

Collection, disposal and exchange of waste agricultural plastics in Japan, the Republic of Korea and China

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This paper shows the collection and disposal systems and activities of waste agricultural plastics (WAP) in Japan, the Republic of Korea and China. Although many WAP collection spots were set up, most of farmers left WAP around their fields. A reason is that WAP are treated as recyclable resources in the Republic of Korea, and only good quality films get good price. In China there is no collection system, except for good-quality WAP. In Japan, WAP collection is almost 100 per cent because it is defined as an industrial waste and collection responsibility is with farmers. In the Republic of Korea, farmers must be given incentives to collect WAP, which is recycled domestically. China has several issues to solve for reduction of environment damage.

Subjects, objects and viewpoints

Today, agriculture is an industry that cannot exist without the use of various plastics, particularly in countries of the Asian temperate zone and the sub-arctic zone. These plastics include films in vinyl houses, multi-films in vegetable fields, wrap films in livestock feeding, seedling boxes in rice paddy, besides watering tubes, fertilizer bags, containers of agricultural chemicals, pots, shipping trays and packaging containers. Are there any studies on how large quantities of such plastics are dealt with, after their use if over?

Waste agricultural plastics (WAP) discharged have different characteristics, are dispersed widely and are collectively large in quantity. If WAP is burned outside, it causes environmental issues such as soil pollution by dioxin. Therefore, establishment of a system for the proper collection and disposal/recycling of WAP is very important for sustainable agriculture. Training for efficient WAP collection, effective co-ordination among stakeholders and innovation are critical aspects, but have received scant attention so far.

It is not well known that the quantity of plastics used for agriculture and discharged in Japan, China and

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the Republic of Korea together total more than 1,450,000 tonnes per year, which is around two-thirds that of the world. This paper analyses the actual conditions related to WAP discharge, and the collection, treatment and disposal of WAP. It then proceeds to look at the construction of WAP recycling systems in these countries.

Resources circulation and its relation with environment preservation are to be given consideration. In this regard, it is important to deal properly with WAP in accordance with related laws, such as the Waste Management and Public Cleansing Law (WMPCL) in Japan, the Basel Convention, etc. Proper disposal includes not only recycling but also reclamation and incineration, all keeping to the required standards. In Japan, waste needs to be approached in terms of 3Rs – Reduce, Reuse and Recycle, and WAP also must be treated according to this basic principle.

On the one hand, is the utilization of polyolefin (PO) films that biodegrade in about 5 years; on the other hand, is the repeated use of films by the farmers for different purposes – first for covering greenhouses, then for side covering, and finally use them for soil mulching. The slump in the prices of horticultural products has forced the farmers to be more conscious about recycling. Recycling concerns not only material, but also chemical and thermal recycling too.

In Japan, WAP is classified as an industrial waste under law. In the Republic of Korea and China, however, law still considers WAP as a recyclable resource. The different classification influences both the collection and disposal management of WAP in a complex fashion, creating different results and issues.

Collection and proper disposal of WAP in Japan

Quantity of WAP discharge and revision of WMPCL

In Japan, the quantity of WAP discharge had kept increasing after the 1950s, reaching the peak of 193,000 tonnes in 1993. Thereafter, the trend reversed, showing a decrease, mainly

due to the rapid increase in imported vegetables after 1995. In 2005, it was 151,292 tonnes. Among agricultural films, PVC films was the most used in Japan. For example, 112,000 tonnes – 60 per cent of the total WAP – of PVC films were used in 1995. In China and the Republic of Korea, in contrast, use of polyethylene films was the highest.

The burning of waste PVC causes dioxin pollution to soil and air, and this became a serious social problem in Japan in the early 1990s. At the same time, greenhouse farming as a whole shrunk owing to the steady increase in vegetable imports. Gradually, the use of PVC films decreased, with PO films stepping in as substitution, as the farmers needed cost reductions to balance the low vegetables prices. In 2005, for the first time in Japan, polyethylene accounted for more than half the agricultural plastics used.

As said earlier, in Japan, WAP is defined as an industrial waste by the law WMPCL, enacted in 1970, and its proper disposal is the obligation of the person who discharged it. Burning of the waste is prohibited if the incineration facility is not equipped as per the standards stipulated by the revised WMPCL in December 1997. In the revision of 1999, a manifest system was introduced for the disposal of all industrial wastes. With the strengthening of the regulation, proper management and disposal of WAP became indispensable. Then, promotion coun-

cils were established in all prefectures and most of the cities and villages to set up a collection system, and to develop systems to recycle WAP. The council is generally comprises the representatives of local government, agricultural co-operatives and agricultural material retailers' association.

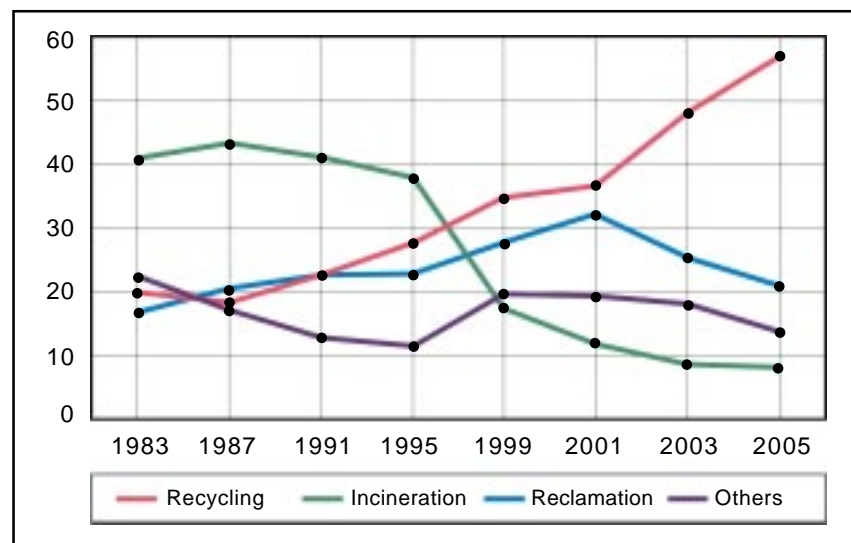
The council has become a centre and its functioning has been strengthened, so that the collection could reach almost 100 per cent today. But, there are a few problems too.

Disposal of WAP

Recycling as a mode of WAP disposal has been increasing in recent years because of environmental considerations. Incineration, which was the main method of dealing with WAP until 1997, has dramatically declined to 8 per cent in 2005 (Figure 1). Recycling moved up to 57 per cent from less than 20 per cent in 1987, while disposal by reclamation was 21 per cent, all following WMPCL standards.

In the case of WAP disposal by recycling, regional differences are observed. Recycling percentage is high in Kyushu and Shikoku, but low in Kinki and Hokuriku, although increase has been noted in almost all prefectures. WAP recycling in Tohoku and Hokkaido in 1999 was 1 per cent and 14 per cent, respectively, which was much below the national average. By 2005, however, both these regions had moved close to the national average.

Figure 1: Percentage change in the type of WAP disposal in Japan



In general, the discharge of WAP per farm is small, but is varying, dispersed and seasonal. Therefore, the establishment of a collection system and its effective management are very important. WAP disposal is well organized and managed in Toyotomi town in Hokkaido region at the northern end of Japan; therefore, its functioning should be analysed as a model.

Most the farmers in Toyotomi town live by dairy farming. Wrap films for feed packing and stack silage are the most discharged WAP. At a training programme organized by the regional government, the Toyotomi agricultural co-operative became aware of its responsibility for the effective collection and proper disposal of WAP discharge from farms. The co-operative then collaborated with the town's government and extension office to establish the town's council. The burden of running it was to be shared by all.

The Toyotomi agricultural co-operative made a definite policy to spread awareness at the farmers' meetings, in co-operation with the extension office. A local transporter was entrusted to convey WAP from farms to stockyard for reducing farmer's burden, and the intervention of the council ensured that the transportation cost is low. The co-operative also arranged for flexible container bags for WAP collection and distributed them among the farmers.

These measures induced almost all farmers to join in the WAP collection drive, and almost 100 per cent collection resulted after four years. The regional council organized a region-wide WAP collection system in August 1998, in which seven agricultural co-operatives took part. WAP collection increased considerably in 2003, with the seven towns of Soya region recording collections varying from 800 kg to 1,200 kg per farm; the collection was 200 kg to 800 kg in 1999.

Toyotomi town government helps farmers subsidize their transport and disposal charge using direct payment from the central government. Each of the stakeholders has clearly identified role and responsibility, as can be seen in Table 1. When there is a clear understanding and collaboration through the entire system, it will function well.

Table 1: Stakeholders' roles for effective WAP collection in Toyotomi town

In/Out	Private	Community (co-operative)	Public
Private	Separation (farmer's responsibility)	Collection of charges	Collection system
Community	Contract and manifest	Farmers' meets	Overall guidance
Public	Subsidy from Central government	Town council	Regional co-ordination

The organization of the WAP collection system in Toyotomi town can be seen in Table 1. The three sectors involved – private, community (co-operative) and public – are arranged in the table in three columns (IN) and three rows (OUT). In the IN column private across OUT row private, it can be seen that it is the obligation of the farmer to separate WAP by kind. The IN column community across the OUT row private shows that the community (co-operative) has the responsibility for contract and manifest works instead of farmers. The IN column private across the OUT row community shows that the farmers pay for the disposal, through the co-operative, to the disposal corporation, and so on. The experience of Toyotomi town is being replicated in many areas in the country.

Waste plastic processing for agriculture

Who implements the disposal processing of WAP? The question needs broad consideration, particularly from the angles of resources circulation and environment preservation. If the monetary profit of the disposal business is low, then the co-operation of WAP processors with the administration and the stakeholders – that is, collaboration among the private, co-operative and public sectors – is necessary for sustainability.

There are three types of waste disposal companies in Japan: private sector, joint sector and association. In the beginning, joint sector waste disposal companies were set up in some prefectures, with support from the government. However, now most of the companies are private type. It should be noted that most of the dis-

posal companies with large investment are facing serious crisis due to severe price competition.

Industrial waste (including WAP) disposal is a regulated as well as a competitive industry. As to regulatory part, it is necessary to take the permission of each prefecture's governor when any person wants to start the business of collecting and processing WAP. Permission is also required to install or alter the facilities.

A main feature of the industry is the large initial capital outlay required. Another trait is that the dischargers of waste is not interested in the quality of processing that is provided; their concern is restricted to seeing the waste disposed of. Therefore, it is hard to see an advanced facility for the proper processing of waste for resource circulation.

The company H in Tohoku region, for example, first innovated circulation technology for regenerating polyethylene from waste for producing multi-films. It had developed its vision and strategy focusing on technology innovation and resources circulation system so that the farmers could see its advantage. The company H achieved breakthrough product innovation and promoted the regenerated films. But it is currently facing economic difficulties because other processors, who can offer lower cost on account of their simple facilities, are showing higher competitiveness.

A new type of disposal company has been entering the collection and processing business of late: processors and dealers who target the regenerating materials market in China, Taiwan-China and South-East Asia. They dispose of WAP only with the

processes of: crushing → washing → pressing for less-volume → shipping. As technology is not high-level – low-cost processing based on destruction technology – these companies are highly competitive and currently predominant in the waste plastics collection and disposal business.

Domestic or overseas recycling?

The second article of WMPCL states: “The waste discharged in the country must be properly disposed of as much as possible in the country.” But the character of this business, that high quality disposal is difficult to ensure, is not easily changed because even with deliberate co-ordination and collaboration among the stakeholders, processors who can work with low costs may obtain contract from local councils for WAP collection and disposal, and export WAP following some processing. Because of this, Japan is not in a position to fully realize the mission of WMPCL.

As the high investments needed and the stiff competition between the processors become fetters on the industry, the farmers want to pay less and less money for waste disposal. The industry is thus being forced to live with financial instability, which is a disincentive for a processor to use innovative technology to achieve high quality in processing.

Hence, export of WAP to foreign countries seems to be the obvious choice. Export of waste plastics from Japan has increased eight-fold from 2000 to 2007. Mainland China, Hong Kong and Taiwan-China are the main export destinations. China has prohibited direct import of WAP after a particular company's export in May 2004 violated the Basel Convention. So now,

it flows to Mainland China via Hong Kong. If the WAP exported from Japan to China through Hong Kong results in water pollution, one cannot say that the solution of switching from domestic disposal to disposal via export is better for the globe.

Discharge, collection and disposal of WAP in the Republic of Korea

Quantity of discharge and collection of WAP

In the Republic of Korea, greenhouse farming started to develop in the '80s. In the '90s, the greenhouse area almost doubled to 51,000 ha, assisted by a government measure related to the Uruguay Round Agreement. With that increase, the farmed area became almost the same as that of Japan, and the export of agricultural produce expanded rapidly. Because the price of crude oil, fertilizer and other such materials soared because of currency devaluation at the time of the Asian economic crisis, greenhouse farming also faced a crisis.

The growth phase returned since 2003 following governmental support for export expansion, introduction of product traceability and the development of cold chain distribution system. The quantity of WAP discharge has kept pace with this growth. The increase after 2004 was remarkable, as can be seen in Table 2. In 2005, the quantity of WAP discharged in the Republic of Korea was 323,000 tonnes, compared with 151,000 tonnes in Japan (the quantity estimated for Japan is dry weight, whereas water and mud are included in case of the Republic of Korea). There is much discharge of multi-films in comparison with the films for the greenhouse and

tunnel. The former was 216,600 t and the latter 40,600 t in 2003. In Japan, in contrast, the quantities were 38,000 t and 96,100 t, respectively, and others 10,500 t in the same year. The quantities of agricultural films usage in 2003 was estimated by local governments in the Republic of Korea as: LDPE 63,289 t, HDPE 18,835 t, PVC 7,920 t and EVA 8,083 t – 98,134 t in total.

In 1977, the then President of the Republic of Korea, Mr. Park Chung Lee, saw accumulated WAP on the field during a local inspection tour, and instructed that WAP collection be made systematic. The Korea Environment and Resources Corporation (ENVICO) was established in 1980 for the collection and disposal of WAP.

But, because the construction of recycling factories was delayed, and the establishment of a collection system and awareness creation among farmers took time, WAP collection exceeded 50 per cent of the amounts of discharge only in the latter half of 1990s and even in 2006, 36 per cent of WAP was left around in the fields uncollected.

Collection system and route of WAP

Figure 2 shows the collection and disposal system of WAP in the Republic of Korea since 2004. There are two routes. Good quality films discharged from greenhouse farming are collected and sold off for a good price. Low quality WAP – which forms around 85 per cent of the WAP discharged from cultivation with multi-films – is collected and disposed of through the route supported by ENVICO, covering the cost through tax and producers' levy. In the latter case, farmers need to reach used films to village collection spots, from where ENVICO collects and sends them to 52 stockyards set up across the country. ENVICO then dispose them of at five processing factories and nine intermediate disposal factories. In addition, ENVICO contracts private disposal dealers who undertake innovative processing of WAP.

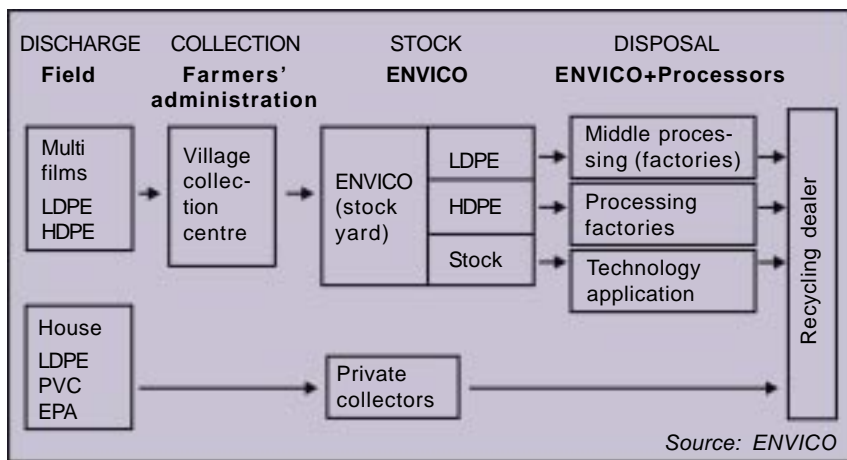
As WAP is characteristically varied in type, originating in small quantities discharged from several dispersed

Table 2: Discharge and collection of WAP in the Republic of Korea (in thousand tonnes)

Activity / year	2001	2002	2003	2004	2005	2006
Discharge	238	261	257	265	323	357
Collection	121	110	151	218	214	229
Recycling	70	84	86	146	216	261
Stock	328	354	394	411	359	276

Source: ENVICO

Figure 2: System of collection and recycling for WAP



sources, it is essential that farmers co-operate for sorting WAP by type, removing foreign objects, carrying to the collection spots, etc. as the starting point of a proper disposal like that in Japan. Although 17,856 spots have been set up in the country till 2007, in co-operation with local governments for collecting WAP at village level, waste multi-films are still discharged by farmers mostly around their fields or homes (Table 3). Only 17 per cent of waste multi-films is carried to the village collecting spots. WAP without removal of foreign substances registered 65 per cent.

In the Republic of Korea, WAP is legally classified not as an industrial waste but as a recyclable resource. It cannot, however, be denied that this classification, provides farmers more freedom to discharge WAP in many ways, in contrast with Japan where farmers have a definite obligation for proper disposal of WAP to its final destination. Thus, in the Republic of Korea, nobody can legally object if a farmer discharges WAP on the field or around his house.

Earlier, the farmers could receive a reward from ENVICO at the time of WAP collection. In October 1998, this was cancelled and it was decided that such rewards should go to the city or county government, as the case may be. Local government then pays the reward money to the farmer, plus or minus the cost of related works carried out or not carried out, as the case may be, by the farmer. Consequently, there was a large element of variability in such payments – in a range of 60 won/kg to 300 won/kg in 2006.¹ In 2007, the uniform reward of 100 won/kg from ENVICO changed to “a grading WAP approach” – a farmer will get 120 won/kg for WAP supplied with foreign substances removed; otherwise, he will get 80 won/kg. This has not made any basic change in the farmers’ attitude, due to “lack of farmers’ understanding, farmers’ age, the passive attitude of local government, etc”.

Until 2004, ENVICO used to collect WAP directly from the village

¹ (US\$1 is about 1,345 won at the current exchange rate)

Table 3: Data on WAP discharge (2007) by farmers in the Republic of Korea (per cent)

Type	Total	Upland	Around home	Collection yard	Others
Multi-films	100	66.3	5.8	16.9	11.0
House films	100	51.6	7.0	29.7	11.7
Total	100	51.6	6.3	29.7	11.3

Source: Mingu Koo at ENVICO

collection spots; from 2004 it has entrusted collection work to private dealers. That made the collection rate to go up by 23 points in 2004, but the rate came down to 60 per cent again with the increase in the quantity of discharge since 2005. This has not changed, and around 40 per cent of WAP is still left on the field.

Recycling of multi-films mixed with water and mud is so costly that it cannot be run as a business. Therefore, ENVICO has taken up the responsibility to collect and dispose of this kind of WAP. Plastic makers must pay a charge of 7.6 won/kg for the disposal in 2007 (150 won/kg in 2012) under an Act that promotes saving and recycling of resources, and the government uses this money plus taxes for the proper disposal of WAP.

Even with WAP classified as a resource, its circulation did not necessarily work well. WAP can be recycled only if it is readily reusable, or the cost of its collection and processing does not exceed its subsidy plus recycled value. Furthermore, even if WAP is fit for circulation, a characteristic of the industry is such that an excellent disposal dealer would often be not favoured by a client (WAP discharger) in a competition with a dealer who can offer lower price because of lower processing cost.

ENVICO started collection of the agricultural chemicals containers after the Waste Management Law (WML) was enacted in 1986 in the Republic of Korea. Except containers of agricultural chemicals, WAP *per se* is not a target of WML. However, as said earlier, WAP is placed in the group of recyclable resources, which includes waste paper. Therefore, there is basically no disposal by reclamation and incineration, unlike in Japan; however, material and thermal recycling are being done.

Recycling and trade of WAP

In the Republic of Korea, when one looks at how WAP from the recycling angle, good quality WAP moves via the private dealers route, while low quality WAP moves through ENVICO to processors. Priority is given to domestic recycling, and WAP is exported only when it is difficult to process it

in the country. WAP export increased from 10,741 t in 2003 to 25,106 t in 2006, but decreased to 12,007 t in 2007. The export is mostly in crushed and compressed form, to destinations such as the Democratic People's Republic of Korea and China. It is seen that there is a tendency towards exports when the demand in the country for recycled goods is smaller than the quantity of regenerated products.

Discharge, collection and disposal of WAP in China

WAP sector in China have some notable features: the largest quantity of plastics discharged; no collection system other than that of private dealers; low collection rate; prohibition on the import of WAP.

Some data can be presented to support these points. Plastic films use for greenhouse/tunnel farming was estimated at 700,000 t (3,330,000 ha of farming) while multi-films use was 450,000 t (for 1,467,000 ha), thus totalling 1,200,000 t for the country in 2006. There are no data available on other kinds of agricultural plastics. The amount of waste agriculture films discharged was reported as 829,400 t, which made 23 per cent of the total waste plastic films in 2005.

The biggest problem in China is that the collection rate for WAP has reached only 15 per cent with good quality of films, while most of the other WAP are left on the field. Private dealers collect good quality films from the greenhouse farmers at good prices. High quality films are, however, limited to just 2 per cent, while the middle quality films make up 20 per cent and low quality films account for 78 per cent (2006 data). In industrialized countries, the percentage mix is 20:50:30 for high-middle-low qualities. The collection and disposal of low quality films cannot as yet be established as a business in the private sector. Of the three countries discussed in this paper, only China has no formal WAP collection system.

The Chinese Government enacted a law in 2001 for the collection and usage of recyclable resources and prepared a 15-year plan in 2002 for the implementation of the law. Both

these aim at industrialization of the waste plastics collection and promotion of use of regenerated products as important objectives. However, so far, only the setting up of trial collection points in 24 cities and the preparation of a model for industrialized recycling of waste plastics have been achieved. The establishment of a formal collection system and construction of disposal facilities for WAP have not yet been scheduled in China, although the government has recognized that "The environmental pollution issue caused by WAP films is becoming serious day by day". The result of some investigations show the concentration of WAP films remaining in the soil to be 3.06 kg/ha (1.3 per cent) in the case of greenhouse and tunnel farms and 10.5 kg/ha (12.3 per cent) in the case of multi-film cultivation. In some serious cases, such as in vegetable and peanut cultivation, this reaches up to 40-60 per cent.

Technology for WAP recycling is still developing in China, and the government has prohibited the import of WAP because of the high possibility of pollution by agricultural chemicals, in the absence of proper processing technology. The safety of the soil and agricultural produce is already under threat from the WAP that is burned or left uncollected. On the other hand, the Hong Kong route is being used to secure plastic materials in view of the vast increase in demand caused by rapid growth. To export WAP from Japan, it has to go through several processing steps – removal of valuable materials → crushing and washing → removal of foreign substances → segregation – have to be carried out besides having a bonafide purpose of recycling, according to Basel Convention. However, under the Con-

vention, a check for agricultural chemicals is not required.

Table 4 shows the change in the amount of waste plastics imported by the regular route and via Hong Kong route. It can be seen that by 2004, more than half the import is through Hong Kong. China occupies "an important position in the international plastic recycling market", and "waste plastic raw materials have been imported from the United States, Japan, the Republic of Korea and European countries for the past several years". It seems that the "one country and two systems" situation is being cleverly used.

A scientist at Chinese Research Academy of Environment Science has pointed out that China is facing the secondary pollution caused by the disposal of collected WAP, such as poisonous gas generated by incineration, melting plastics down to oil without the required gas treatment equipment, and exhaust of hazardous substances without filtration.

China, as the largest user of agricultural films in the world, is facing important challenges such as the establishment of WAP collection system, including for low-quality films, the introduction of segregation, observing environmental standards in the WAP recycling process, and prevention of pollution. The country is expected to solve issues that cannot be tackled under the market mechanism, and to move towards sustainable farming.

At the same time, as international merchandise market dealings make China a core country, and as WAP materials flow largely in to that country, among the three countries, the need to have a proper WAP disposal system is most urgent in China.

Table 4: Estimated amount of waste plastics import in China (in thousand tonnes)

Activity / year	2000	2001	2002	2003	2004	2005
Regular import	2,007	2,228	2,458	3,024	4,096	4,957
Total import	3,238	4,580	3,870	5,434	8,350	n.a.
Rate of reg. import	62.0	48.6	63.5	55.6	49.1	-

Source: Department of Solid Waste Pollution Control at China Environment Science Institution

Conclusion

Today, in the countries of the Asian temperate and the sub-arctic zones, agriculture is a business that cannot exist without using various plastics. Plastics discharged from agriculture without proper disposal cause severe environmental issues. Although it is very important to consider this issue seriously for achieving sustainability in agriculture, it is very seldom done. In examining the collection and disposal systems and activities of WAP in Japan, the Republic of Korea and China, the following key points have become evident.

- In the Republic of Korea, although the public corporation ENVICO has set up many collection spots for WAP, most farmers do not deposit WAP at those points but discard it about their fields. One reason for this is that WAP is legally considered as a recyclable resource – not as an industrial waste, as in Japan – and therefore the farmers need not have responsibility to ensure their proper disposal.
- In Japan, most of the WAP gets collected with the cooperation of the local government, agricultural co-operatives and stakeholders. In the Republic of Korea, there are two routes for collecting WAP: all good-quality films get sold at fair prices, while ENVICO incentivates farmers for collecting medium and low quality WAP. Still, 40 per cent

of WAP get left on the field. The farmers in China leave most of the WAP about their fields, as there is no collection system except for good quality WAP.

- The Republic of Korea strives for domestic recycling of all the WAP, but some get exported in view of lack of processing technology. It also differs from Japan, where reclamation, incineration as well as recycling are practised, at least partially.
- In China, as there is an official ban on WAP import, more than half of WAP is imported via Hong Kong. China occupies an important position in the international plastics recycling market, making use of the “one country and two systems” approach. Therefore, a proper disposal system for WAP should be established in China.

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Seed Alliance Without Boundaries (SAWIB)

An FAO initiative for Global Partnership on Seed Security

In order to establish a sustainable seed supply and thereby facilitate food security of member countries, the Plant Production and Protection Division (AGP) started an initiative termed “Seed Alliance Without Boundaries (SAWIB)”. The seed-based initiative will cut across crop production and food industry domains. The objective is to create a forum to bring together stakeholders from the private and public sector of developed and developing seed and food industries for dialog that will facilitate the: (a) transfer of technological and entrepreneurial skills for sustainable seed production and distribution; (b) linkage of seed sector with farmers or crop producers; and (c) linkage of crop producers to crop-value-addition industries. Overall, the initiative will facilitate the creation of seed industry that is market-driven and ensure sustainable use of plant genetic resources for food and agriculture.

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