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Forecasting Waste Agricultural Plastics Generation in the Republic of Korea and its Policy Implications

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Abstract

The generation of waste plastics mulch is predicted to decline after 2019 and then stabilize at around 200,000 tons per year. This is within the current gross treatment capacity of private and public facilities. However, the Korean Waste Agricultural Plastics (WAP) management system is vulnerable to market uncertainty, which might lead to uncontrollable accumulation of untreated waste plastics as experienced in 2005. Shifting from the KECO (Korea Environment Corporation)-led system to a more flexible market-oriented system is recommended.

Keywords: Waste agricultural plastics, Recycling, Waste management.

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Contents

1. Introduction

Modern farming takes advantage of a wide range of plastics and large amounts of WAP are inevitably generated. Vinyl-house horticulture and insulated rice seedbed preparation are practiced nationwide and, in 2015, approximately 320,000 tons of WAP was generated. This figure has remained almost the same over the last decade. The collection rate has stagnated at just under 60%. Therefore, collection and proper treatment of WAP, including recycling, is a serious social concern in Korea.

In Korea, WAP are classified as municipal solid waste, the final treatment of which is the responsibility of the basic administrative districts (i.e., eup, myon, dong)[1]. Therefore, in principle, these districts have to collect and recycle or conduct final disposal (landfilling and incineration) of WAP. However, farmers do not have sufficient incentives to take waste plastics to private collectors or public collection points voluntarily and the basic administrative districts do not have the resources to deal with the waste fully. Waste vinyl-house plastic coverings are relatively clean and thus well-collected and almost recycled through market. However, the most prevalent type of waste plastics, mulching Low Density Polyethylene(LDPE) and High Density Polyethylene(HDPE), which accounted for 76% of the total 322,964 tons of waste generated in 2015, would create a serious problem if left intact in fields. Uncollected and improperly treated waste plastics are detrimental to the environment and also undermine agricultural land productivity.

For this reason, the KECO has established collection and treatment networks and subsidizes farmers and treatment firms in cooperation with local governments. In 2010, on average, 100 won per kg of collected waste came from subsidies of which 14 won was provided by the provincial government, 76 won by the city governments, and the remaining 10 won by the central government. However, this subsidization scheme has not been strong or flexible enough, resulting in insufficient and stagnated collection rates. As urbanization has advanced, now in farms only the old people are left. This trend is making it more expensive to bring waste plastics to collection points, but the level of subsidies has remained almost the same for a long time. On the treatment side, there has sometimes been overcapacity and insufficient capacity at other times. This disequilibrium in market may be resolved by price adjustment. However, this takes time and there are highly likely to be negative impacts such as a backlog of untreated waste plastics. To ease this fluctuation in demand and supply KECO operates treatment companies and subsidized private treatment companies. The focus of this paper is not on the design of this system but only on the provision of materials to aid discussion by estimating and predicting WAP generation and collection.

The paper is organized as follows. In the next section, we provide an overview of the Korean WAP management system, including time trends of WAP generation and collection, WAP-related materials flow, and so on. In section 3, we forecast WAP generation and collection for the next 5 years and compare this with the current treatment capacity. We then discuss the policy implications of our empirical results. Finally, Section 4 contains some concluding remarks.

2. Korean WAP Management System

2.1. Legal Position of WAP in the Korean Waste Management System

WAP is municipal solid waste and the collection and final treatment of it is the responsibility of the basic administrative districts in Korea. Therefore, farmers here do not have as strong an incentive for collecting and properly treating as farmers in Japan and Taiwan, who are responsible for the proper final treatment and thus almost all WAP is collected and treated via proper channels [1, 2].

2.2. Materials Flow in WAP Management and KECO

As shown Table 1 the total amount of generated WAP has remained around 320,000 tons per year for the last decade. Mulching LDPE is the most prevalent type of waste (approximately 40%), followed by HDPE (35%) and vinyl-house LDPE (20%).

Table-1. WAP Generation, Collection, and Treatment in Korea

Unit: tons

Year	Generation	Collection	Collection rate (%)	Treatment	Untreated Inventory
2009	310,009	189,238	61.04	236,259	72,973
2010	324,101	176,849	54.57	208,377	41,444
2011	331,490	181,609	54.79	185,424	37,628
2012	337,877	178,130	52.72	180,950	34,809
2013	332,575	189,306	56.92	174,181	49,934
2014	329,239	188,279	57.19	193,065	45,168
2015	322,964	186,965	57.89	211,143	21,141

Source: KECO internal data

Farmers are advised to bring any generated WAP to community collection points. At this stage local governments subsidize farmers to increase their collection rate, combining the subsidies from the KECO (or central government) and the provincial government. Designated private collectors then bring the collected WAP to KECO-operated storage facilities. (see Figure 1). The collection rate has not exceeded 60% for the last decade. What has contributed the most to the low collection rate was House LDPE (see Table 2), but this one was almost recycled voluntarily through market. A total of 72,000 tons of mulching LDPE, HDPE, PVC and other waste plastics went uncollected, which is a real problem.

[1]This does not mean that farmers are legally allowed to leave WAP in fields. They are legally prohibited from disposing waste improperly.

Table-2. Collection Rate by Type (2015)

Unit: tons per year, %

	Generation(a)	Collection(b)	Collection rate((b/a)*100)
House LDPE	69,414	4,964	7.15
Mulching LDPE	128,241	88,275	68.84
HDPE	118,715	92,064	77.55
PVC and others	6,594	4,914	74.52
Total	322,964	186,965	57.89

Source: KECO internal data

KECO has two options for the treatment of collected WAP: KECO itself treats or gets it done by private firms. As of 2016, KECO operates seven treatment facilities with a treatment capacity of 80,000 tons per year. In 2015, just over 100 thousands tons should be left for private firms. Six of treatment firms have the capacity to process 6,000-8,000 tons each per year. KECO auctions off some part of the remaining WAP to private firms and for the other part of the remaining WAP, KECO subsidizes private firms to treat. The treatment subsidy was introduced in 2005 when the volume of untreated WAP became a serious social concern. The subsidy was at its highest level in 2008 but has been declining since then.

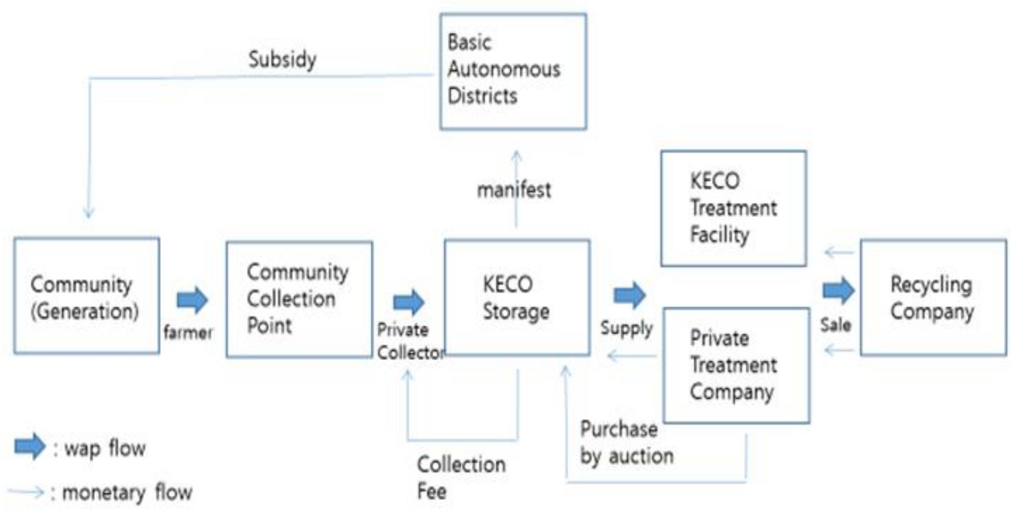

Figure-1. Flow diagram of WAP generation, collection, and treatment

Source: KECO internal data

3. Forecasting Wap Generation

3.1. Methodology

Forecasting is a two-state process. First, we attempt to identify the determinants of WAP generation (*MPE*) through a regression analysis. Specifically, WAP generation is regressed on potential determinants such as paddy size (*paddy*), field size (*field*) and vinyl-house farming (*House*) as follows

:

$$\mathrm{MPE} = \beta_0 + \beta_1 \mathrm{paddy} + \beta_2 \mathrm{field} + \beta_3 \mathrm{House} + \varepsilon \quad (1)$$

Based on this estimation, we then forecast the future MPE. To do this, we need to estimate the future values of explanatory variables: we regress each of the explanatory variables on the respective previous values and time. We use the estimated value of one coefficient as its future value if it is statistically significant. If there is no statistical significance, we will average the previous 5 years' values to use as future values for each variable over 5 years.

3.2. Data

We use panel data covering nine regions across 12 years (2004 through 2015)[2]. As our dependent variable, we use only waste mulching plastics generation, which accounts for approximately 80% of the total, because the remainder, vinyl house coverings, is almost recycled voluntarily through the market. Table 3 provides summary statistics for our data.

Table-3. Summary Statistics

	MPE	Paddy	Field	House
Mean	26,289.56	106,379.23	4,439.76	80,904.06
Stand. dev.	12,146.60	61,947.29	4,729.77	27,252.56
Min.	1,319.00	18.00	0.00	52,100.00
Max.	59,634.00	219,337.00	18,287.00	152,095.00

Note: MPE, paddy, field, and House stands for mulching plastics generation, size of paddy field, size of dry field, and size of vinyl house, respectively. MPE is measured in tons and the other variables are measured in hactares.

Source: KECO internal data and the Korea Statistical Information Service(kosis.kr).

[2] As of 2018, there are 16 so-called wide autonomous administrative units in Korea. However, due to the availability of data, we have merged these units into nine regions. For example, Seoul and its surrounding Kyunggi Province were merged into an area referred to as the Captial area.

3.3. Empirical Results

We first checked the poolability of the time-series and cross-sectional data. Based on an F-statistic (0.42652) we could reject the null hypothesis that the coefficients are not stable at the 5% level. We then checked for autocorrelation in error terms using the Breusch-Godfrey/ Wooldridge test, which has detected the presence of autocorrelation. We have added the lag term for dependent variable to set our final regression model as follows:

$$\mathrm{MPE} = \beta_0 + \beta_1 \mathrm{paddy} + \beta_2 \mathrm{field} + \beta_3 \mathrm{House} + \beta_4 \mathrm{lag(MPE)} + \varepsilon \quad (2)$$

We have found no autocorrelation in error terms after testing this new model using the Breusch-Godfrey/ Wooldridge test (chi-square statistic=2.1548). In addition, the Honda Test showed no individual effect (standard normal statistic=0.024989), but a time effect (standard normal statistic=4.6167). Finally by using the Hausman test we selected a random effects model (chi-square statistic=5.6698) [3, 4].

Table 4 presents the results of regression analysis. House (size of vinyl house farming) and lag(MPE) are significant at the 5% and 1% level, respectively. The effect of lag(MPE) is statistically significant and is strong. Almost 67 percent of WAP generated in the last year is again generated any of this year in inertia. Notice that the effect of field (size of dry field) is almost the same as that of House (size of vinyl house farming), but it is not statistically significant.

Table-4. Results of Regression Analysis

	Coefficient	Standard error	t-value	P-value
Intercept	574.9600	1901.1000	0.3024	0.7630
Paddy	0.0189	0.0116	1.6276	0.1070
Field	0.0893	0.1403	0.6361	0.5263
House	0.0737	0.0302	2.4409	0.0165 *
Lag(MPE)	0.6715	0.0749	8.9676	0.0000***

Note: *,**,and *** represent the 10%, 5%, and 1% significance level, respectively.

We now turn to predicting the future values of explanatory variables. We then insert them into Equation (2) to obtain the future values of MPE. Table 5 shows a summary of the future values of explanatory variables obtained using the aforementioned method.

Table-5. Future Values of Explanatory Variables

Year	Paddy	Field	House
2016	998,953.6	273,912.4	989,065.2
2017	992,768.4	274,119.1	973,989.8
2018	985,095.7	274,911.6	984,324.6
2019	940,259.2	258,131.9	992,162.6
2020	914,167.4	234,499.8	968,638.2

The 95% confidence interval for the predicted values of MPE is summarized in Table 6.

Table-6. 95% Confidence Interval for the Prediction of MPE

Year	Lower Bound	Point Estimate	Upper Bound
2016	221,466.6	247,363.4	273,260.2
2017	224,616.4	247,827.1	271,037.8
2018	226,404.7	248,955.6	271,506.6
2019	190,964.2	232,544.9	274,125.6
2020	174,274.4	209,293.8	244,313.2

As shown in Table 6, the generation of MPE is predicted to decline after 2019. It is also predicted to stabilize at around 200,000 tons per year after that. Although there is a little increase in the MPE collection rate, for example 80%, there would be no repeat of the huge accumulation of WAP that occurred on 2005 because the present treatment capacity (approximately, private 50 thousand and public 80 thousand annually) would suffice. However, due to the uncertainty in the recycled products market (for example, China's recent suspension of recycled vinyl imports and fluctuations in petroleum markets) private WAP recycling firms may go bankrupt, causing a supply shortage for treatment services, which occurred in 2005.

4. Conclusion

The amount of WAP collected by KECO is predicted to stabilize at around 160,000 tons per year. Given the current treatment capacity, this would not lead to issues if the amount of untreated WAP significantly increased, as it did in 2005. However, this KECO-led system is vulnerable to various market uncertainties regarding recycled products and petroleum markets.

Unlike Korea, Japan and Taiwan define WAP as industrial waste. Therefore, farmers in these countries are responsible for the proper treatment of WAP. In both countries the central government does not play such active a role as it does in Korea. Collection and treatment occur in response to market mechanisms [5-7]. In light of the situation in these countries, Korea also needs to strengthen the legal responsibility of producers and consumers (farmers) of agricultural plastics to ensure proper WAP management. Specifically, we can consider the alternatives that by putting agricultural plastics into EPR(Extended Producer's Responsibility) items, producers are made responsible for collecting and treating WAP or that by reclassifying WAP into industrial waste farmers are made responsible for proper treatment [8].

We do not exclude the role of governments in WAP management. Governments may adopt the role of facilitating the smooth operation of markets. Taiwanese government compensates farmers for sorting and bringing waste plastic containers to treatment firms, but not for general WAP. Japanese government also compensates farmers for bringing waste plastics to collection points. In addition, it also operates a minimum level of public treatment facilities as a buffer for market uncertainty [6, 7].

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