Greening of a campus through waste management initiatives

Experience from a higher education institution in Thailand

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Received 30 October 2015
Revised 23 April 2016
Accepted 20 May 2016

Abstract

Purpose – This paper aims to describe the effects of 3R (reduce, reuse and recycle) waste management initiatives on a campus community. It ascertains the environmental attitudes and opinions of the residents and investigates their behavioral responses to waste management initiatives. Practical implications for enhancing sustainable waste management are discussed in this paper.

Design/methodology/approach – Demonstration projects on waste segregation and recycling, as well as waste a reduction campaign, were set up on the campus to ascertain people's attitudes and investigate their behavioral responses toward 3R practices. Data were collected through a questionnaire survey, observations, interviews and the project's document review. A waste audit and waste composition analysis was carried out to assess waste flows and actual waste management behaviors and measure the change in the recycling rate.

Findings – 3R waste management initiatives had positive effects on people's attitudes about resources, waste management and consciousness of the need to avoid waste, but these initiatives did not affect recycling and waste management behavior. A voluntary approach-only cannot bring about behavioral change. Incentive measures showed a greater positive effect on waste reduction to landfills. Nevertheless, the demonstration projects helped to increase the overall campus recycling from 10 to 12 per cent.

Originality/value – This paper addresses a literature gap about the 3R attitudes and resulting behavior as part of campus sustainability of higher education institutions in a developing country. The authors' results revealed hurdles to be overcome and presents results that can be compared to behavioral responses of people

The authors wish to thank Miss Phyoe Thet Khaing for fieldwork assistance, technical and information support from the Office of Facility and Assets Management, AIT.

International Journal of Sustainability in Higher Education
Vol. 18 No. 2, 2017
pp. 203-217
Emerald Publishing Limited
1467-6370
DOI 10.1108/IJSHE-10-2015-0175

from other developed countries. These findings can be used as a guide for higher education institution's policy-makers, as they indicate that voluntary instruments alone will not yield effective results, and other mechanisms that have an impact on people's behavior are required.

Keywords Thailand, Recycling, Campus sustainability, Higher education institution, 3R, Packaging waste

Paper type Research paper

1. Introduction

Consumerism and convenience following a buy-use-dispose system (or a linear approach) accelerate resource use. Presently, there has been an increase in waste generation in most of the developing countries. This has resulted in a large volume of municipal solid waste (MSW) being discarded into landfills (Ngoc and Schnitzer, 2009). Total MSW generation in Thailand in 2013 was about 26.8 million tonnes. About 5.2 million tonnes were recovered and recycled and only 7.4 million tonnes were suitably handled, while the rest of the MSW was unsuitably disposed (Pollution Control Department, 2013). Packaging waste in Thailand accounts for a major proportion of municipal solid waste. The proportion increased due to lifestyle changes. In 2001, of the 14.1 million tonnes of waste discarded, 3.4 million tonnes (24 per cent) were packaging waste. This number rose to 31 per cent in 2004 (Chulalongkorn University, 2004). There has so far been no updated data available on packaging waste in MSW. However, it is projected to increase as MSW volumes in Thailand have been rising by about 10 per cent annually (Mungcharoen, 2006).

Higher education institutions (HEIs) are change agents in society. They require services and infrastructure, including waste management on the scale of a small city. They also have a recognized role in achieving sustainability (Vagnoni and Cavicchi, 2015). HEIs are considered role models in their communities, as well as leaders in social and environmental responsibility (Velazquez *et al.*, 2005; Zhang *et al.*, 2011). Generally, HEIs can become engaged in sustainable development in two ways. First, they can form linkages between knowledge and dissemination in the community. Second, they contribute to societal development through outreach and use of knowledge to serve society (United Nations, 2011). Recently, HEIs have been called upon to commit to the development of sustainable practices by the United Nations Conference on Sustainable Development or Rio+20. As a result, many HEIs around the world are engaging in sustainable practices with concrete and tangible programs on their campuses. The International Sustainable Campus Network (ISCN) was established to promote and provide a platform for exchanging information, ideas and best practices among colleges and universities. This was done to achieve sustainable campus operations and to integrate sustainability and research (ISCN, 2015). ISCN has members from more than 20 countries. Many HEIs worldwide put waste management activities as a beginning point for campus sustainability initiatives. For instance, Massey University implemented a source separation and concourse-based recycling program in New Zealand (Kelly *et al.*, 2006), and a recycling market program in Japan encourages students to donate used books, furniture and electronic appliances to be reused by new students. The Moving Towards Zero Waste program in the United Kingdom aims to implement reuse schemes in student residence halls of their campus (Zhang *et al.*, 2011). Similarly, many HEIs in Thailand have shown their commitment to create green campuses by promoting reduction, reuse and recycling (3Rs) of waste through various voluntary initiatives (Table I).

Implementation of 3R programs has long been regarded as an alternative approach to traditional waste management practices. Many studies emphasized the benefits of minimizing the amount of waste sent to landfills, as well as the factors influencing recycling rate. However, the lack of information about attitudes and behavior of well-educated people

HEI	Description	Source
King Mongkut's University of Technology Thonburi	Implemented "no plastic foam for food" initiative on the campus in 2005 and promotes the use of personal reusable mugs and tumblers under its waste management policy	KMUTT (2010)
Thammasat University	Established a recyclable waste bank and launched waste separation campaigns under its sustainable university action plan in 2014-2017	Thammasat University (2014)
Mahidol University	Declared its 3R policy to reduce plastic bag use; and implemented a tumbler project that encourages the use of personal beverage containers for discounted merchandize and a waste segregation project	Mahidol University (2013)
Chulalongkorn University	Initiated a styrofoam food-packaging reduction initiative and established a central waste management recycling center to promote waste separation as part of their green university policy in 2011	Chulalongkorn University (2012)

Table I.
Waste management programs in HEIs (Thailand)

in response to 3R programs and associated effects to MSW stream has remained as information gaps that hinder progress toward campus sustainability (Kelly *et al.*, 2006).

Controlling consumption is the most important goal for effective source reduction and sustainable waste management. People's choices, behaviors, awareness and attitudes about waste generation and management serve as precursors to achieving sustainable development (Jackson and Michael, 2003). The present study primarily focused on sustainable initiatives in HEIs promoting "3R" practices. It is believed that 3R programs implemented on campuses positively influence the awareness of the campus community, as well as its attitudes and behaviors. To validate this hypothesis, the current study investigated how people's attitudes and behaviors were influenced by sustainable 3R initiatives in an HEI. The Asian Institute of Technology (AIT), an international higher education institution located in Thailand, was used as a case study.

2. Methodology

2.1 Context of study area

Located in Pathumthani Province, Thailand, the AIT plays a leading role in promoting sustainable development in the Asia-Pacific region through higher education, research and outreach. It is committed to becoming a sustainable institution as evidenced by its adhering to voluntary commitments resulting from Rio+20. This requires teaching sustainable development across all disciplines, encouraging research and dissemination of knowledge about sustainable development, developing green campuses, supporting local sustainability efforts, engaging and sharing information with international networks (United Nations, 2011). AIT is a multi-cultural educational institution of about 3,000 persons from more than 40 countries, including students, staff members and their families. While AIT's orientation is purely international, their waste management handling practices follow Thailand's law and regulations. Tha-Khlong Municipality has the direct responsibility to collect and transport waste generated on the campus for final treatment and disposal.

The physical infrastructure of AIT includes office buildings, laboratories, a conference center, accommodations, sport facilities and commercial establishments. Waste generation is primarily from three areas. These are staff and student housing, academic buildings and

commercial areas. Typical mixed waste collection was adopted on campus, where the residents discard waste into a one-bin system without separation.

The waste stream on the AIT campus is illustrated in Figure 1. Waste from bins is collected and temporarily stored at a campus-based transfer station before being sent for final disposal at landfills by the Tha-Khlong Municipality. The informal sector is a key player in recyclable waste collection and segregation for recycling. A small fraction of the recyclables (especially the packaging waste including plastic and glass bottles and metal cans) is sorted and sold by the housekeeping staff and waste collectors (janitorial staff) to earn extra income. A small amount of segregated food waste is utilized as animal feed. These basic waste management facilities did not guarantee an optimized waste segregation and utilization on the campus.

Since 2014, AIT has operated under the concept of being "a Sustainable Living Laboratory", integrating its components to transform itself into a green campus. For this, campus-wide solid waste programs were launched and initiatives were carried out by groups of student-volunteers, with the support from faculty and the Office of Facilities and Asset Management (OFAM). This demonstration set up aims to increase people's awareness and promote 3R practices on campus. It mainly included a voluntary approach and incentive measures, segregation of recyclable packaging waste by installing packaging-waste segregation bins to sort recyclable packaging (plastic bottles, glass bottles and metal cans in particular). The bins were located at prominent locations across the campus. A plastic bag reduction campaign was carried out in collaborative action with convenience stores in the institution, and a cash-for-trash program was initiated, which allowed people to sell their segregated recyclables to waste buying shops.

These initiatives were introduced and communicated continuously from the beginning of the project by distributing information door-to-door, internal e-mails, the AIT webpage, posters/banners, presentation of 3R initiatives to students at special annual events, e.g. orientation day and food fairs. Information was given about project activities, locations and the number of waste separation facilities, as well as information to raise awareness to inform people about the ways in which they can participate and to encourage the residents to contribute toward greening of their campus. Results of these initiatives were recorded and reported through campus media and e-mails on a monthly basis.

2.2 Research approach and methodology framework

3R solid waste initiatives were used to determine if the availability of these options could have positive impacts on the waste management behaviors and environmental attitudes of the campus community. A mixed method approach was applied to gather qualitative and

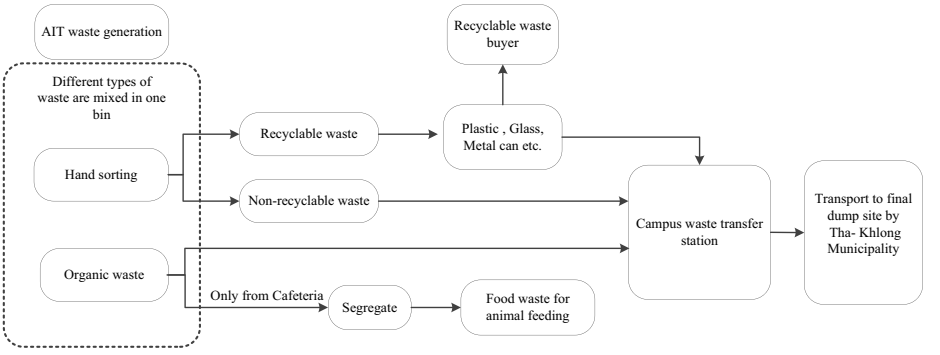

Figure 1.
Campus waste handling system

quantitative data. An overall framework for the methodology of this study is presented in Figure 2. The results were obtained through waste audits, waste composition analysis, field observations, key informant interviews and fieldwork records and were used to assess the actual behaviors of the community. Furthermore, the survey was designed to ascertain people's attitudes, knowledge and self-reported behavior regarding sustainable solid waste practice. Quantitative data of the 3R performance results and waste composition analysis was gathered on a monthly basis beginning in August of 2014. A questionnaire survey was undertaken during a 3-month period, October to December 2014.

2.3 Sample and data collection

The questionnaire survey was carried out using a simple random sampling method. The sample size was determined according to Yamane (1967). The survey involved about 12 per cent of the total campus population. The questionnaire was organized into three sections. The first section was related to general information about respondents, followed by questions that assessed self-reported awareness, attitudes and perceptions of waste and resource issues. The last section included questions to determine methods used to dispose of recyclable waste. Responses were expressed using check boxes. A five-point Likert scale was used to measure attitude and opinion as follows: strongly disagree = 1, disagree = 2, indifferent (neither agree nor disagree) = 3, agree = 4 and strongly agree = 5. Additional space was given in the survey for the respondents to make written comments and suggestions.

The sample was split into two groups. These were respondents who cooperated and actively participated in the 3R sustainable solid waste management initiatives (hereafter, referred to as "Group A") and those who did not (hereafter, referred to as "Group B"). The purpose of classifying the sample into these two groups was to determine the effect of 3R initiatives on people with the same (high) education level but different levels of involvement in campus 3R programs. Their awareness, attitude and knowledge were assessed to determine whether the 3R initiatives translated into behavioral changes or not. Results revealed 46.5 per cent of respondents belonged to "Group A", while 53.5 per cent fell into "Group B".

A *t*-test was used to elucidate the different levels of awareness and attitudes about resource and waste issues, disposal and recycling. A chi-square test for independence was utilized to explore the relationship between the 3R program and the campus community's environmental consciousness. Lastly, correlation analysis was used to examine the

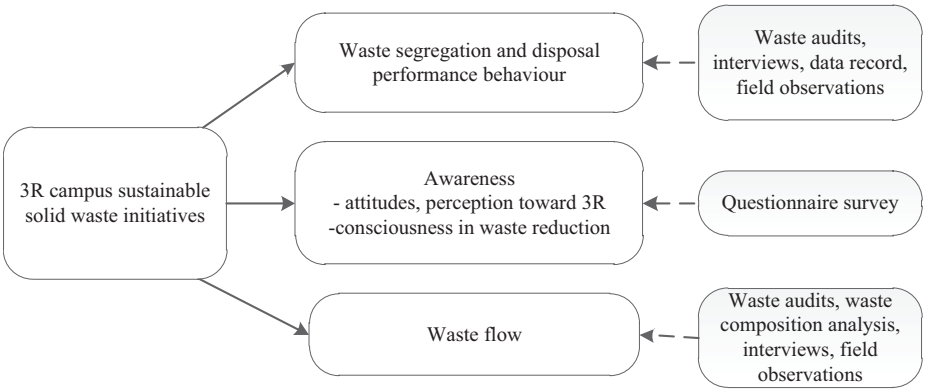

Figure 2.
Overall methodology and framework of the study

relationship between the amount of waste sent to landfills and the performance of 3R solid waste projects on campus. Waste composition analyses, field observations and key informant interviews were done to investigate material flows and the effect of 3R initiatives on these flows. The characterization of waste was performed according to the ASTM (American Society for Testing and Materials) D5231-92 standard method (ASTM, 2008). Secondary sources of data were obtained from the cash-for-trash records maintained by the OFAM, 3R solid waste project records and key informant interviews.

3. Results and discussion

3.1 Existing situation of waste quantity and characteristics

AIT generates about 1.3 tonnes of waste per day, which corresponds to 0.5 kg per capita. This value is comparable with that of other Thai universities (Table II). At the national level, Thailand's urban areas generate approximately 1.2 kg waste per capita each day. In an attempt to control waste generation, national policy aims to limit daily per capita solid waste generation to not more than 1 kg (ONEP, 2012; PCD, 2013).

Although waste generation rate in AIT and many of Thailand HEIs does not exceed the 1 kg per capita limit targeted by national government, it is gradually increasing as can be noted by comparison with previous studies (Soulalay, 2006; Dev, 2007), particularly due to the increasing use of packaging. Evidence of this is revealed by a field survey conducted in 2014 on the AIT campus. It was found that packaging waste had the second largest share in the campus MSW stream (36.2 per cent by wet weight), after food waste (55 per cent). Further detailed analysis of discarded packaging showed that plastic constituted the highest amount (25 per cent), followed by glass (6.5 per cent) and metal (1.6 per cent). When compared to the previous study, there was an increase in the proportion of packaging waste. Notably, of total packaging waste at the campus transfer station, the proportion of recyclable packaging waste in MSW stream was 34 per cent and that which could not be recycled was 66 per cent. This implied that an increasing amount of non-recyclable waste was being sent to uncontrolled landfills, which is common in Thai municipalities.

Controlling the generation of waste has been quite challenging due to weak regulations and the lack of effective policy mechanisms to control waste generation and disposal. The MSW market has no economic incentive for waste reduction. This is true for HEIs as well. AIT pays a fixed waste collection fee to the municipality of only 8,000 Baht a month (approximately US$250/month). This is an example of the lack of incentives to reduce waste according to the weight and volume. Furthermore, recycling is not as widely practiced as it should be, thus providing considerable opportunity for improvement in MSW management.

3.2 Environmental attitudes about resource and waste management issues

Respondents from the two previously defined groups were asked to indicate their level of agreement with a series of statements. Figure 3 shows the score for each statement. Campus residents who were not involved in any 3R campus sustainability programs appeared to have less awareness and concern about 3R practices and waste issues than those who were

Table II.
Per capita waste generation in Thai HEIs

HEIs in Thailand	Waste generation per capita (kg)	Source
Asian Institute of Technology	0.5	Authors
Prince of Songkhla University	0.3	Prince of Songkhla University (2011)
Thammasat University	0.4	Thammasat University (2009)
Nakhon Ratchasima Rajabhat University	0.2	Viriya (2015)

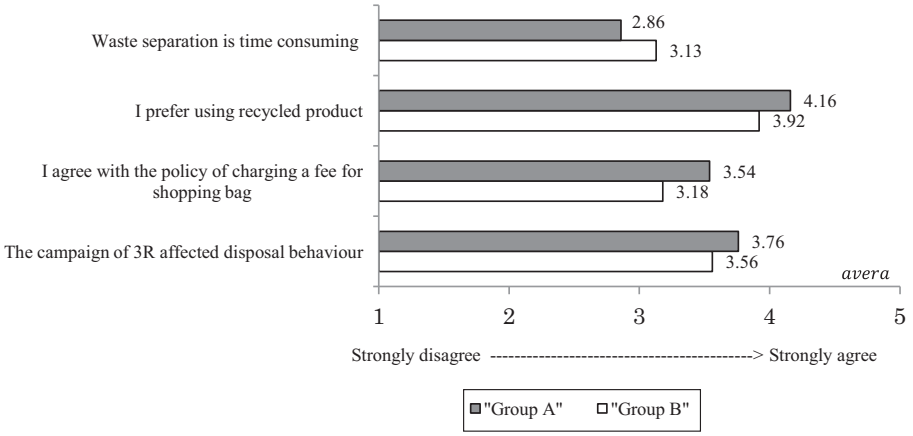

Figure 3.
Responses regarding attitudes about 3R and waste issues

more informed about the importance of waste separation for recycling and how they influence 3R activities. An independent sample *t*-test was done to compare the levels of awareness and attitudes of "Group A" and "Group B" respondents. This study found that "Group A" respondents showed different attitudes and levels of awareness. They strongly believed in the positive role of recycling for better waste management. There were significant differences between these groups as indicated by *t*-tests ($p \leq 0.05$). Furthermore, a very significant difference was observed in terms of the level of acceptance of the policy of charging for shopping bags [$p < 0.01$].

3.3 Environmental consciousness

Differences in levels of environmental consciousness of waste reduction between "Group A" and "Group B" are presented in Figure 4. Majority of "Group A" respondents had a higher level of environmental consciousness about waste reduction. About 20 per cent stated that they very often refuse to take plastic bag from grocery shops, while about 17 per cent of "Group B" said no to plastic bags. However, there was a higher percentage of "Group B" respondents that stated that they never (13.7 per cent) or rarely (27.9 per cent) refuse to take plastic bags, compared to people of "Group A" who responded in the same way at rates of 3.7

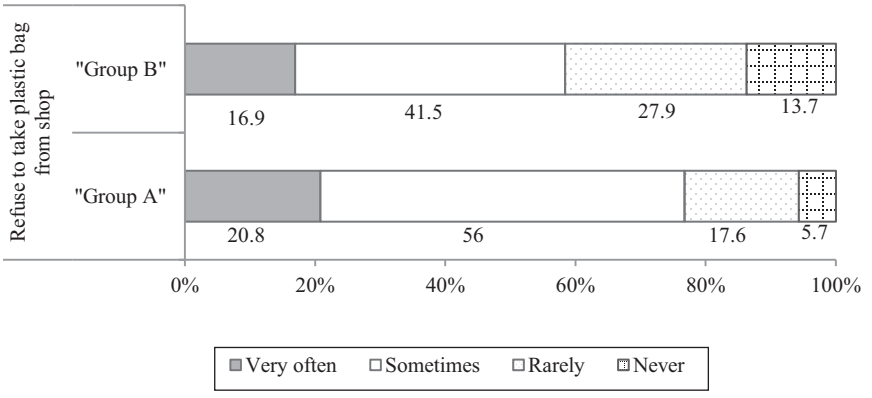

Figure 4.
Campus community waste avoidance behaviours

and 17.6 per cent, respectively. This revealed that "Group A" respondents "sometimes" to "very often" engaged waste avoidance, whereas "Group B" "rarely" to "never" did so when asked about refusing to take plastic bags from shops. The relationship between environmental consciousness and 3R campus initiatives and their effect on campus community awareness among "Group A" and "Group B" was examined. It was found that significant relationships exist between "Group A", who actively participated in 3R campus initiatives, and their responses to "Do you refuse to take plastic bags from shops/convenience stores?" ($\chi^2 = 13.97$, df = 3, $p = 0.003$) according to the chi-square test for independence.

In short, recycling and resource efficient attitudes of respondents who cooperated and actively participated in 3R activities were found to be positive on resource and recycling issues, especially about accepting charges for plastic shopping bags, which differs from those who did not. Similarly, the study revealed a significant relationship between waste avoidance when purchasing products and active participation in 3R programs.

3.4 Knowledge on waste management hierarchy

In sustainable solid waste management practice, the first priority in the waste hierarchy is accorded to "reduction of waste" followed by "reuse" and "recycling". Although 3R knowledge is not essential for individual 3R practices, it explains the intention or effort in adopting a specific behavior (Wang *et al.*, 2014). Respondents were asked to prioritize the importance of "reduce", "reuse" and "recycle" by ranking them based on what they understood. If a respondent makes the correct selections by choosing "reduce" as the first priority, then "reuse" and "recycling" as the second and last, respectively, it was concluded that he/she understands the concept and principle of sustainable waste management.

Environmental knowledge regarding the priority of the 3Rs among campus residents is shown in Table III. Response of "Group A" was the most accurate as they ranked "reduce" as the first option, followed by "reuse" and "recycle". On the other hand, "Group B" perceived that "recycle" is the most important. Even though an HEI is a highly educated community, the 3R waste hierarchy was clearly not grasped by all. It was also found that a minority of "Group A" did not understand differences in the priorities of recycling and reducing waste.

Respondents who cooperated and actively participated in 3R initiatives had a more accurate and better understanding of sustainable waste management options compared to the group that did not. Recycling was often perceived as the most preferential option. These results revealed that environmental knowledge and perception of the 3R's can significantly determine campus community awareness and its behaviors in waste reduction efforts. It

Sample group	1st priority (%)	2nd priority (%)	3rd priority (%)
Reduce			
"Group A"	39.6[a]	33.3	27.1
"Group B"	32.1	30.5	37.1[a]
Reuse			
"Group A"	27.1	40.3[a]	32.6
"Group B"	26.8	40.1[a]	32.9
Recycle			
"Group A"	33.3	26.4	40.3[a]
"Group B"	41.1[a]	29.3	29.9

Note: [a] The highest percentage among the same group of each column (priority ranking)

Table III.
Results of priority ranking of the waste hierarchy by respondents

detected significant differences in terms of attitudes and environmental consciousness among groups. However, the waste management hierarchy and waste reduction should be highlighted and put into action through proper policy measures to achieve the goal of sustainable consumption. Recycling options or building a recycling culture alone may lead to priority being given to recycling practices, which would result in the increased use of resources.

3.5 Effect of 3R solid waste campus initiatives on people's behavior

3.5.1 Waste disposal behavior. There were four alternatives to dispose of recyclable packaging waste in the campus. These were to:

(1) discard and mix with general waste;

(2) self-segregate recyclable waste at its source and give it to housecleaners;

(3) segregate and sell waste to earn money through a "cash-for-trash" program; and

(4) bring segregated waste-to-waste separation facilities.

Overall, discarding unseparated waste in a single bin was still the primary disposal method. Figure 5 shows that a large percentage of respondents disposed of recyclable packaging waste by mixing it with general waste (38 per cent), even though 3R programs provided residents with other waste disposal options. It was found that a relatively low percentage of respondents brought recyclables to recycling facilities (19 per cent). Interestingly, 38 per cent of respondents voluntarily segregated recyclables and gave them to housekeepers for sale. Only 5 per cent of respondents collected and sold them for extra income. People opined that "inadequate waste separation facilities" and "inconvenience" were the main hindrances to their practice of waste separation. Most respondents who answered open-ended questions raised technical issues and requested for an increase in the number and location of easily accessible waste separation bins. Notably, most of issues cited were of a technical nature and indicated a lack of information (Table IV).

This study also statistically tested differences between waste disposal methods of people who cooperated and actively participated in 3R initiatives and the group that did not. Surprisingly, there was not a statistically significant difference between the two groups in their disposal behaviors. The 3R programs did have positive effect on awareness and

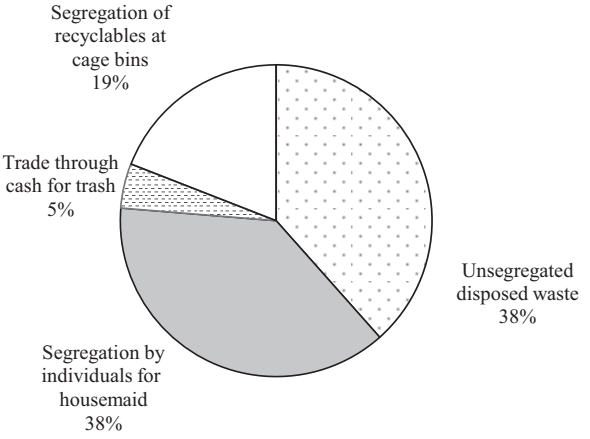

Figure 5.
Recyclable packaging-waste disposal methods

environmental attitudes, but not on disposal and waste management behaviors. This finding contradicts a previous investigation by Lee and Paik (2011) who examined Korean recycling behavior, and concluded that environmental attitudes affect recycling and waste management behaviors. In the context of developing country, 3R related knowledge and environmental attitudes does not necessarily translate into practice, unless identified barriers are addressed. Also, appropriate policy instruments and correct mechanisms are required.

3.5.2 Campus waste stream and actual performance behavior. A previous study cautioned that self-reported behavior may differ from actual behavior (Barker *et al.*, 1994). To test this, the current study also examined actual behavior by doing a packaging-waste separation project, a cash-for-trash program, a waste audit and waste composition analysis.

Of the total packaging waste by weight, the percentage of potentially recyclable packaging (metal cans, plastic bottles and glass) was 31 per cent, while non-recyclables (e.g. styrofoam, plastic bags and paper/plastic cups) was about 69 per cent. The main sources were convenience stores, food vendors, cafeterias and coffee shops. On campus, most students do not cook, but rather they buy food from shops that offer single-use packages, which cannot be recycled. Therefore, the proportion of single-use packaging is on the rise.

Around 31 per cent of all packaging was potentially recyclable, but it remained in the MSW stream. This could have been diverted from the stream to ensure resource recycling rather than being sent for downstream management. People might argue that if they do not practice waste sorting, waste pickers will do it anyway. Therefore, source segregation might be overlooked. Although the traditional waste management system of developing cities included the important role of informal sector in the recycling system, upstream waste separation should be promoted. It will not only increase the level of awareness, but also build and contribute to a higher recycling rate. However, the large proportion of recyclable packaging found in the campus MSW stream indicated that people discard both recyclable and non-recyclables with general household waste, even though voluntary 3R initiatives were in place to encourage people to engage in 3R practices.

3.5.3 Correlation between the campus 3R program performance and waste proportions at transfer station. It is believed that the proportion of recyclable packaging found at campus final transfer station was reduced when a higher amount of recyclable waste was collected through 3R waste separation and recycling programs. The percentage of recyclable packaging at the transfer station may have a significant relationship with effectiveness of 3R initiatives. To investigate this, the total weight of recyclable packaging from the waste separation project and the cash-for-trash program were used to determine if they influenced the amount of packaging waste that remained in the MSW stream.

Technical issue (43.4%)	Knowledge issue (34.7%)	Awareness issue (17.3%)	Others (4.6%)
"Not much access to recyclable bin allocated for packaging waste or food waste" "Inadequate number of recyclable bins"; and also "distances/location between recyclable cage bin and general bin"	"I am confused with the classification of general waste and recyclable waste" "There is lack of clarity in the labels of the bin"	"Time consuming" "Too many type of waste to be separated" "Inappropriate disposal of waste in the bins is discouraging, and demotivates me to do the segregation"	"Inconvenient as I want to throw all types of waste in a plastic bag"

Table IV.
Qualitative comments and suggestions by respondents

Recycling activity through the cash-for-trash program had a positive effect on reducing the proportion of recyclable packaging remaining in the MSW stream, whereas the recyclable packaging-waste separation project did not. Financial incentives and consistent participation in the cash-for-trash program are possible explanations for this positive result. Those who participated earned money by selling recyclables. However, there was no incentive or perceived benefit in the packaging-waste separation project. The current study found a significant negative correlation between the cash-for-trash program results and the proportion of recyclable packaging sent to the transfer station. Pearson's r data analysis revealed a strong negative correlation, $r = -0.96$, $p < 0.001$, using a two-tailed analysis (Table V). Results of the recyclable packaging-waste separation project did not have a significant relation with the amount of waste sent for disposal ($r = 0.22$, $p = 0.62$). To reduce waste through voluntary measures, there is a need to create more and better waste recycling infrastructure, which may require financial support. Alternatively, 3R activities with incentives (cash-for-trash program) had a greater effect than voluntary measures in this HEI context.

3.6 Effect on campus waste flow

The campus packaging waste flow with 3R measures in place was assessed as illustrated in Figure 6. The annual waste generation at AIT is about 529 tonnes. Waste flow at AIT is predominantly linear in its nature. Most of the generated waste is sent to the AIT transfer station and then to final disposal in uncontrolled landfills. Of the total packaging waste from AIT, 196.1 tonnes produced annually, about 173.3 tonnes (88.3 per cent of total) was sent to landfills. It was estimated that 60.8 tonnes of this was potentially recyclable and 135.3 tonnes was non-recyclable. The ratio of non-recyclable

Variables	% recyclable packaging found at final transfer station
Recyclable packaging-waste separation	0.22
Cash-for-trash	−0.96**

Note: **Significant at $\alpha = 0.01$ level

Table V.
Correlation results between variables

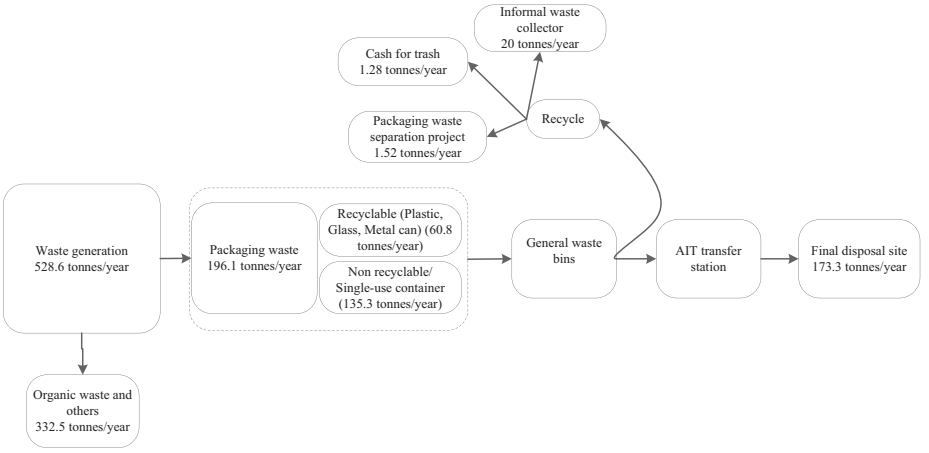

Figure 6.
Flow of packaging waste

to recyclable packaging can be used as an indicator of consumption behavior to track the impact of 3R initiatives in the community. Through the efforts of waste pickers on campus, about 20 tonnes per year (33 per cent of recyclable packaging) was collected, which resulted in a significant recycling rate. Generally, in developing countries, the recycling rate achieved by the informal sector can often be in the range of 20-50 per cent (Wilson *et al.*, 2009).

Due to the 3R campus initiatives, it was determined that the amount of recyclable packaging increased by approximately 2.8 tonnes annually (approximately 1.28 tonnes through the packaging-waste separation project and an additional 1.52 tonnes through cash-for-trash activities), boosting the recycling rate by 1.8 per cent, to an overall recycling rate of 12 per cent for all packaging waste. Based on these findings, the AIT campus needs to improve its recycling rate to meet the national target of at least 30 per cent of all waste generated (PCD, 2012) by setting attainable recycling targets and regulatory measures. Most important, restriction of single-use packaging should be undertaken to control the use of disposable packages on the campus. This could help to reduce non-recyclable waste, which constitutes a significant amount of the MSW stream (69 per cent) on campus.

For the 31 per cent of the material that is potentially recyclable, diverting waste away from disposal can be done by increasing participation in waste segregation programs and other voluntary 3R initiatives, along with provisions for a proper recycling infrastructure on campus. However, better management of packaging waste on the AIT campus will not be successful and sustainable, unless the use of non-recyclable packaging is reduced at the point of generation.

4. Conclusions and recommendations

3R solid waste initiatives have positive effects on environmental attitudes and consciousness of the need to avoid producing waste in a highly educated community. The presence of 3R initiatives creates an accurate understanding about options in sustainable waste management. However, these initiatives did not affect recycling and waste disposal behavior. Three barriers to good recycling practices were inadequate recycling infrastructure, inconvenience, and a lack of specific and clear information about what can and cannot be recycled. Results of the current study demonstrated that in the context of developing countries, environmental attitudes, awareness and knowledge do not affect recycling behavior. This finding is in contrast to responses of people in developed countries.

The 3R initiatives on the AIT campus may take some time to have an impact. It also depends on other factors such as participation and project information. However, the presence of recycling facilities and visible campaigns at AIT increased the recycling rate by 1.8 per cent to 12 per cent. Although the current recycling rate has not yet reached the national target of 30 per cent, these initiatives have established recycling loops as sustainable options that minimize waste to final disposal. The result of this study shows a huge opportunity for the AIT community to improve its recycling rate by enhancing its ongoing 3R initiatives and increasing participation. These are key requirements for increasing and maximizing the campus-recycling rate.

Based on these findings, despite the fact that HEI community is well aware of waste and resource issues, building a recycling culture and bringing 3R practices into action for a successful 3R system requires some prerequisite actions. These include developing a complimentary package of clear directions and gaining a commitment on the part of the institution to implement green actions such as 3R initiatives. Implementation of a basic waste separation infrastructure is first needed. The lesson learnt from this study is that the

most important factor to engage an HEI community in 3R practices is continuous communication of 3R activities, along with information about waste management results and achievements. In particular, the amount of waste reduction and waste recycling are considered basic indicators. It should be acknowledged that these actions are a part of job creation and income generation in the informal sector. This can potentially enhance the waste recycling rate on campus. However, to raise awareness among inactive residents, there is a need to ensure them that individual actions contribute to positive impacts by diverting waste from landfills. Generally, these people were demotivated to practice 3R, because they did not believe in an operational and waste collection system, which dumps all types of waste and mixes them together downstream.

To achieve the goal of campus sustainability, there is a need to build a 3R culture within the campus community by creating recycling infrastructure and making it convenient for people to practice waste segregation. Waste management programs must ensure that introduction of recycling facilities will not cause over consumption of resources. Based on research findings, voluntary measures are not sufficient to promote pro-environmental behavior in a developing country's context. Even though environmental awareness and increasing knowledge through voluntary 3R initiatives is important to guide people's behavior, 3R activities should be promoted with economic and fiscal measures and a ban on single-use packaging under the framework of a clear waste management policy.

At AIT, a recycling-only effort was not a sustainable solution because non-recyclable packaging tends to increase and comprises a large percentage of the material in the MSW. One of the strategies to curb the generation of non-recyclable packaging waste is to develop suitable alternatives, such as economic incentives/disincentives and regulatory measures for avoiding the use of disposable packaging. Alternatively, decision makers may consider installing or improving water fountains on campus and ensure their water quality. This is a potential way to reduce the use of plastic bottles. Charging for grocery bags and plastic food trays, as well as banning the use of styrofoam and one-time use of packaging for food and beverage containers, may bring about behavioral changes. These could be initially implemented at many campus events, e.g. sport days and food fairs. It might be also adopted in many HEIs in developing countries with the similar socio-economic background. Next steps for further improvement include monitoring performance of an increased waste management infrastructure and levels of participation, using the suggested campus waste management indicators. Campus sustainability reporting is a recommended communication tool for following-up, keeping people informed, sensitized and encouraged to practice 3R activities. This can serve as source of reliable information for institutional decision-makers for proper intervention.

In the long run, voluntary measures should also be promoted to consistently sensitize and encourage people to reduce waste generation. Additionally, incentive measures could potentially have greater impact on waste reduction and minimization. Therefore, incentive measures are strongly recommended for HEIs in developing countries. This can be done in conjunction with development of a campus waste-management policy and by setting up waste-reduction targets. Campus waste-management policies should use a mix of regulatory and incentive measures along with voluntary participation to establish sustainable loops of resources and waste management. It is hoped that this study influences institutional decision-makers rather than guiding people with only voluntary initiatives. It might be better to investigate how the use of motivational measures, incentives and regulatory mechanisms impact people's behavior.

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