largest property damage from 1904~2015.
- Rice inventory has increased significantly during 1999~2003.



Trend and Determinants of Food Loss

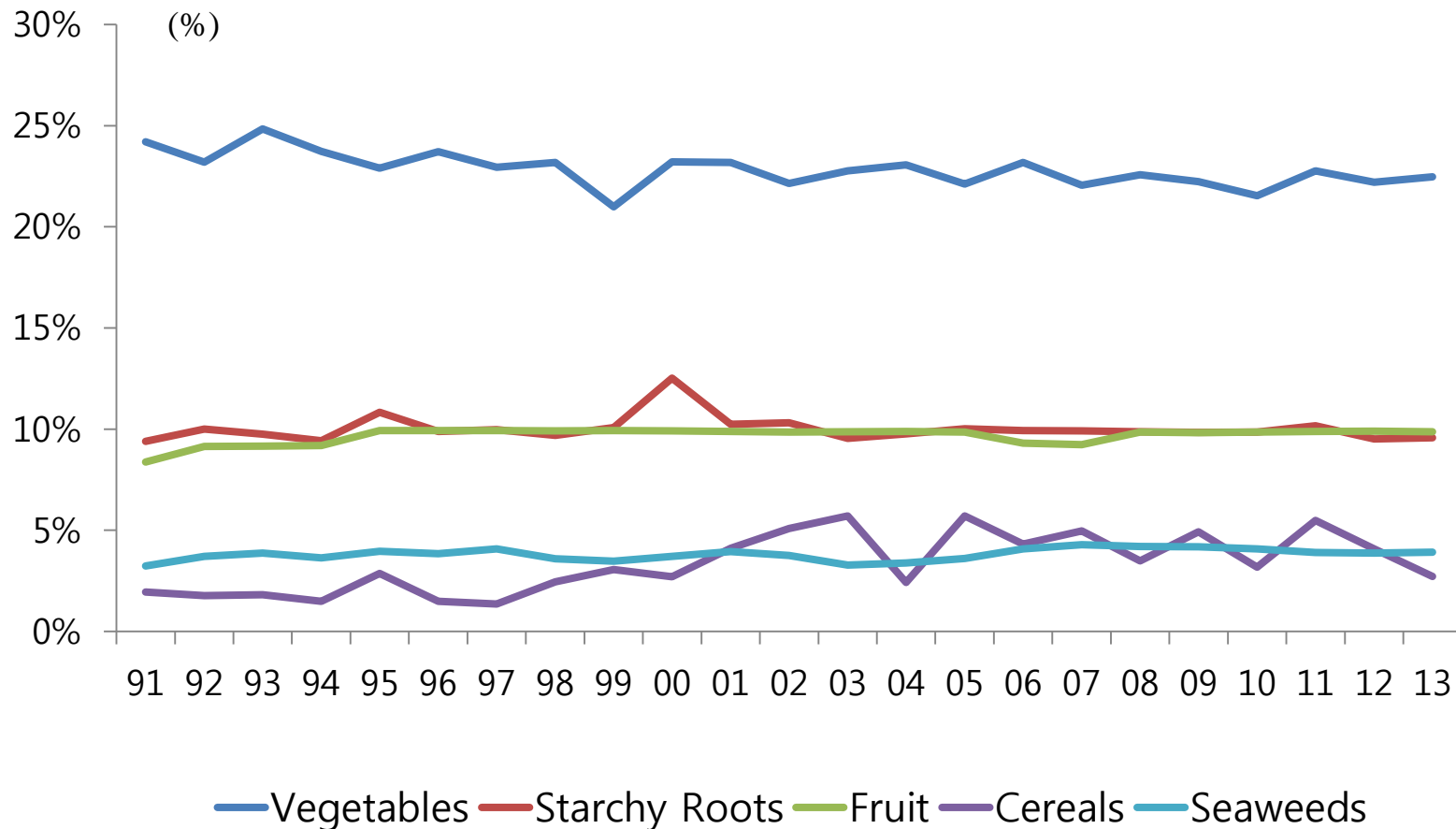


- Losses of cereals are affected by precipitation
- It means that rainfall causes significant losses in cereals.
- We can interpret that adverse weather conditions contribute to high post-harvest losses.



Trend and Determinants of Food Loss

The ratio of food loss to total supply (loss/supply)



- About 25% of vegetables supply are lost.
- About 10% of total supply in starchy roots (potato, sweet potato) and fruits are lost.
- Others are less than 5%, while cereals shows fluctuations.



Trend and Determinants of Food Loss

- Estimated ratio of food loss in terms of “marketing margin”

	Cabbage	Radish	Onion	Potato	Lettuce	Cucumber	Apple	Pear
Loss rate	5.5	4.6	6.7	3.5	11.8	3.4	3.6	3.9

- ✓ Seoul Agro-fisheries and Food Corporation surveyed the ratio of food loss in marketing margin in the Garak wholesale market in Seoul.



Policies Related to Food Loss

■ Gark wholesale market

- ✓ To modernize Korea's dilapidated agricultural and fisheries distribution facilities and improve the distribution system, the rule of "one market per city" was abolished in 1976.
- ✓ Thus, Grak wholesale market was opened in June 1985 as the first public wholesale market in Korea.
- ✓ It has achieved major innovations of the distribution structure.



Policies Related to Food Loss

■ Rice Processing Complex (RPC)

- ✓ RPC were introduced in the rice production areas for efficient post-harvest management.
- ✓ RPC reduces rice post-harvest loss to 0.5% ~ 1% significantly from 6% before the RPC processing era.



Policies Related to Food Loss

- Attempts to reduce food losses on logistics system development
 - ✓ Physical distribution (1980s ~ middle of 1990s)
 - To maximize the efficiency of distribution
 - Focusing on delivering food product from the farm to market
 - ✓ Logistics (middle of 1990s ~ middle of 2000s)
 - To minimize transportation costs
 - Improving food quality and mitigating safety concerns
 - ✓ SCM (middle of 2000 ~ present)
 - Reduction of logistic related risks in food supply chain



Food Loss Estimation

- Regression analysis

- ✓ To see how certain factors affect amount of losses, especially focusing on cereals, vegetables and fruits.
- ✓ Precipitation and typhoon are considered as weather conditions, and road expansion as transport condition.

Dependent variable	$loss$ = total amount of loss (ton/year)
Independent variables	$supply$ = total amount of supply * $supply$ = production + import + carry-in
	$carryin$ = total amount of carry-in
	$prec$ = average precipitation (mm/year)
	$typhoon$: typhoon occurrence (dummy variable)
	$highway$ = highway road (km)



Food Loss Estimation

■ Grain

$$\begin{aligned} \log(loss_{cr_t}) \\ = -44.966 + 4.026 \log(supply_t) + 0.474 \log(prec_t) + 1.027 \log(highway) \\ \quad (16.585)** \quad \quad \quad (1.646)** \quad \quad \quad (0.338) \quad \quad \quad (0.183)*** \end{aligned}$$

Period 1990 ~ 2013, F-statistics 13.99, R-squared 0.68

- ✓ Amount of supply, weather condition, and transport improvement affect the amount of food loss.
- ✓ Improving efficiency in transport could reduce food loss because logistics in food supply chain might lead to food loss during transportation from farm to table. However, transportation efficiency does not reduce food loss in durable grain.



Food Loss Estimation

■ Summary – Grain

- ✓ Rice accounts for the largest portion.
- ✓ As pointed out in Park et al. (2011)'s study which was conducted to re-estimate the existing statistics on the ratio of rice loss,
 - Amount of rice loss has large variation.
 - It does not make sense because technology for post-harvest management has improved. Thus, it might make sense that the amount of rice loss should gradually decrease.
 - Park et al. (2011) suggest that more reliable statistics are required to analyze and propose an alternative ratio of rice loss to improve existing statistics.



Food Loss Estimation

- Vegetables and Fruits

$$\log(loss_vg_t) = -0.401 + 0.949 \log(supply_t) - 0.076 \log(highway)$$

(0.881) (0.103)*** (0.024)***

Period 1990 ~ 2013, F-statistics 22.36, R-squared 0.88

$$\log(loss_fr_t)$$
$$= -2.778 + 1.018 \log(supply_t) + 0.034 typhoon + 0.037 \log(highway)$$

(0.527)*** (0.117)*** (0.017)* (0.060)

Period 1990 ~ 2013, F-statistics 185.06, R-squared 0.97



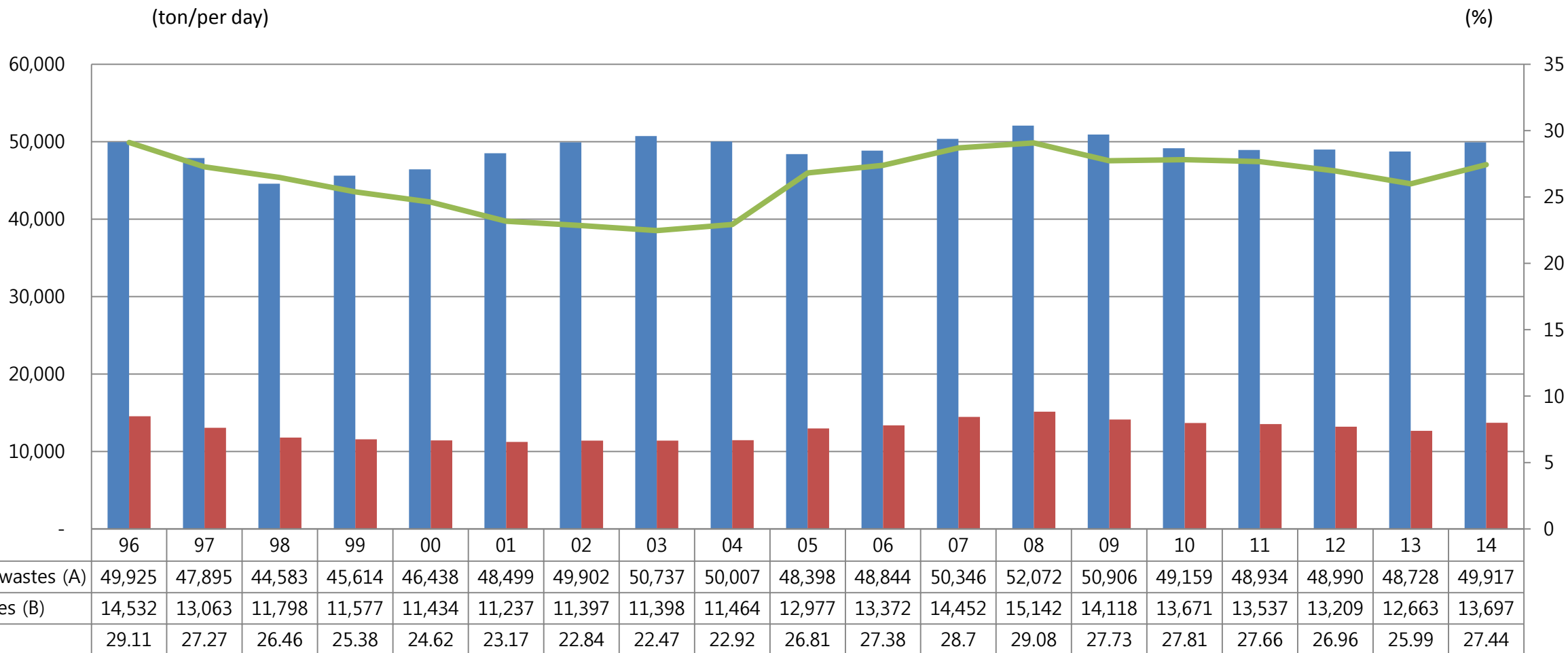
Food Loss Estimation

- Summary - Vegetables and Fruits
 - ✓ A percentage increase in food supply leads to 0.95% increase in losses of vegetables which account for the largest portion of total food loss.
 - ✓ Improving efficiency in transportation could reduce food loss of vegetables (e.g., decreases transportation spoilage or spillage), but not for fruits.
 - ✓ For fruits, the adverse weather conditions (typhoon) could increase the amount of loss.



Trend and Determinants of Food Waste

The amount of food waste from 1996 to 2014

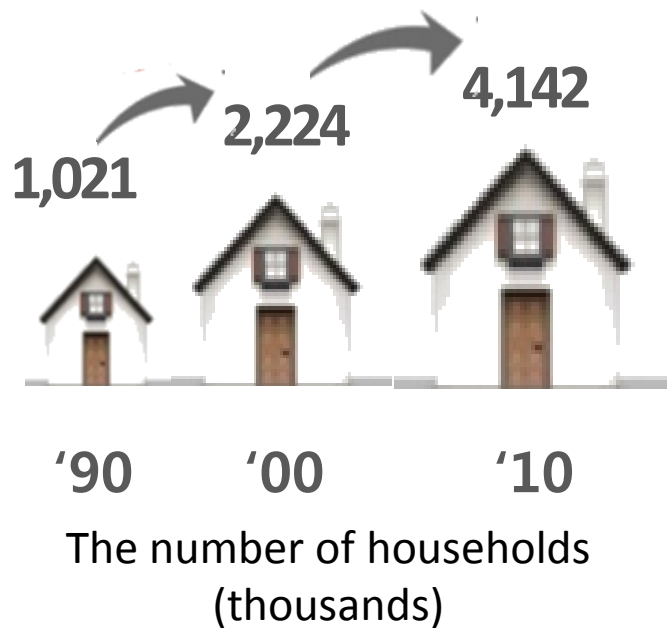


*Source: The status of waste generation and treatment in Korea (Ministry of Environment)

Trend and Determinants of Food Waste

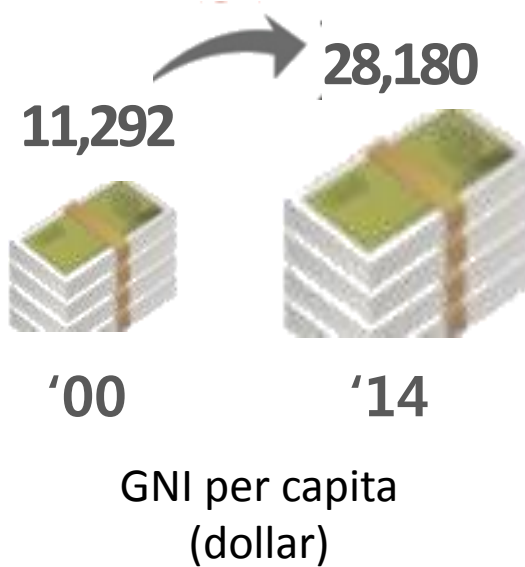
■ Why does food waste occur in Korea? – The key contributing factors

(1) One people households growth



(2) Change of eating pattern

- Income growth
- Eating-out



(3) Cultural background

- Prepare for abundant meal
- Serve lots of side dishes

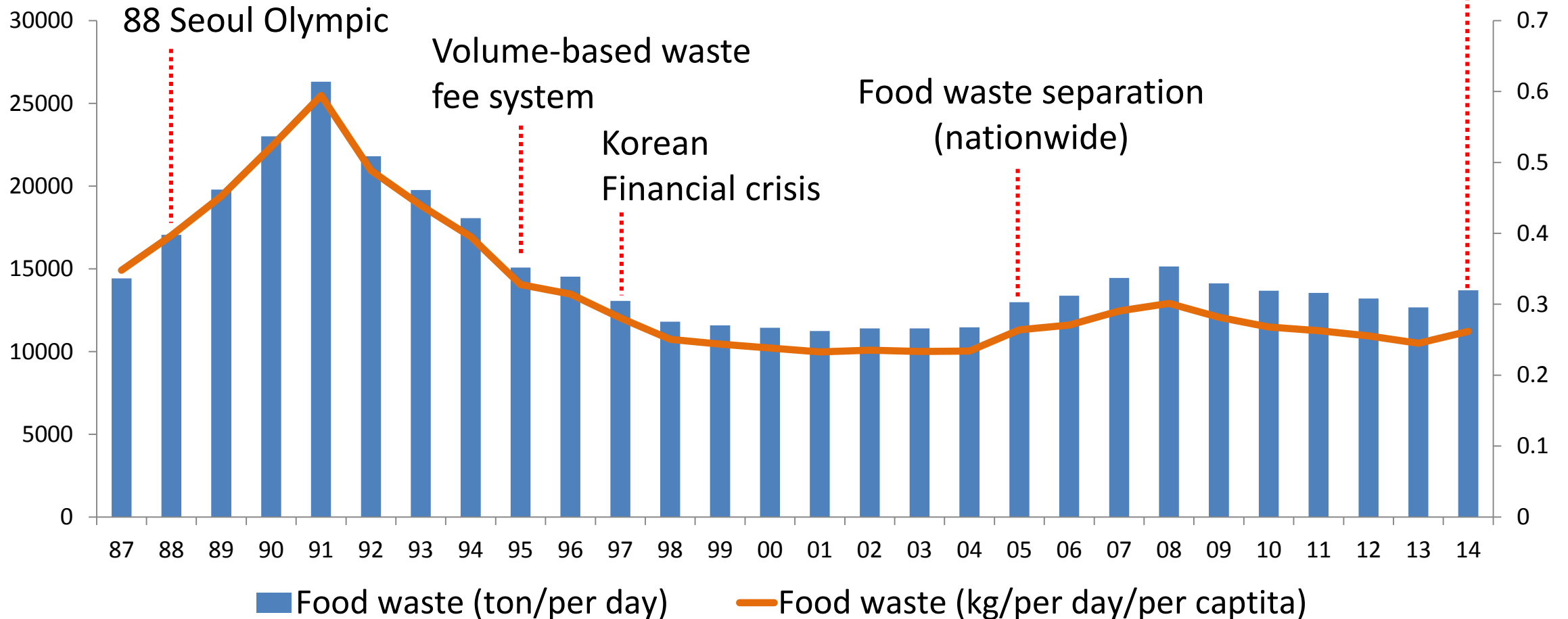




Trend and Determinants of Food Waste

The amount of food waste from 1987 to 2014

Volume-based food waste disposal system (nationwide)



*Source: The status of waste generation and treatment in Korea (Ministry of Environment)



Policies Related to Food Waste





Policies Related to Food Waste

- Volume-based Waste Fee system (VBWF system) was implemented to all over the country in Korea on Jan. 1, 1995.
 - ✓ The first nationwide VBWF system in the world.
 - ✓ Increasing amount of wastes was serious problem during early 1990s due to population growth and over-prepared meal or a large number of small dishes.
- Before VBWF system, waste collection fee was charged with fixed rate through property taxation or monthly fee, regardless of the amount of waste generation.



Policies Related to Food Waste

■ 'Pay as you throw' principle

- ✓ With VBWF system, households and small-sized private sectors are required to purchase government-issued plastic bags of different sizes.
- ✓ Each municipality imposes the price for the plastic bags, and therefore, households pay for disposal according to the amount of waste generated.
- ✓ Economic incentive has proved to be very successful.
 - During the periods of 1994~2004, municipal solid waste generation has decreased by 13.96%.



Policies Related to Food Waste

- In the beginning of VBWF system, food waste was discarded in VBWF bags with other solid waste.
 - ✓ Soggy food waste creates large amount of leachate and results in high treatment costs.
 - ✓ Food waste is collected in food waste-only bags starting from 1997 mainly targeting for large-scale food waste generators.
 - ✓ In 2010, government announced the introduction of the pilot Volume-based food waste fee system to 144 local regions by 2012.
 - Make people to control their food consumption.
 - Plastic garbage bags, chips or stickers, RFID tags



Policies Related to Food Waste



Plastic Bags

- ✓ Disposal bag's capacity ranges from 1 liter to 5 liter (households), and many of local governments raised the price of bags.
- ✓ Same cost regardless amount of food disposal (before VBWF)
→ Different cost depends on disposal amount (VBWF)
- ✓ Achievement: 15% reduction of food waste in 2012 → 30% in 2015



*Payment chip
or sticker*



RFID system

- ✓ Residents buy 'payment chip' and attach to collection container.
- ✓ Radio Frequency Identification system: attach electric chip on collection container, impose fee to discharger by weight.



Policies Related to Food Waste

- Voluntary agreements, Campaign for reducing food waste
 - ✓ Reduction of the number of side dishes
 - Traditionally, Korean households prepare meals with a large number of small dishes, which is considered courteous.
 - ✓ “Taking leftover foods” (Bring home the leftovers.)
 - ✓ “Empty bowls” movement
 - ✓ Food market (food bank)
 - Distribute the surplus of food to low-income households.



Policies Related to Food Waste

- Beyond the separate collection for food waste, government has also recognized the importance of alternative policies for waste reduction.

- Ministry of Environment implemented the 'Master Plan on Utilizing Food Waste as a Resource' (1998-2002).
 - ✓ Direct landfilling of food waste was banned as of Jan. [2005](#).
 - ✓ [Separate collection of food waste](#) has been launched and food waste recycling activities have been intensified.
 - ✓ Government has been providing financial support for public recycling facilities that transform food waste into feed for poultry, compost, and bio-mass.



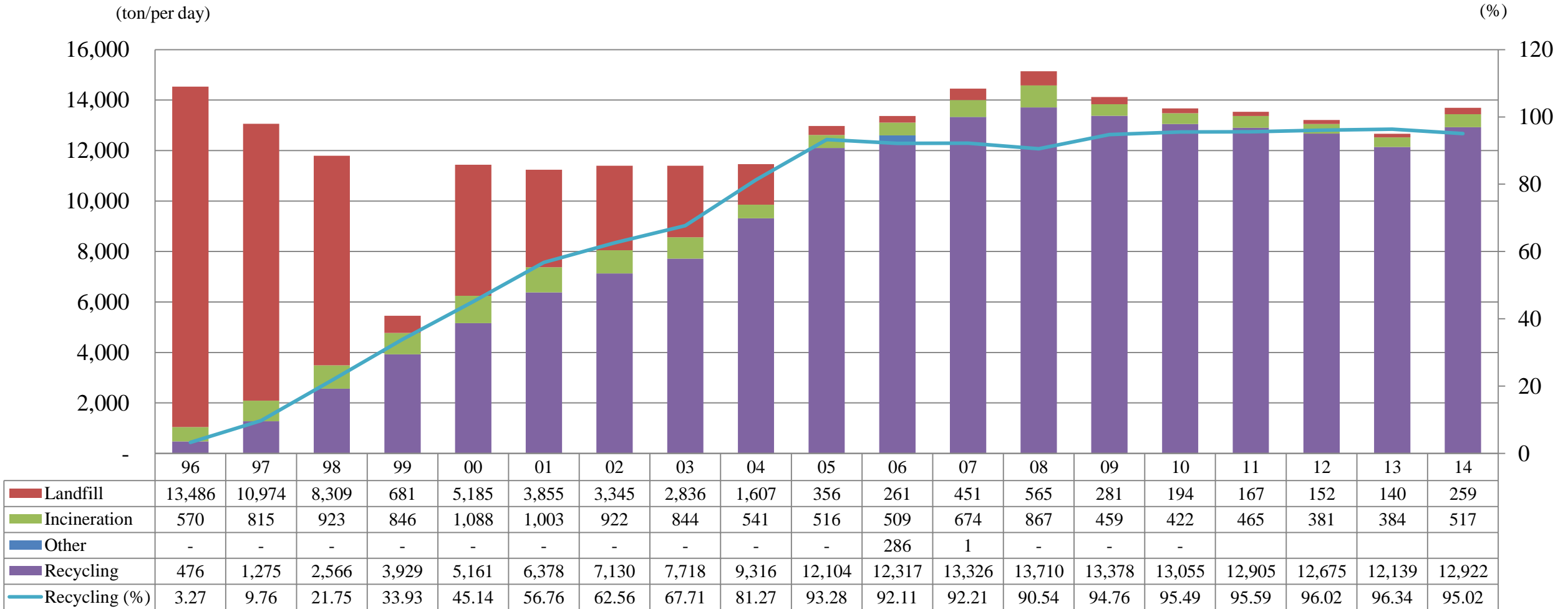
Policies Related to Food Waste

- Food waste separation policy starting in 2005
 - ✓ Food waste must be separated from general waste and placed in disposal bags that can be purchased at local supermarkets.
 - ✓ It is necessary to conduct so that food waste is recycled and turned into energy, animal feeds and compost.
 - ✓ Over 95% of municipalities implemented food waste separation.



Policies Related to Food Waste

The status of food recycling

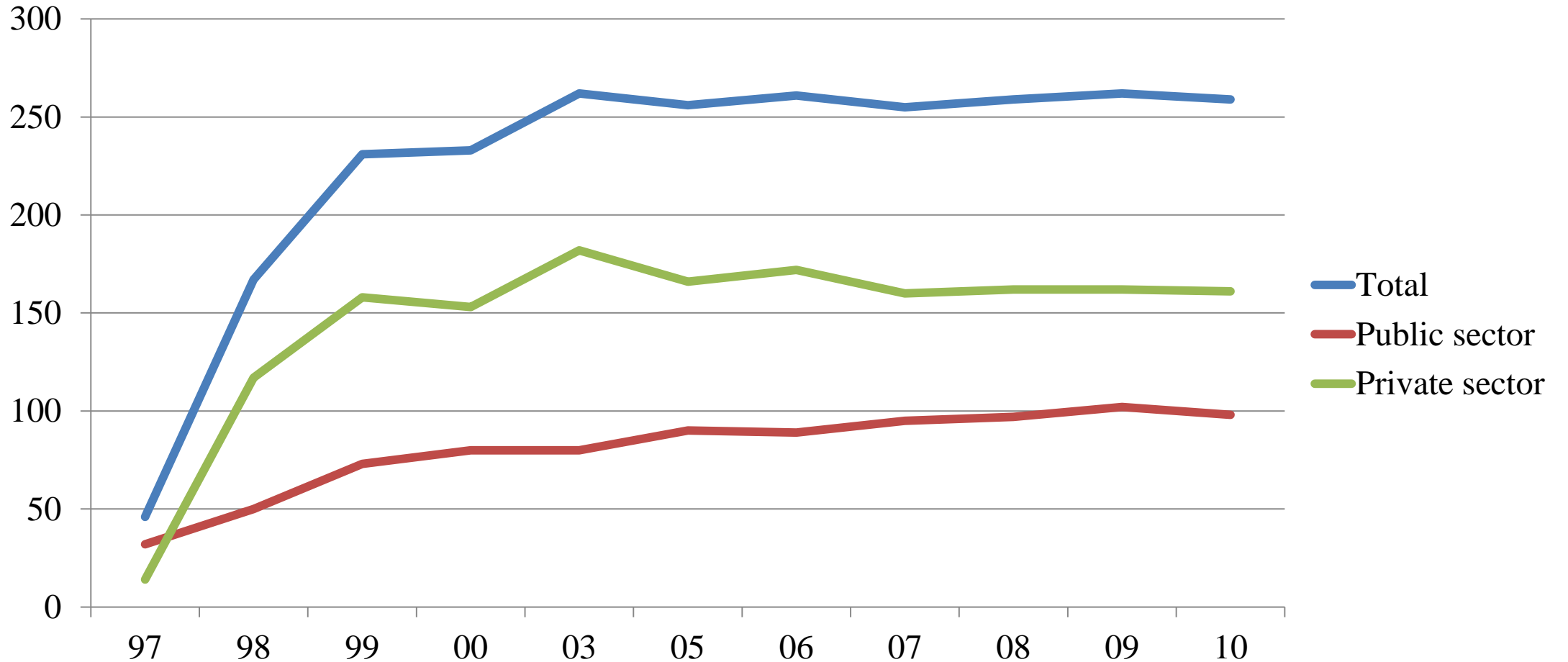


*Source: The status of waste generation and treatment in Korea (Ministry of Environment)



Policies Related to Food Waste

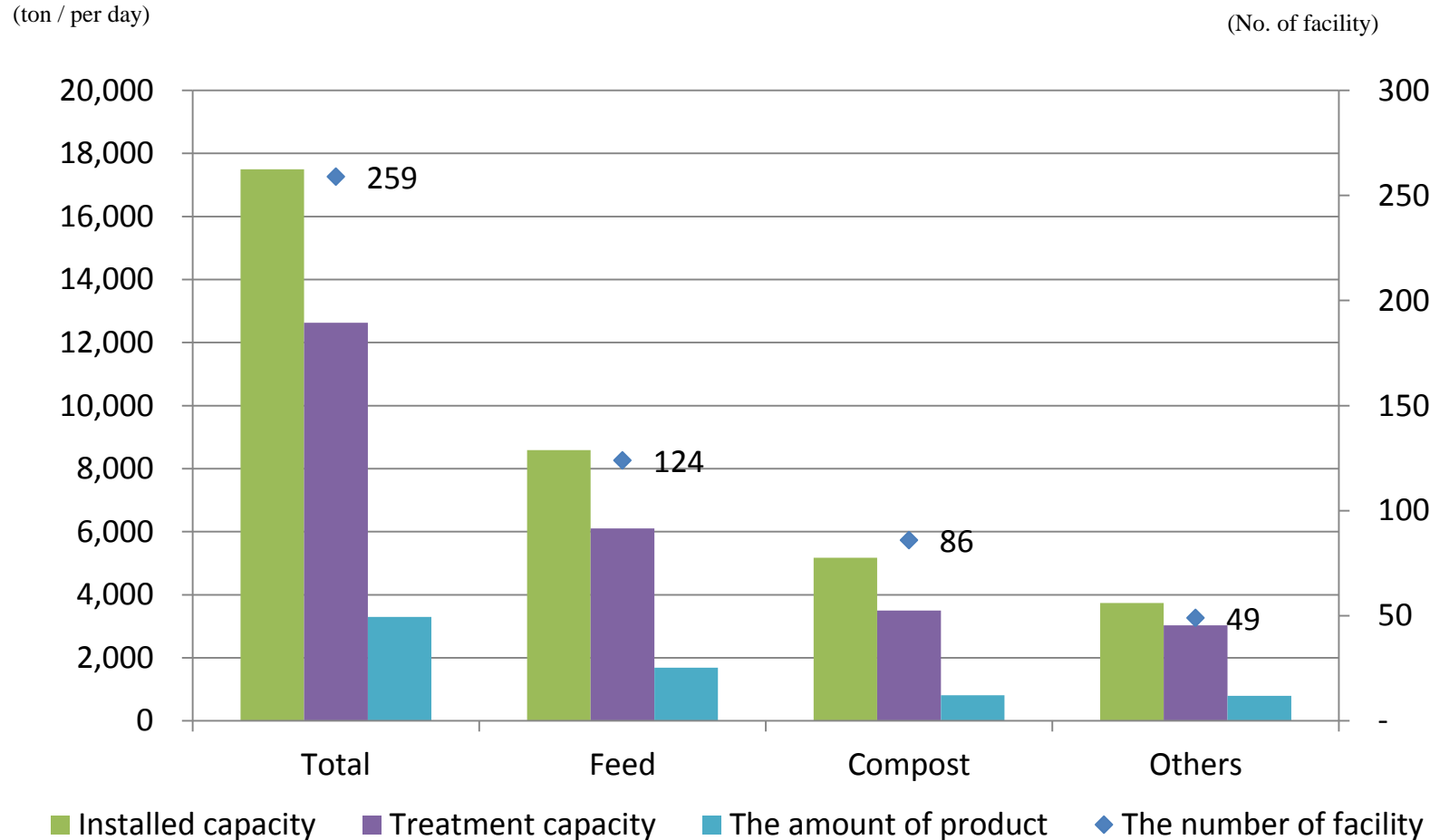
The number of facility for food waste into resources (2010)





Policies Related to Food Waste

Food recycling facility (2010)



- When food waste are recycled, they are mostly returned into feed and compost.
- The total number of recycling facilities was 259 in 2010, and those for feed and compost accounts for 81%.



Policies Related to Food Waste

- Energy Recovery from Organic Waste
 - ✓ Food waste buried in landfill site will bring an issue of bad smell and safety of the site.
 - ✓ Incineration also causes air pollution with dioxin and a high disposal cost.
 - ✓ Thus, conversion of organic wastes to biogas is more preferable.
 - Substitute for land disposal
 - To produce renewable energy and reduce greenhouse gas



Policies Related to Food Waste



Organic Waste



Food Waste-to-Biogas Plant, Busan



Food Leachate-to-Biogas Plant



Sewage Sludge-to-Fuel Plant



Food Waste Estimation and Program Evaluation

- Volume-based Waste Fee (VBWF) System 1995
- Separate collection of food waste 2005

- ✓ We considered 15 city or province – Seoul, Busan, Daegu, Incheon, Gwangju, Daejeon, Gyeonggi, Gangwon, Chungbuk, Chungnam, Jeonbuk, Jeonnam, Kyeongbuk, Kyeongnam, Jeju. (Ulsan and Sejong is included in Kyeongbuk and Chungnam, respectively.)
- ✓ Data from 1992 to 2014 (23 years)
- ✓ Data obtained from “The National Waste Generation and Treatment” yearly published by Ministry of Environment in Korea.
- ✓ We first analyze panel data, and then evaluate the effect of policy programs related to food waste.



Food Waste Estimation and Program Evaluation

- Volume-based Waste Fee (VBWF) System 1995
- Separate collection of food waste 2005

$$\log(fw_{it}) = \alpha + \sum_{k=1}^k \beta_k X_{itk} + \beta_p Program + v_i + \varepsilon_{it}$$

where $u_{it} = v_i + \varepsilon_{it}$

Dependent variable	fw = amount of food waste (ton/year)
Independent variables	population = total number of population (thousands)
	budget = budget for waste management (thousands won)
	VBWF (dummy) = volume-based waste fee system from 1995 *before implementation = 0, after policy implementation = 1
	Sep (dummy)= separate collection of food waste from 2005 *before implementation = 0, after policy implementation = 1



Food Waste Estimation and Program Evaluation

- Volume-based Waste Fee (VBWF) System 1995

<Random effect model>

$$\log(fw_{it}) = -8.450 + 1.044 \log(pop) + 0.008 \log(budget) - \mathbf{0.500 VBWF}$$

(1.283)*** (0.088)*** (0.015) (0.028) ***

Period 1992 ~ 2014, Number of obs. 345, R-squared 0.85

<Fixed effect model>

$$\log(fw_{it}) = -6.523 + 0.912 \log(pop) + 0.008 \log(budget) - \mathbf{0.500 VBWF}$$

(1.606)*** (0.110)*** (0.015) (0.028) ***

Period 1992 ~ 2014, Number of obs. 345, R-squared 0.85



Food Waste Estimation and Program Evaluation

- Volume-based Waste Fee (VBWF) System 1995
 - ✓ In fixed-effect model, we assume that city-specific effect is correlated with the independent variables. And also, population and city budget for waste management are considered.
 - ✓ According to the Hausman test, the random-effect model is appropriate.
 - ✓ We can conclude the VBWF system could reduce amount of food waste.
 - ✓ To solve heteroskedasticity and autocorrelation in random effects model, the GLS is estimated



Food Waste Estimation and Program Evaluation

■ Volume-based Waste Fee (VBWF) System 1995

<GLS (Generalized Least Squares)>

$\log(fw_{it})$

$$= -8.645 + 1.094 \log(pop) - 0.027 \log(budget) - \mathbf{0.366 VBWF}$$

(1.538)*** (0.052)*** (0.012)** (0.029)***

Period 1992 ~ 2014, Number of obs. 345, R-squared 0.85

- ✓ After implementation of VBWF system in 1995, the amount of food waste reduced.
- ✓ The 1% increase of population leads to 1.09% of increase in food waste.
- ✓ If the budget for waste management increases, the amount of food waste decreases.



Food Waste Estimation and Program Evaluation

- Separate collection of food waste 2005

<Random effect model>

$$\log(fw_{it}) = -5.326 + 1.017 \log(pop) - 0.166 \log(budget) + 0.080 Sep$$

(1.574)*** (0.108)*** (0.021)*** (0.028)***

Period 1992 ~ 2014, Number of obs. 345, R-squared 0.83

<Fixed effect model>

$$\log(fw_{it}) = 1.597 + 0.550 \log(pop) - 0.170 \log(budget) + 0.102 Sep$$

(2.242) (0.152)*** (0.021)*** (0.027)***

Period 1992 ~ 2014, Number of obs. 345, R-squared 0.79



Food Waste Estimation and Program Evaluation

- Separate collection of food waste 2005
 - ✓ As mentioned in analysis of VBWF system, we assume that city-specific effect is correlated with the independent variables with Fixed-effect model (here, population and budget for waste management in each city).
 - ✓ According to the Hausman test, we choose the fixed-effect model.
 - ✓ As we can expect, population growth is one of the key elements for increasing food waste. Generally, the more budget for waste management is allocated, the less food waste is generated.
 - ✓ However, after tests for heteroskedasticity and autocorrelation in random effects model, we conclude GLS is more preferable.



Food Waste Estimation and Program Evaluation

- Separate collection of food waste 2005

<GLS (Generalized Least Squares)>

$$\begin{aligned} \log(fw_{it}) &= -1.217 + 0.536 \log(pop) - 0.016 \log(budget) + \mathbf{0.138Sep} \\ &\quad (0.874) \quad (0.321)^{***} \quad (0.011) \quad (0.034)^{***} \end{aligned}$$

Period 1992 ~ 2014, Number of obs. 345, R-squared 0.85

- ✓ After separate collection of food waste in nationwide, the amount of food waste has been included in statistics.
- ✓ But, we have to interpret that the increase amount means the amount of separated food waste. That is, we cannot conclude that the total amount of food waste increase.



Food Waste Estimation and Program Evaluation

With aggregated dataset

- Volume-based Waste Fee (VBWF) System 1995

$$\log(fw_t) = -2.8984 + 0.794 \log(\text{population}_t) - 0.058 \log(\text{budget}_t) - 0.437 \text{VBWF}$$

(26.99) (1.777) (0.227) (0.118)***

Period 1992 ~ 2014, Number of obs. 23, R-squared 0.70

- Separate collection of food waste 2005

$$\log(fw_t) = 15.075 + 0.426 \log(\text{population}_t) - 0.620 \log(\text{budget}_t) + 0.390 \text{Separation}$$

(16.621) (1.041) (0.098)*** (0.047)***

Period 1992 ~ 2014, Number of obs. 23, R-squared 0.89



Food Waste Estimation and Program Evaluation

With aggregated dataset

- Volume-based Waste Fee (VBWF) System 1995
- Separate collection of food waste 2005
- ✓ With aggregated dataset, we also obtained the same conclusion with the results of panel data analysis.
 - Volume-based waste fee system reduced food waste.
 - After separate collection of food waste, food waste has increased.
- ✓ Food waste increases as population grows. With more budget for waste regulation and management, the amount of food waste could decrease.



Future Challenges of Food Loss and Wastes in Korea

- Data availability on food waste at consumer or household level is relatively good, while food loss data along food supply chain should be improved.
- Methodological improvement is needed to measure food loss and to know comprehensive status of where most food loss occurs in whole food supply chain.
- We need to estimate the economic value of food loss and waste in supply chain to see how much of food waste can be efficiently prevented.



Future Challenges of Food Loss and Wastes in Korea

- Data of food loss and waste are either reported by different ministries or researchers using different measurements and methodologies.
 - ✓ The amount of food loss is reported every year in Food Balance Sheet by Korea Rural Economic Institute in Ministry of Agriculture, Food and Rural Affairs.
 - ✓ Meanwhile, food waste is reported by Ministry of Environment.
- To establish a reliable dataset, mutual collaboration between two ministries are needed and we also should keep developing methodological framework for food loss and waste estimation.



Thank you.