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Sustainable Campus Through Solid Waste Minimization Strategies Case study: Universitas Agung Podomoro in Indonesia

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ABSTRACT

A large amount of solid waste (SW) generation becomes inevitable for campus due to its population and various activities. Therefore, it is a challenge to develop and implement an SW minimization plan to encourage sustainable campus practices. This study aimed to develop sustainable strategies to support this plan for Universitas Agung Podomoro (UAP), included evaluating the SW management condition by monitoring the SW generation and surveying the perception and willingness to participate in campus society. The results showed that the SW generation was 52.63 kg/day or 0.08 kg/person/day. The composition consisted of 32.29% biodegradable and 67.71% non-biodegradable. The recycling potential was 61.01% consisted of 22.28% composting and 38.73% recycling. The social survey showed that respondents had positive perceptions about SW minimization. The complete evaluation resulted in the development of strategies to decrease the SW generation rate, increase the recyclable material rate, and increase campus society's participation.

Keywords: *solid waste management*, *solid waste minimization*, and *sustainable campus*

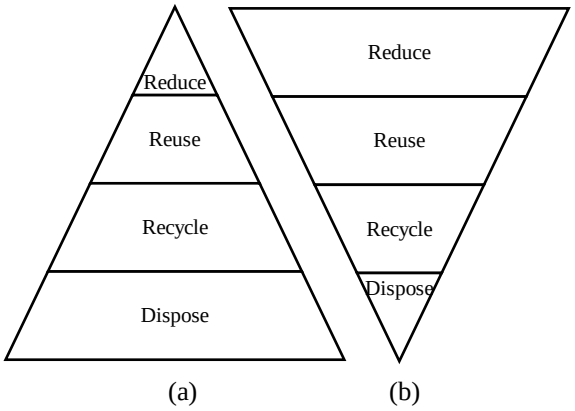
1. Introduction

The growth of Indonesia's population was followed by an increase in solid waste (SW) generation [1]. Based on the Ministry of Environment and Forestry, SW generation in DKI Jakarta went up to 6,200 tons/day during 2017/2018. The educational institution contributed 0.52% of the total SW.

Various activities on campus, such as learning, teaching, consuming, and administrating, impact a large amount of SW. The composition of SW on the campus generally consisted of food waste, leaves, wood, paper, plastic, textile, styrofoam, metal, glass, rubber, and others that potentially recycled [2]. For instance, the recycling potential of SW at the Universitas Putra Indonesia in Padang was 79.11% [2], and the Universitas Indonesia was 51.33% [3]. The same phenomenon occurred in America, where Georgetown University has recycled up to 45% and Rutgers University's 67% of total SW per year [4].

Campuses should initiate their own sustainable SW management plans due to their ethical and legal responsibilities about environmental actions. The SW management plan should have transformed into a new paradigm that emphasizes SW minimization by Reduce, Reuse, and Recycle (3R). A useful new paradigm of SW management needs a complete understanding of the generation amount of SW in the first place. Its plan is prepared based on this 3R concept and the targets determined within the scope of the zero SW principle [5]. The concept of 3R was intended to be implemented due it would prevent the SW from being disposed of into the environment. However, its implementation depended on-campus management's commitment [6].

The contrast between the old and new paradigm of SW management was shown in **Fig. 1**.



Source: Damanhuri E, Padmi T (2015) [14]
Figure 1. (a) Old paradigm SW management, (b) New paradigm SW management

The old (traditional) paradigm is focused on SW collecting and disposing. In comparison, the new paradigm significantly put effort into minimizing SW from the beginning [7]. In essence, it encourages society to set the highest value on source reduction and extended producer responsibility, then focuses on waste conversion processes that recover materials and energy from wastes and/ or the production of compost.

Therefore, the development and implementation of an SW management plan, which includes proactive initiatives, has prime importance to initiate sustainable campus practices. The new paradigm SW management will be successful, accompanied by community (campus society) participation because SW management knowledge is strongly correlated with its activity. Education can support actions and generate awareness, concern, and recognition of the effect of activities [8]. The activities like SW minimization is expected on its participation.

The SW minimization is an indicator of the green campus concept according to the UI Greenmetric World University Ranking [9]. It is a program in implementing a green campus concept for universities in the world, initiated by Universitas Indonesia. Simultaneously, the green campus concept aims to realize a sustainable campus through three aspects: economics, social, and environment [10]. An example of a campus that has implemented that concept in SW management is Universitas Diponegoro [11]. The sustainable campus principle also supports Sustainable Development Goals (SDGs) number 12, "Responsible Consumption and Production," which halves SW's amount in 2030. A comprehensive SW management, specifically, is one of the major components in achieving campus institutional sustainability [5]. For example, Australian National University's (ANU) Green, Sustainability Office, and ANU students researched how to recycle food waste from the kitchens using the "HotRot" digester, which converts it into organic matter without releasing harmful emissions to the environment [22].

Universitas Agung Podomoro (UAP) is one of the newly established campuses that apply the old paradigm SW management concept. It was indicated from the current SW management that not segregated and directly transferred to the SW collection room owned by building management. Next, the collected SW of the building tenants would be transported to the final disposal. Therefore, it was necessary to develop sustainable strategies that would support the SW minimization plan for UAP based on current conditions: SW generation, its compositions, and social perception about SW minimization.

2. Material and Methods

The following three steps to developing sustainable strategies in SW minimization: 1. scoping, 2. collecting data, 3. evaluating data. In the first step, the source of SW generation was assessed by visit each point. The second

stage was conducted by interviewing the administrators responsible for SW management on the campus, collecting secondary data, and monitoring SW generation for 14 days, then analyzing its composition and recycling potential. A questionnaire survey was also conducted to understand the campus society's perception and willingness to participate in SW minimization. For the last stage, the current SW management and social perception condition was assessed to consider some steps required to minimize SW at UAP.

The study presented in this paper can contribute to literature since studies with similar integrated evaluation methodology were still few.

2.1 Scoping

UAP was located at Podomoro City, West Jakarta, Indonesia. It was established in 2013. The campus area is 7,593.28 m2, and it has 9 study programs. In 2020, the numbers of campus society are 959 students and 235 lecturers and administrative staff.
UAP was a place for learning and many activities, so the SW generation came from some points: 23 classrooms; 9 laboratories; 18 lecturers and administration rooms; canteen; kitchens; toilets; and corridors.

The SW storage container has consisted of two types of capacity 5 liters or 80 liters located depending on the amount of its generation throughout classrooms, lecturers and administration rooms, kitchens, canteen, toilets, and corridors. Both were “level-1” storage due collected the SW from the sources. Next, they will be collected in trash bags capacity of 100-120 liters as a “level-2” storage located in a room of (8x4) meters at UAP. Next, transfer to the SW collecting room of (7x5) meters owned by building management to be then transported to the final disposal by permitted.

2.2 Collecting Data

a. Interview
It was begun by interviewing the administrators responsible for SW about what kind of SW generated, how frequently the SW was collected, the SW management steps, and issues related to SW management on the campus.

b. Daily SW Generation Monitoring
The SW sampling method referred to SNI 19-3964-1994 and had been carried out for 14 days. The daily SW sample was evaluated using plastic bags, sampling boxes 40 liters, scales, and a note. Its composition was then analyzed by segregating and weighing each component to calculate the recycling potential of recyclable waste. Studies on the recycling potential of food waste by composting were not included in this study.
The formula used in calculating SW generation and its composition:

1) $SW\ generation\ (kg/day)$:

$$= \frac{waste\ (kg)}{numbers\ of\ sampling\ days\ (day)} \quad (1)$$

2) $SW\ generation\ (kg/person/day)$:

$$= \frac{waste\ (kg/day)}{numbers\ of\ waste\ producers\ (person)} \quad (2)$$

3) $SW\ Composition\ (\%)$:

$$= \frac{waste\ A\ (kg)}{total\ waste\ (kg)}\ x\ 100\% \quad (3)$$

with:
A= types of SW

c. Survey of Social Perception and Willingness to Participation
The successful SW management strategy could not be separated by social participation [12]. To understand the campus society's current awareness, an online questionnaire was conducted among 92 respondents consisting of students, lecturers, and administrative staff through random sampling in April 2020.
Data collected was analyzed using a frequency distribution table to describe how often each variable's value occurred on several observed objects [13]. The chi-square method with "IBM SPSS Statistics 23" software was applied to determine the effect or relationship of a variable with the thing observed [6].

Decision making of the chi-square test results was determined by two statements:

1) If the significance value of chi-square test<critical value (0.05), the H_o was rejected and H_a was accepted (there was a relationship between variables x and y, or the variable x could affected the variable y).
2) If the significance value of chi-square test>critical value (0.05), the H_o was accepted and H_a was rejected (there was no relationship between the variables x and y, or the variable x not affect the variable y).

2.3 Evaluating Data

The complete data about SW management and social perception would be evaluated to obtain the appropriate sustainable strategies applied on the campus that including steps per stage.

3. Results and Discussions

The findings showed that the SW management practices pointed to administrators responsible for handling the SW. On the other hand, it showed neither a new hierarchical paradigm nor the holistic approach of SW management was implemented on the campus. There was no segregation either at the source or in the collection room. The SW was collected from its source twice a day by a cleaning service (CS) and transferred to the collection room. Then, the collected SW during a day would be transferred to the main collecting station own by building management in the afternoon. The SW collected from all tenants would be transported directly to final disposal by permitted transporter at night.

3.1 SW generation at UAP

The SW could be classified into various types depending on their sources. **Tab. 1** showed the details of its general classification.

Table 1. General classification of SW at UAP

No.	Sources	Type of SW
1.	Classrooms	Office paper, styrofoam, plastic bottles and cups, carton, packaging, plastic bags, tissue, etc.
2.	Lectures and administration rooms	Office paper, styrofoam, plastic bottles and cups, packaging, plastic bags, tissue, etc.
3.	Kitchens	Food waste, leaves, packaging, plastic bags, cardboard, etc.
4.	Canteen	Food waste, leaves, brown paper, carton, packaging, plastic bags, styrofoam, etc.
5.	Toilets	Tissue, plastic bags, etc.
6.	Corridors	Styrofoam, plastic bottles and cups, carton, packaging, plastic bags, tissue, etc.

Source: (Author, 2020)

The SW generation was one of the essential steps in planning a sustainable SW management strategy at UAP. Daily monitoring was conducted to estimate the temporal variation of SW generation amount on the campus for 14 days. The results showed that the total SW generation per day varies between 0 and 100.54 kg. The daily average SW generation was 52.63 kg/day. The result was shown in **Tab. 2**.

Table 2. SW generation at UAP

No.	Day	SW generation (kg)
1.	1	89.61
2.	2	38.90
3.	3	76.83
4.	4	48.50
5.	5	69.00
6.	6	13.30
7.	7	0
8.	8	77.10
9.	9	77.69
10.	10	69.20
11.	11	62.00
12.	12	103.54
13.	13	11.20
14.	14	0
Total (kg)		**736.87**
Average (kg/day)		**52.63**

Source: (Author, 2020)

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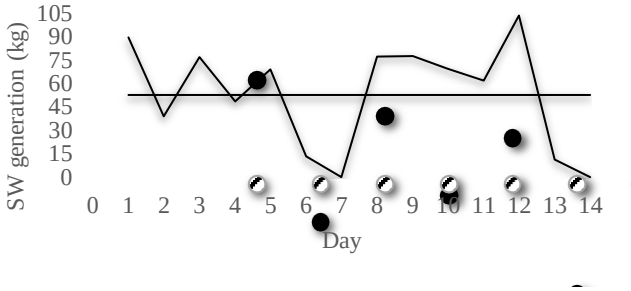
Seen in **Tab. 2**, the total of SW generation amount during 14 days was 736.87 kg with the average SW generation of 52.63 kg/day. **Fig. 2** showed the fluctuation of daily SW at UAP.



Source: (Author, 2020)
Figure 2. Fluctuation of SW generation during 14 days

The fluctuation showed in **Fig. 2** was related to various activities happened. The highest one occurred on the 12th-day (103.54 kg) since it was the first opening day of a minimarket so that impacted to increasing of daily SW. While the least amount was on the 7th and 14th-days, due to no activity at UAP.

Events like seminars and workshops contributed the increase of SW until 18.65%. This was indicated by the comparison of daily SW generation without events of 65.16 kg/day (1st, 5th, 8th, 10th and 11th-days) while there were events of 77.31 kg/day (1st, 2nd, 3rd, 9th and 12th-days).

Next, the SW generation per person per day was calculated at 0.08 kg/person/day. There was no higher education SW generation was determined in SNI S 04-1993-03. The educational institution was only represented by "school" at 0.01 – 0.02 kg/person/day. It could be seen the contrast of the amount of SW generation in SNI and the UAP was quite significant. Consumption patterns [14] between students and "college" students could be one of the factor.

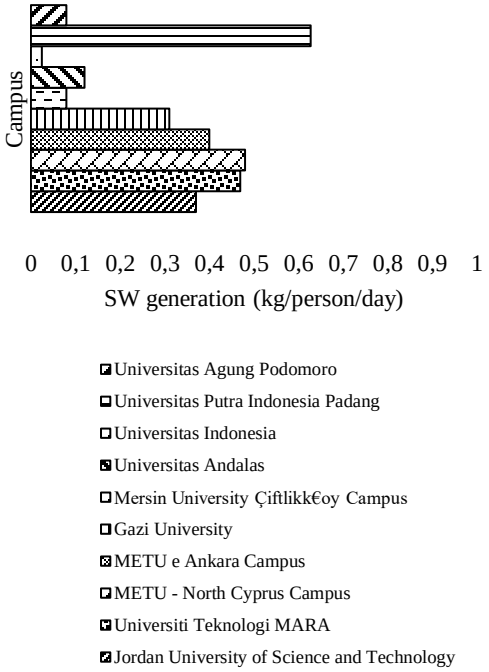
Associated to other campuses, the SW generation among other campus was varied. The SW generation per person per day was shown below in **Tab. 3**.

Table 3. SW generation from various campuses

No.	Campus	SW Generation Factor (kg/person/day)	Reference
1.	Universitas Agung Podomoro	0.08	This study
2.	Universitas Putra Indonesia Padang	0.6271	[2]
3.	Universitas Indonesia	0.024	[1]
4.	Universitas Andalas	0.12	[15]
5.	Mersin University Çiftlikkoy Campus	0.08	[5]
6.	Gazi University	0.31	[5]
7.	METU e Ankara Campus	0.4	[5]
8.	METU - North Cyprus Campus	0.48	[5]
9.	Universiti Teknologi MARA	0.47	[5]
10.	Jordan University of Science and Technology	0.37	[16]

Source: (Author, 2020)

Seen in **Tab. 3**, there were SW generation factor at local and foreign campus. Then, **Fig. 3** showed the comparison of SW generation from various campuses.



Source: (Author, 2020)
Figure 3. Comparison of SW generation from various campuses

Fig. 3 showed that SW generation per person on some campuses were range 0.02 – 1.00 since there were several factor influenced such as: total population, lifestyles, season, and mobility [14]. As seen in **Tab. 3**, the SW of UAP was below the average. The least SW generation per person was Universitas Indonesia (0.024 kg/person/day) that already applied SW minimization in Indonesia. According to its area, UAP was the smallest area and the only campus that was part of the main office building. So that, there was no yard SW contributed.

3.2 Composition of SW at UAP

The composition of SW was expressed as a percentage (%) by weight. The composition of SW during the measurement period was shown in **Tab. 4**.

Table 4. Composition of SW at UAP

No.	Composition of SW	Average (kg/day)	%composition
Composition by category			
1.	Biodegradable SW	16.769	32.29%
2.	Non-biodegradable SW	35.155	67.71%
Composition by type			
1.	Food waste	16.617	32.00%
2.	Plastic bottles and cups	9.001	17.34%
3.	Tissue	6.865	13.22%
4.	Carton	3.226	6.21%
5.	Plastic bags	2.689	5.18%
6.	Styrofoam	2.687	5.18%
7.	Cardboard	2.530	4.87%
8.	HVS paper	2.387	4.60%
9.	Snacks packaging	1.779	3.43%
10.	Brown paper	1.58	3.04%
11.	Residue	1.501	2.89%
12.	Glass bottle	0.321	0.62%
13.	Cans	0.191	0.37%
14.	Tetra pack	0.154	0.30%
15.	Leaf	0.151	0.29%
16.	Plastic spoon	0.113	0.22%
17.	Iron	0.05	0.10%
18.	Hazardous waste	0.036	0.07%
19.	Wood	0.033	0.06%
20.	Magazines and newspapers	0.011	0.02%

*Notes: residual SW consists of shoes; sanitary napkins; baby diapers; and others.

Source: (Author, 2020)

Seen in **Tab. 4**, the composition of SW by category at UAP consisted of 32.29% biodegradable and 67.71% non-biodegradable. Food waste came from the kitchen lab and canteen generated 16 kg/day. This results showed that UAP has a strong compost potential with the 5.6 tons/year or about 32% of the total average SW generation.

Seen in **Tab. 4**, the 5th highest composition of SW were food waste 32%; plastic bottles and cups 17.34 %; tissue of 13.22%; carton 6.21%; and plastic bags and styrofoam at 5.18%. Compared to other campuses, the composition of SW at Jordan University of Science and Technology (JUST) were plastic 36%, organic 25%, paper 24%, glass 8%, metals 4%, and others 3% [16]. Furthermore, the Mexicali I campus of the Autonomous University of Baja California had a SW composition: paper and cardboard 43.6%; 6.7% plastic; 10.2% organic; 2.5% metal; 3.6% glass; 1.8% construction; 0.3% hazardous waste; and 31.3% others [17]. While Universitas Andalas consisted of 26.6% food waste; garden 9.76%; wood 1.18%; 25.25% paper; plastic 30.04%; 1.13% glass; 1.33% cans; 0.19% textile; 0.05% rubber; 0.12% metal; and 4.35% others [15]. Universitas Putra Indonesia Padang consisted of 21.94% food waste; 5.4% leaves; 0.39% wood; 32.8% plastic; 31.64% paper; 0.13% rubber; 0.07% textile; 1.72% glass; 1.46% metal; 0.46% cans; and 3.58% others [2]. It could be seen that the composition of SW on campus was dominated by non-biodegradable SW.

According to Damanhuri and Padmi [14], the product packaging was one of factors influence the composition of SW. Observation in canteen

showed that many package like bottles, plastic, cup, and styrofoam were used to wrap food because of convenience reasons. Even more, the technology development had simplified the delivery of foods affecting to consumption pattern of the campus society. The delivery service activity was related to overpackage issued [18]. For instance, in delivering a meal, it required a container like styrofoam or mica, in addition, plastic bag to ease in handling. Reflecting from the SW composition that dominated by package show the lack of reduce and reuse (2R) applications in daily activity of campus society.

3.3 Description of campus society participation in SW management at UAP

3.3.1 Individual internal factors

An online questionnaire was conducted among 92 respondents consisting of students, lecturers, and administrative staffs to determine their perception and willingness to participate in SW management at UAP. Survey consisted of 47.83% male and 52.17% female, randomly selected from different departments. The majority of the respondents were categorized as late teens (18-25 years) 60.87%, followed by students. Out of 92 respondents dominated by students 56.52%. Evaluations were based on their knowledge, experience, and willingness to participate.

a. Knowledge
   Types of questions and the results of respondents' answers related to knowledge was shown in **Tab. 5**.

Table 5. Types of questions and the results of respondents' answers related to knowledge

Knowledge Criteria	Respondents' Answers			
	Know	%	Don't know	%
Understanding the 3R concept	88	95.65%	4	4.35%
Biodegradable SW	92	100%	0	0%
Non-biodegradable-economics	69	75%	23	25%
Non-biodegradable-residue	62	67.39%	30	32.61%
Hazardous waste	81	88.04%	11	11.96%
How to manage SW	86	93.48%	6	6.52%

Source: (Author, 2020)

Seen in **Tab. 5**, the majority of respondents had known knowledge about SW terms, segregation, and ideal management (up to 65%). While most respondents (95.65%) had understood the 3R concept. On the other hand, most respondents had understood the principles of segregation. In the future socialization about segregation of non-biodegradable SW according to its economic value (able to be sold to local SW bank).

b. Experience
   The types of questions and answers to respondents regarding their experience was shown in **Tab. 6**.

Table 6. Types of questions and results of respondents' tires related to the experience

Criteria	Do	%	Don't	%
Use stationery/paper until they run out/are damaged	58	63.04%	34	36.96%
Bring your cutlery	59	64.13%	33	35.87%
Bring your bottle	76	82.61%	16	17.39%
Bring your shopping bag instead of a plastic bag	55	59.78%	37	40.22%
Segregate organic and inorganic SW	31	33.70%	61	66.30%
Exchange the SW into cash (trash for cash)	25	27.17%	67	72.83%

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Criteria	Do	%	Don't	%
Make crafts from used things	21	22.83%	71	77.17%
Campaigning friends and the community to sort/reuse SW	17	18.48%	75	81.52%

Source: (Author, 2020)

Seen in **Tab. 6**, the SW reduction was the most preferred minimization method among 3R approach. While, only a minor part experienced segregating and recycling showed by less than 40% of respondents.

In general, the results showed that the respondent had a good understanding of SW management but lacked the motivation to commit to applying 3R in daily life. According to Bahçelioglu et al. [5], the most crucial factor that demotivates people participating in good practices is that others do not pay enough attention to these practices.

Besides campus society's knowledge, education also plays an important role [8]. In this case, the campus has initiated a campaign program called "Sadar Diri" to educate the campus society to minimize plastic bottles by supply drinking water in a 19-L container on campus. According to the initiator of this program, it was spent 19-L per day. If it assumed that each participant of this program using a 600 mL bottled (weighed 30 grams) and refiling it, it was estimated that 32 bottles (weighed 960 grams) were reducted to this program. The plastic bottle's average composition resulted in this study was 9 kg/day, so the reduction percentage was 9,6%.

3.3.2 Individual external factors

Analysis of individual external factors using a statistical test of the frequency distribution were as follows:

a. The role of campus
   Community-based SW management required both community participation and institution as a motivator and facilitator, in this case, campus management [19]. The result was shown in **Tab. 7**.

Table 7. Types of campus actions that had been taken and the results of respondents' answers

Campus Role Criteria	Respondents' Answers			
	Yes	%	No	%
Socialization on SW reduction	20	21.74%	72	78.26%
Socialization of SW segregation	16	17.39%	76	82.61%
Socialization of SW recycling	17	18.48%	75	81.52%

Source: (Author, 2020)

Seen in **Tab. 7**, a majority of respondents (up to 70%) had not been socialized about 3R. The role of campus in motivating 3R action was still not optimal.

b. Facilities and infrastructure
   Facilities and infrastructure could supported the SW management process on the campus. The campus facilities and infrastructure with the results of the respondents' answers was shown in **Tab. 8**.

Table 8. Campus infrastructure and facilities as well as the results of respondents' answers

Facilities Criteria	Respondents' Answers			
	Yes	%	No	%
The number of container was adequate	54	58.70%	38	41.30%
Sorting container available	5	5.43%	87	94.57%

Source: (Author, 2020)

Seen in **Tab. 8**, the amount of storage container on the UAP was adequate, but the sorting facilities on the UAP was not available yet.

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3.3.3 Campus society participation

Participation is the key to successful 3R implementation due to the SW minimized from the beginning [8]. Segregation participation was also vital if the SW already generated in order to support the recycling process. The perception and willingness to participate in SW management shown in **Tab. 9**.

Table 9. Participation in SW management and the results of respondents' answers

Criteria of Community Participation	Respondents' Answers			
	Yes	%	No	%
The principle of "reduction" of SW is efficient in overcoming the problem of SW	91	98.91%	1	1.09%
The principle of "segregation" of SW is efficient in overcoming the problem of SW	89	96.74%	3	3.26%
The principle of "recycling" SW is efficient in overcoming SW problems	84	91.30%	8	8.70%
Willingness to reduce SW	88	95.65%	4	4.35%
Willingness to segregate SW	89	96.74%	3	3.26%
Willingness to "recycle" SW by exchanging SW into rupiah	88	95.65%	4	4.35%

Source: (Author, 2020)

Seen in **Tab. 9**, analyzing the participation level of campus society in SW management was almost all respondents (> 95%) were willing to participate in SW management at UAP.

3.3.4 The influence of individual internal and external factors on campus society participation

Analysis the effect of individual internal and external factors on campus society participation using the chi-square test were as follows:

a. The influence of knowledge factors on campus society participation
   Provided the chi-square test between knowledge and campus society participation was $\alpha = 0.00 < 0.05$, means that knowledge could affect respondent's participation, because knowledge is strongly correlated with activity.

b. The influence of the respondent's experience on campus society participation
   Provided the chi-square test between experience and campus society participation was $\alpha = 0.041 < 0.05$, which means that the experience might affect participation. Experience has a significant relationship with perception of SW management because it is the basic to perceive something.

c. The influence of campus role factors on campus society participation
   Provided the chi-square test between the role of the campus and campus society participation was $\alpha = 0.313 > 0.05$, which means that the role of the campus did not affect participation, because it role in terms of socialization or campaign had not been done.

3.4 Evaluation and recommendations

UAP is one of the campuses that contributes to SW generation in DKI Jakarta. The results showed that there were no recycle practices on the campus. The SW composition showed that 32% of biodegradable SW came from food waste, which was compostable [5]. However, research about the composting feasibility study was still required. At the same time, the non-biodegradables SW (67.71% of the total SW) were recyclable. The calculation of the recycling potential of SW at UAP required a recovery factor of each component of the SW shown in **Tab. 10**.

Table 10. Percentage of recycling of each component of SW

No.	SW Component	%Recycling
1.	Wet garbage	69% **(*)**
2.	Paper	50% **(*)**
3.	Plastic bags	50% **(*)**
4.	Glass	65% **(*)**
5.	Wood	10% **(*)**
6.	Metal	80% **(*)**
7.	Foam	0% **(*)**
8.	Plastic bottles and cups	100% **(**)**
9.	Plastic spoon	40% **(**)**
10.	Packaging	50% **(**)**
11.	Iron	100% **(**)**
12.	Tissue	50% **(**)**
13.	Cans	100% **(**)**
14.	Hazardous waste	0% **(**)**
15.	Residue	0% **(**)**

Source: (*[20] and **[Author, 2020])

Plastic bottles and cups were supposed to be 100% recyclable since pure, transparent plastic could be processed into new products with lower quality. Hazardous waste could not be recycled because explicitly handled by the government. Last, the residue could not be recycled because it could no longer be processed into other products. For this case, a campus can utilize the local SW bank as the intermediary party collecting this recyclable SW before the further process in a recycling factory.

Table 11. Recycling potential of SW at UAP

No.	Recycling type	Recyclable (kg/day)	Residue (kg/day)	%
1.	Composting	11.57	-	22.28%
2.	Recyclable	20.111	-	38.73%
3.	Residue	-	20.242	38.99%

Source: (Author, 2020)

Based on **Tab. 11**, potential SW recycling was 61.01% consisted of 22.28% of composting and 38.73% of recyclable SW and the residue was 38.99%. Observation were conducted to nearest local SW bank accepting and exchanging the recyclable SW into cash.

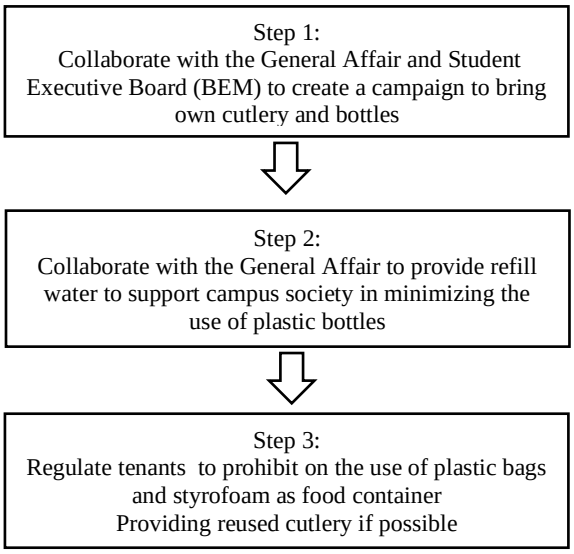
3.5 Strategies for applying the 3R concept in efforts to minimize SW at UAP

Reducing the SW at the source is the first step of the new paradigm hierarchy and coping mechanism. The campus management must decide the target of landfill diversion rate since the existing condition showed almost no diversion rate. Then transform this target into various activities. It is done by developing awareness by the societies among the individuals. Source segregation must be strictly followed through various capacity building and coping mechanisms for getting material for recycling and treatment process [21]. Therefore, the campus (university/faculty/study program) should arrange some regulations and procedures that show clear consequences and incentives. Besides, a campaign about SW should also be encouraged. Detailed steps of recommendation strategies are shown below.

3.5.1 Reduce dan Reuse (2R)

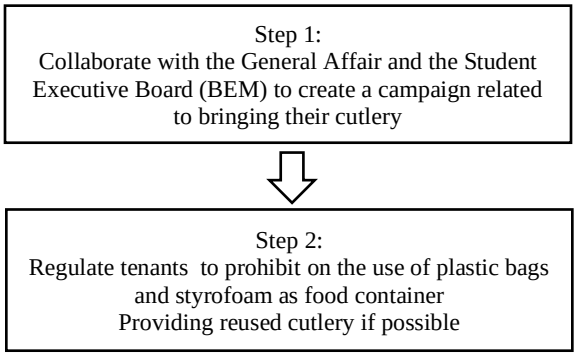
Although the social survey showed that most campus society already understood and applied to reduce and reuse concepts, some programs should be encouraged so that the entire campus has the same commitment and responsibility in SW minimization. The programs are as follows:

a. Minimize the use of the food packaging
   Various packaging was dominated the compositions at UAP including plastic bottles, cups, bags and styrofoam. So, it is necessary to minimize the packaging with following steps shown in **Fig. 4**.



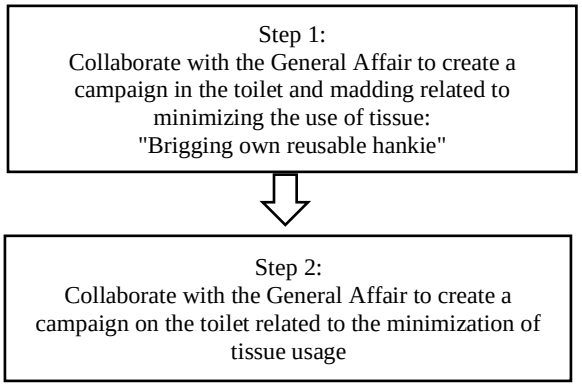
Source: (Author, 2020)
Figure 4. Steps of plastic packaging minimization strategy

b. Minimize the use of carton packaging
The composition of carton packaging was the 4th highest (6.21%), so it is necessary to minimize carton packaging with the steps shown in **Fig. 5**.



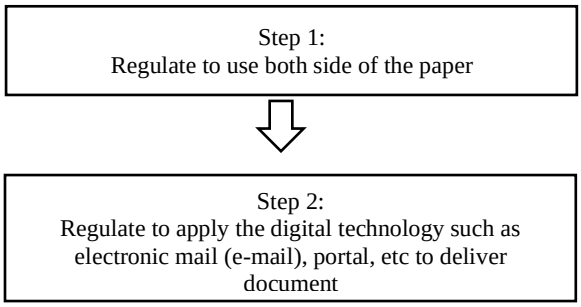
Source: (Author, 2020)
Figure 5. Steps of carton packaging minimization strategy

c. Minimization the use of tissue
The composition of tissue was the 3rd highest (13.22 %), so the steps to minimize the tissue by increasing the awareness of the campus society shown in **Fig. 6**.



Source: (Author, 2020)
Figure 6. Steps of tissue minimization strategy

d. Minimization of paper usage
The composition of the paper was 3% to 4% but still needs to be minimized with the steps shown in **Fig. 7**.



Source: (Author, 2020)
Figure 7. Steps of paper usage minimization strategy

3.5.2 Recycle (R)

The social survey showed that most respondents did not experience recycling. Besides, there was no SW segregation facility at UAP. In applying this concept, it is necessary to provide a sorting center located in the SW collecting room and firstly supported by a responsible administrator. As the awareness increases, it can be spotted in some other areas considered as the primary SW generation source. Then, the collected recycling SW will be exchanged to the local SW bank for some cash. The steps to minimize SW in recycling are shown in **Fig. 8**.

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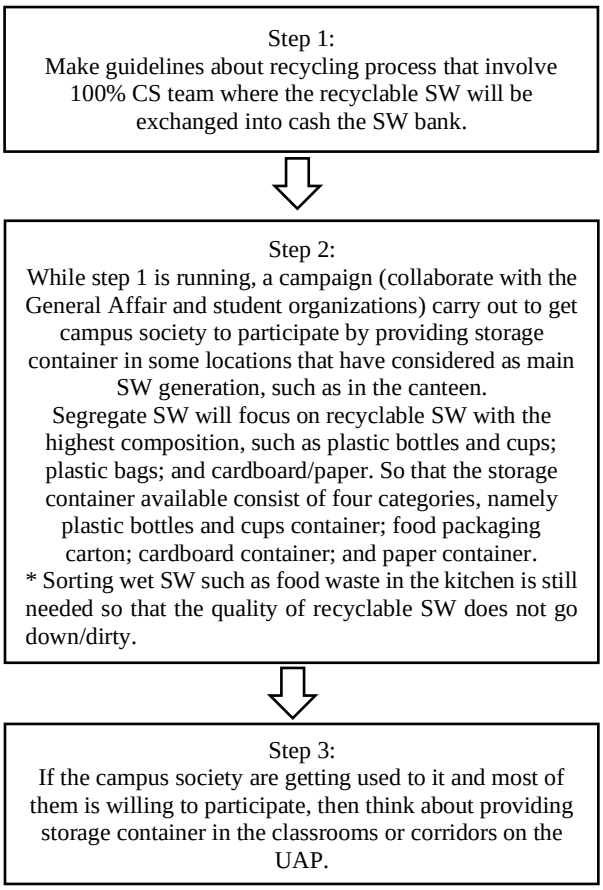

Source: (Author, 2020)
Figure 8. Steps of recycling minimization strategy

Regarding the step 1 strategy shown in **Fig. 8**, the economic potential of the recyclable SW can be calculated based on the amount of SW generated on the UAP. The economic potential of recyclable SW based of local SW bank near campus is shown in **Tab. 12**.

Table 12. The economic potential of recyclable SW

No.	SW component	SW generation (kg/day)	Price per kg	The selling price of SW
1.	HVS	2.387	Rp. 1,500	Rp. 3,581
2.	Brown paper	1.580	Rp. 400	Rp. 632
3.	Magazines and newspapers	0.011	Rp. 2,000	Rp. 23
4.	Carton	3.226	Rp. 400	Rp. 1,290
5.	Cardboard	2.530	Rp. 1,500	Rp. 3,795
6.	Plastic bottles and cups	9.001	Rp. 3,000	Rp. 27,000
Total (Rp.)				**Rp. 36,281**

Source: (Author, 2020)

Tab. 12 shows that the selling price of recyclable SW at the nearest local SW bank is Rp. 36,281/day. If accumulated in a month, the exchange cash will reach Rp. 1,088,430/month. The cash can be managed to sustain programs related to environmental sustainability, such as supporting the "Sadar Diri" program, funding other campaign programs, or providing incentives for cleaning officers to sort the SW. The SW can be exchanged to the North Tanjung Duren SW Bank that receives recyclable SW from any sector around North Tanjung Duren, including housings, individuals (collectors), and education institutions (schools and campuses). The procedure for exchange SW is quite simple by dropping directly or pick up requests with no additional fee for the SW already sorted. For this reason, it is essential to sort the SW at the source.

This segregation is one aspect of SW management that supports the concept of a green campus. The green campus concept application is a challenge that requires a long-term commitment from the entire campus society. According to the EPA, this effort will provide benefits in terms of environmental and economic sustainability, experiences expected to be applied in real life; and improving the quality of life on campus. The transformation into better SW management may not be immediate but gradual, depending on the management and society's readiness.

4. Conclusion

The SW generation on the UAP averaged 52.63 kg/day. At the same time, the SW generation factor was 0.08 kg/person/day. The SW

composition by its category on the UAP consisted of 32.29 % biodegradable and 67.71% non-biodegradable. In contrast, the 3rd highest composition of SW based on types were food waste 32%; plastic bottles and cups 17.34%; and tissue 13.22%. The social survey pointed out that campus society has a positive perception and willing to participate in future SW management. On the other hand, educational activities and communication (such as socialization and posters) are necessary to make them a part of the sustainable campus studies. Regulations and procedures should support their activities.

Based on the research above, the strategies that can be implemented on the UAP was the implementation of the 3R concept regarding decrease the SW generation rate, increase the recyclable material collection rate, and increase social participation level.

For the SW management plan's sustainable application, monitoring of SW generation should be continued and reported regularly to evaluate the SW minimization achieved by applying the plan. Last, the recovery of food waste in UAP by analyzing the compost potential should be conducted in further research since it was relatively high in SW composition.

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