ORIGINAL ARTICLE

Assessment of citizens' environmental behavior toward municipal solid waste management for a better and appropriate system in Indonesia: a case study of Padang City

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Abstract
Waste separation system which has been relatively successful in developed countries is expected to be the solution for municipal solid waste's problems in Padang city, Indonesia. However, the existing solid waste (SW) bank (a system for waste separation implementation in Padang city) is claimed to be ineffective proved by the low percentage of waste that can be treated by it. This study aims to understand the social condition toward citizens' environmental behavior which brings to the conclusion of readiness of Padang citizen for plan of waste separation-based system application in the future and propose a new system that is appropriate for Padang city's social condition. The study conducted structural equation modeling (SEM) [including exploratory factor analysis (EFA) and confirmatory factor analysis (CFA)] and a scoring system of social evaluation by surveying 609 residents. This study showed that Padang citizens are not completely ready for the plan of modification of the solid waste management system and that the city needs to improve citizens' pro-environmental behavior. This study proposes the waste FUN system as a solution to improve the level of readiness of the citizens that has a high potential for application in Indonesia and other developing countries with similar social condition.

Introduction

Waste recycling, which is expected to reverse the negative impacts of solid waste on the environment, has been relatively successful in developed countries [1]. The successful application of waste recycling by separation at the source in developed countries prompted the decision-makers in developing countries to replicate the method without paying particular attention to the cost, required skills, education, and technical expertise which cause the same learning process repeating that the developed countries experienced and same mistake making as the others before them made [2]. Previously, the focus of assessment of a waste facility was on technical aspects but the information about the application related to the performance of the project was not provided. However, Experts agreed that integrated solid waste management goes beyond technical and environmental aspects. They found that various environmental problems are caused by human behavior and can be mitigated by changing the behavior [3]. Therefore, social assessment toward citizens' behaviors and causal relationship among the behaviors are needed to do first before designing a sustainable waste management system because citizens need to accept and understand the design to use those innovations properly.

Padang city is the capital city of west Sumatera province of republic of Indonesia and is the largest city on the western coast of Sumatera Island. It has an area of 695 square kilometers and the population of 914,968 in 2016 [4]. Mismanagement of municipal solid waste leads to widespread problems

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in many cities in Indonesia including Padang. Since 2008, the government regulation number 18 year 2008 about waste management stating that MSW should be managed by reduction and handling was published, but unfortunately has not been fully implemented [5]. The local government of Padang, which has the "open dumping" system (all waste is mixed) looks for solutions to the city's waste problems [6]. Some parts of Padang have already changed the waste collection system of a mixed-based system into a separation-based system by providing separate bins but did not succeed in its implementation because the citizens do not follow the rules and regulations of waste separation-based system. Moreover, most of separated waste collected was not treated properly and ends up in landfill in a mixed state [6]. The local government has high eagerness to create a better waste management system in Padang city by applying waste separation-based system according to instructions of the government regulation number 18 year 2008 but they do not know how to make citizens accept and understand the system [6].

Therefore, this study assessed the readiness of Padang citizens toward the plan of waste management system modification (waste separation-based system) by examining the citizens' behaviors to understand the social condition of citizens so that local government can do further action for the establishment of appropriate sustainable waste management system in Padang city. Previous research on the solid waste management system in Padang and other cities in Indonesia have examined the social aspects of waste management limited to the discussion on community participation such as household solid waste management in Jakarta [7], determinants of sustainability in solid waste management in Gianyar [8], household income, living and working conditions of dumpsite wastepickers in Bantar Gebang [9], pilot project of increasing the public awareness in household waste management by separation method in Padang city [10], community participation in waste management in Jombang, Semarang [11], community behavior and participation of local government in waste management in Tembilahan. Riau [12], public and private participation in urban waste management [13], evaluation of community participation in the implementation of waste management system in Padang city [14], the cause of ineffectiveness of waste management in Makassar [15]. However, there has been no discussion on direct or indirect effects of the indicators of human behavior related to the waste management system leading to the understanding of factors that influence the behavior changing which then can be a core idea to improve the system's performance. The results of this study can be used as a first step to establish a sustainable solid waste management system not only for Indonesia but also for many cities in other developing countries. The specific objectives of this study are summarized as follows:

- Determine the factors affecting citizen behavior related to municipal solid waste management and relationship among the behaviors using structural equation modeling (SEM);
- examine condition of environmental behaviors of citizens related to solid waste management system in Padang by performing a scoring system of social evaluation;
- define the readiness of Padang citizens for plan of modification of solid waste management system from a mixed-based system into a separation-based system by combining the results of SEM and the social evaluation;
- suggest an improved framework as a solution of the results.

Methodology

One of the theories widely acknowledged by researchers in term of behavior-based research is theory of planned behavior (TPB) by Ajzen (1991) which is a revised and extended version of theory of reason action (TRA) by Ajzen and Fishbein (1980) [16, 17]. They pointed out that individual's behavior is not merely based on their will but also by factors such as attitudes toward behavior (personal attitude and individual conduct), subjective norms (influence of significant others; perceived social pressure), and perceived behavioral control. In term of environmental behavior, several researchers found that people are more likely to recycle if they have concern in environment [18] but the individual behavior will undertake consistency if he or she has positive attitude toward environmental issues where family, friends, neighbors or colleagues may influence the positive environmental behaviors [19]; environmental concerns are outweighed by laziness or lack of interest in protecting the environment [20]; the actions of neighbors can strongly influence recycling behavior among householders [21]; actions, attitudes and motivation of recycling are biased toward individuals rather than communities [22]; social, cultural and structural influence household waste recycling [23]. Furthermore, in particular field of waste separation behavior, Zang et al. (2015) have conducted research in case study of China which suggest that attitudes, subjective norms, perceived behavioral control, intentions, and situational factors significantly predicted household waste separation behaviors [24], Oztekin et al. (2017) have distinguish the recycling behavior based on gender perspective [25], Stoeva and Alriksson (2017) revealed that attitude, subjective norm, perceived behavioral control, and satisfaction with local facilities influence the intention and behavior of inhabitants' participation in separation of household waste in Sweden and Bulgaria [26], and Plepiene et al. (2016) compared the recycling behavior of citizens between an early stage of development (Lithuania) and a more mature recycling scheme (Sweden)

[27]. Based on those studies and typical condition in case study area, this study constructed two main hypotheses where the relationship between the factors is illustrated in the predictive model path diagram in Fig. 1:

H1: There is a causal relationship between intention and behavior.

H2: The intention score is determined by several factors, i.e., social norms, environmental awareness, environmental knowledge, government role, habit, and law enforcement.

A survey in this study was conducted with a select group of Padang citizens on the solid waste management system in Padang and the survey results were analyzed by SEM consisting of the exploratory factor analysis (EFA) using the statistical package for social sciences (SPSS 17.0) and confirmatory factor analysis (CFA) using the analysis of moment structure (AMOS 22). The responses to the questionnaires were also analyzed by a social evaluation method (scoring system) based on a predictive model to support the SEM model results and determine the readiness of Padang citizens for the plan of modification of the solid waste management system. The scope of this study is limited to the Padang citizens and to the solid waste management problem but the findings and proposed framework idea have a great potential for application to other cities in Indonesia and other developing countries.

Data collection by Questionnaire

Prior to the survey, three pilot tests were conducted to test the reaction of the respondents against the questions in the lists using SPSS software. The questionnaire in the pilot tests were adapted from the previous studies [28, 29] and actual experience in case study area with as many as 45, 24, and 81 questions for test 1, 2, and 3, respectively. Sample size for pilot studies has no specific recommendation number [30,
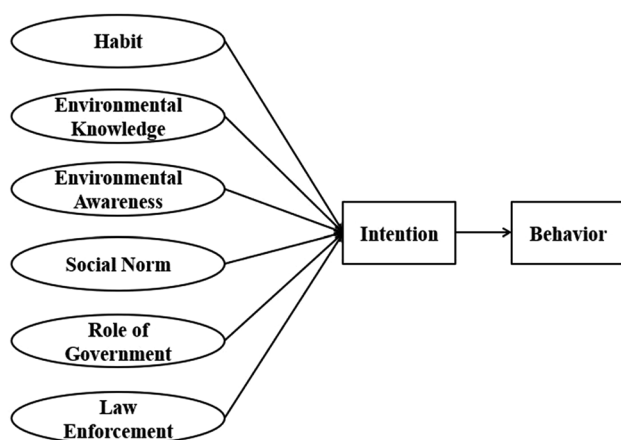

Fig. 1 Predictive model path diagram

31], but other researchers recommend obtaining approximately 10 respondents [32].

Due to the right moment for collecting data by visiting Padang city directly, a lot bigger sample size compared to the number recommended for pilot test could be collected which were 127 respondents. Six factors were assumed to represent the characteristics of Padang citizens; attitude (3 variables), knowledge (13 variables), time (2 variables), environmental awareness (22 variables), convenience (3 variables), and social norms (2 variables). After the dimension reduction analysis in SPSS, some unexpected results have been obtained, such as not all variables could be calculated, not all the factors could be extracted from the data, and loading factor were very low (less than 0.5). Therefore, the second pilot test was conducted.

The second pilot test involved 15 respondents because of the reason of time and cost limitation but still within the recommendation of sample size which is 10 respondents. The variables and factors in questionnaire of pilot test 2 were taken from revised version of questionnaire in pilot test 1 added with other variables that are perceived to represent. There were nine factors including environmental awareness (4 variables), environmental knowledge (3 variables), inconvenience (4 variables), social norms (3 variables), individual initiatives (3 variables), the availability of disposal facilities (3 variables), intention (1 variable), behavior (1 variable), and law enforcement (2 variables). After the assessment by SPSS, the results of pilot test 2 were not significantly different from the results of test 1. Consequently, establishment of pilot test 3 were still needed.

The third pilot test was organized at a larger scale of variables because we wanted to avoid the next failure of pilot test with the hope that the more number of variables the more likely data can be extracted. The variables were selected considering the real conditions of the local environment by interviewing the citizens about the waste management system of Padang city. The interview results and previous pilot tests results were combined into 81 questions for eight factors including habits (10 questions), environmental knowledge (10 questions), environmental awareness (11 questions), social norms (10 questions), role of the government (10 questions), law enforcement (10 questions), intention (10 questions), and behavior (10 questions). The survey was conducted with 30 citizens of Padang city which is more than minimum recommendation sample size for pilot test. The results were satisfactory to proceed to the actual test.

In the actual test, the questions were same as the ones in pilot test 3 because of the satisfactory result obtained by pilot test 3. The questions were presented on a four-point Likert scale: 4 = strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree. In the pilot tests, respondents who were too lazy to think of an answer, did not want to answer, or did not answer seriously, tended to choose the option "neutral". Therefore,

the "neutral" option was not used in this survey to obtain more valid and reliable data. The questions of the survey in actual test are provided in Table 1.

Structural equation modeling (SEM)

SEM is a robust technique used extensively in behavioral science research to conceive and define the relationship among the elements in a system [33]. The elements or variables in the SEM usually include observed variables that are directly measured and latent variables that cannot be measured (its presence is inferred from what is observed) [24]. In waste management study, to observe each household and conjecture, the latent variables are improbable. On the contrary, the degree of the latent variables can be measured indirectly by questionnaire deployed to individuals. SEM had been used in many research related to environmental behaviors such as environmental concern and recycling behavior in Selangor, Malaysia [34], pro-environmental behavior of consumers in Canada [35], quantification of attitudes and perceptions on enhanced solid waste management practices in Sri Lanka [36], housewives' recycling behavior in Turkey [37], structural relationship between environmental attitudes, recreation motivations, and environmentally responsible behaviors [38], contractor's construction and demolition waste management behavior in mainland China [39], and waste separation behaviors at the source [24].

Because hypothetical model of this study implicates multiple-path linkages that suggest complex associations among the variables, and also many researchers had verified that SEM technique could be employed in environmental behavior related studies successfully, the SEM is selected as an appropriate tool for this analysis. To conduct SEM, factor analysis steps were adopted due to the limited tools reason. The procedure includes instrument development, an exploratory factor analysis (EFA), a confirmatory factor analysis (CFA), and a test of a structural model. EFA specifies many latent variables underlying the complete set of items. The reliability of the data-set can be determined by Cronbanch's Alpha, which is one of the most widely used metrics for reliability evaluation [33].

Exploratory techniques assist the researchers to develop hypothesized measurement models which can subsequently be examined using CFA. The use of CFA was proposed by many researchers to assess uni-dimensionality [40]. The goodness-of-fit of the model can be detected by the indices of Chi square, p-value, comparative fit index (CFI), goodness of fix index (GFI), adjusted goodness of fit index (AGFI), standardized root mean square residual (SRMR), root mean square error of approximation (RMSEA), and p of close fit (PCLOSE) [41]. The discriminant and convergent validity can be detected by the indices of composite reliability (CR), average variance extracted (AVE), maximum

shared variance (MSV), and average shared variance (ASV). The shared variance between a construct and any other construct, which is less than the variance that the constructs shares with its indicators, determines the discriminant validity [42]. When the model passes the requirement processes of EFA and CFA, the structural model can be established by considering the goodness-of-fit. The result of the structural model can then be compared with that of the predictive model formulated to determine whether the results support the hypotheses or not.

Social evaluation

In this study, social evaluation methods were used to support the SEM results by scoring system. SEM used a predictive model as a starting point to test the hypotheses, see factors affecting the citizens' behaviors and the correlation between factors and variables, while the social evaluation used the predictive model to determine level of the behavior of citizens by scoring the survey responses. Afterwards, the total number of respondents who chose each option were counted and rated with assumption of the following scale; 85–100% (A, very good), 75–84% (B, good), 60–74% (C, fair), 50–59% (D, bad), and 0–49% (E, very bad). For example, if > 85% or more of total respondents gave a positive answer to the questions in the "behavior" factor, "behavior" factor of the respondents was considered very good. It is assumed that the level of the citizens' pro-environmental behavior is comparable to the number of respondents who responded positively. Using this scale, the level of pro-environmental behavior can be measured to define the readiness of the citizens for the modification of the solid waste management system.

Proposed model (a new framework)

An improved framework is designed as a solution for the better waste management system in Padang city starting from SEM and social evaluation results. The idea of creation is developed based on the citizens' behavior condition so that the citizens as a technology's users can accept, understand, and apply the system in their day-to-day life. Preliminary concept of the proposed model is separation-based system through solid waste bank (SW bank) system. The SW bank system has established in Padang city since 2010 which was managed by community-based and private institutions. Currently, there are 29 waste banks consist of eight community waste banks and 21 educational institution waste banks which have difference only by the source of depositors. However, the effectiveness of current waste bank was still very low seen by percentage of treated waste that is only 0.05% of total Padang city's waste in 2015. The small amounts of waste that can be handled by waste bank

Table 1 The questions list in the questionnaire

Factor	Questions	Factor	Questions
Habit	Q1. I throw away my garbage just anywhere	Role of Government	Q42. Government does not provide adequate bins
	Q2. I throw away my garbage into rivers		Q43. Government is not doing enough to fix the garbage problems
	Q3. I throw away my garbage into sea		Q44. Government is not putting sufficient emphasis on environmental education
	Q4. Littering is usual/normal because everyone do		Q45. Government is not giving seminars about waste management
	Q5. Garbage is littered and unpleasant smell is common for my communities		Q46. Government might be already giving environmental education to people but it does not reach me
	Q6. Where I live, garbage is piled everywhere		Q47. Government does not provide enough advertisement, pamphlets or slogan about disposing garbage properly
	Q7. I often burn my garbage by myself		Q48. Government does not place the bins evenly
	Q8. I do not feel ashamed when littering		Q49. Government does not provide sufficient number of workers to transport garbage to landfills so garbage piled up for days
	Q9. I am lazy to separate my garbage because it is bothersome and difficult		Q50. Government takes very long time to fix the garbage problems
	Q10. I have no time to separate my garbage		Q51. Government does not provide enough information about waste separation
Environmental knowledge	Q11. If the population increases, the amount of garbage will also increase	Law Enforcement	Q52. I obey the rule about garbage if viewed by security personnel
	Q12. If people do not care about the environment, it will harm living beings		Q53. I obey the rule if it benefits me
	Q13. If people do waste separation, it will help much environmental conservation		Q54. Socialization of waste management rule is not clear for me
	Q14. If people do waste separation, it will improve environmental quality		Q55. I persuade my family to obey the rules related to waste management
	Q15. If people do waste separation, it will reduce pollution		Q56. I obey the rules because I fear of the penalty
	Q16. If people do waste separation, it will reduce wasteful use of landfills		Q57. I obey the rules because of my awareness
	Q17. If improper management of waste happens, it will cause many diseases		Q58. I do not know about the rules related to waste management
	Q18. If improper management of waste happens, it will cause water, land, and air pollution		Q59. I obey the rules because there are CCTV which monitor my waste management activities
	Q19. If improper management of waste happens, it will precipitate the breed of flies, microorganism, fungi, bacteria, viruses as the source of many diseases		Q60. I obey the rules because I feel guilty of myself if I do not obey
	Q20. If people do waste separation, it will benefit the community in the form of a healthy life also maybe green energy will be produced by waste treatment		Q61. I obey the rules because I am ashamed of myself if I do not obey

Table 1 (continued)

Factor	Questions	Factor	Questions
Environmental awareness	Q21. Schools should give environmental education to the students	Intention	Q62. From here on I would like to separate my garbage according to the rules in my day-to-day life
	Q22. People should increase the awareness of the importance of cleanliness		Q63. From here on I would like to separate my garbage continuously in my day-to-day life
	Q23. People should increase sensitivity to the environment		Q64. From here on I would like to reduce amount of my garbage by reusing the things I have used
	Q24. People should increase environment discipline		Q65. From here on I would like to learn how to separate my garbage well
	Q25. Radio, TV, and other media should telecast more programs about environment		Q66. From here on I would like to increase my environmental awareness
	Q26. I should be careful to use things effectively without wasting		Q67. From here on I would like to increase my discipline for environment
	Q27. I should try to reduce amount of waste		Q68. From here on I would like to increase sensitivity to the environment
	Q28. Personal initiative should be taken to conserve the environment		Q69. From here on I would like to use things effectively without wasting
	Q29. I am interested in the news about environmental issues		Q70. From here on I would like to participate when there are environmental activities in my community
	Q30. I should learn how to separate my waste well		Q71. From here on I would like to obey the rules related to waste management
	Q31. I feel I should not waste anything if it could be used again		
Social norm	Q32. People around me tend not to remind/reprimand if they see someone littering	Behavior	Q72. I will do waste separation
	Q33. People around me tend not to care about waste separation		Q73. I will reduce the amount of my waste
	Q34. People around me tend not to care about environmental issues		Q74. I will reuse the things I have used before throwing them away
	Q35. People around me tend not to interested about waste problem		Q75. I will obey the rules related to waste management because of my awareness
	Q36. People around me tend not to persuade me to separate my waste		Q76. I will learn how to separate my garbage well
	Q37. People around me tend not to feel responsible for the waste problem in our community		Q77. I will participate in environmental activities in my community
	Q38. People around me tend not to have a concern about the waste problem in our community		Q78. I will be more responsible for my waste
	Q39. People around me tend not to feel guilty when they litter		Q79. I will watch or read more news about environmental issues to increase my environmental awareness
	Q40. People around me tend not to worry about the danger if they do not care about the environment		Q80. I will be more careful about environmental problems
	Q41. People around me tend not to participate in environmental activities		Q81. I will watch or read more news about environmental issues to increase my discipline and sensitivity to environment

suggest that the direct participation of people in Padang city's MSW is relatively poor [43]. The lack of participation, planning procedure, and time contribution and resource to educate participants also happen in waste bank project in Mahasarakham municipality, Thailand [44], meanwhile the high participation is obtained from low income family of waste bank in Quran education park, Sleman, Yogyakarta, Indonesia [45], and waste bank in Surabaya, Indonesia [46]. Therefore, establishment of advanced level of waste management system in Padang city is needed, not only reaching the low-income families' participation, but also high-income families'.

Results

By formula suggested by Krejcie and Morgan (1970) about sample size determination [47], we decided to take 609 samples with 95% confidence level and 3.97% margin of error due to the reason of time and cost limitation. The surveys were conducted for approximately two months with 300 students of Andalas University located in Padang city and 309 people from the general public. Determining the number of sample was decided based on statistic of whole Padang population percentage based on age range [48] which are age 0–4 years old = 25.9%, age 15–24 years old = 23.5%, age 25–34 years old = 15.7%, age 35–44 years old = 13.5%, age 45–54 years old = 10.7%, age 55–64 years old = 6.9%, and age more than 65 years old = 3.8%. Meanwhile, the percentage of data are age 0–4 years old = not considered, age 15–24 years old = = 49.3%, age 25–34 years old = 15.6%, age 35–44 years old = 13.8%, age 45–54 years old = 10.8%, age 55–64 years old = 6.9%, and age more than 65 years old = 3.6%. The percentage of age 15–24 years old between data and statistic is different, but percentage of other age ranges are almost same, so that this sample can represent the whole Padang city's condition.

Data collection lasted two weeks for university students beginning of July 2015. The university student respondents consisted of 50 agricultural engineering students, 45 civil engineering students, 92 industrial engineering students, 41 environmental engineering students and, 72 students from other departments. The collection of samples from certain department was based on ease of access in gathering data quickly and widely. The public participants were interviewed in each of the eleven 11 districts in Padang; those are East Padang district (28 respondents), West Padang district (28 respondents), North Padang district (29 respondents), South Padang district (28 respondents), Bungus district (28 respondents), Nanggalo district (28 respondents), Lubuk Kilangan district (28 respondents), Koto Tangah district (28 respondents), Kuranji district (28 respondents), Lubuk Begalung district (28 respondents), and Pauh district (28

respondents). Data collection lasted 1.5 months for the public sample (from the middle of July to the end of August 2015). The respondent category for the general public was a random group, not limited by demographics.

Structural equation modeling (SEM)

Exploratory factor analysis (EFA)

A total of 11 factors screened by EFA were extracted from 48 questions (variables). The number of factors was determined based on eigenvalues above 1, and the fitting method procedures was maximum likelihood. Those factors are labeled as, behavior, social norm, intention related to waste separation (separation intention), environmental awareness, environmental knowledge related to environmental quality (quality knowledge), intention related to willingness to increase positive environmental feeling (feeling intention), role of government related to provision (government provision), environmental knowledge related to pollution and diseases (pollution knowledge), habit, role of government related to information socialization (government information), and law enforcement. The results of EFA as well as the Cronbach's Alpha value are shown in Table 2 where the result had been rotated by the rotation method of Promax with Kaiser Normalization. The value of Cronbach's Alpha for the satisfactory reliability of each construct is 0.75 [49].

Confirmatory factor analysis (CFA)

CFA is the next step after the exploratory factor analysis to determine the factor structure of the dataset. In this calculation, the measurement model was developed and satisfactory goodness-of-fit was obtained. In this regard, Kline suggested that there should be a minimum of four tests that are acceptable and compatible with the model fit. Table 3 shows that six out of eight values passed the threshold value; Chi square/df (cmin/df), CFI, AGFI, SRMR, RMSEA, and PCLOSE value. The results suggest that this structure fits the data well.

Furthermore, the validity and reliability tests for the CFA model in this study showed that the model had no validity concerns (Tables 4, 5). Table 4 shows that the threshold value of CR should be greater than 0.7, AVE should be greater than 0.5, MSW should be less than AVE, and ASV should be less than AVE, where all the factors passed the threshold values. Table 5 shows that to reach the state of "no validity concern" of the model, the value of the square root of AVE of each factor should be greater than the value of the inter-construct correlations (all values passed the threshold values). Based on the results of the validity and reliability tests, the measurement model was established as shown in Figs. 2 and 3.

Table 2 Factor analysis result (of all data)

Pattern matrix

Predictors	Behavior	Social norm	Sep. intention	Environ. awareness	Quality knowledge	Feeling intention	Government provision	Pollution knowledge	Habit	Government Information	Law enforcement
Q79	0.811										
Q75	0.797										
Q77	0.769										
Q81	0.764										
Q78	0.727										
Q80	0.726										
Q74	0.715										
Q73	0.667										
Q38		0.911									
Q37		0.876									
Q39		0.860									
Q40		0.797									
Q41		0.707									
Q34		0.648									
Q36		0.536									
Q62			0.985								
Q63			0.940								
Q65			0.819								
Q72			0.585								
Q30			0.567								
Q23				0.917							
Q22				0.854							
Q24				0.848							
Q21				0.705							
Q14					0.970						
Q15					0.811						
Q13					0.763						
Q16					0.616						
Q67						0.951					
Q68						0.876					
Q66						0.866					
Q64						0.515					
Q49							0.808				
Q50							0.747				
Q48							0.716				

Table 2 (continued)

Pattern matrix

Predictors	Behavior	Social norm	Sep. intention	Feeling intention	Environ. awareness	Quality knowledge	Government provision	Pollution knowledge	Habit	Government Information	Law enforcement
Q51							0.687				
Q18								0.944			
Q19								0.886			
Q17								0.745			
Q2									0.926		
Q3									0.882		
Q1									0.744		
Q43										0.833	
Q42										0.775	
Q44										0.727	
Q52											0.857
Q53											0.728
Q59											0.591
Reliability (Cronbach's Aplha)	0.910	0.908	0.898	0.907	0.901	0.882	0.845	0.914	0.883	0.855	0.772

The measurement model in Figs. 2 and 3 imply that there are 11 latent variables (represented by ellipses) and each latent variable has a correlation (more than 0.5 deg.) with their own observed variables (represented by squares) [50]. The information of connection in the measurement model includes the estimation of standardized regression weights, the estimation of squared multiple correlations and the estimation of correlations. The estimate of the standardized regression weights is distinguishable between each latent variable and its measurement. For example, when the value of question 79 refer to willingness of citizens to watch or read more news about environmental issues to increase their environmental awareness increases by one standard deviation, the value of behavior will increase by 0.74 of the standard deviation. The estimate of the squared multiple correlations refers to the correlation that exists between the latent variables and their measurements. For instance, the predictors of Q75 (I will obey the rules related to waste management because of my awareness) are estimated to explain 78% of its variance. Conversely, the market share error variance is approximately 22% of the market share variance itself. The estimates of correlations are detectable between latent variables. For example, the correlation between behavior and social norms is 0.08.

Structural model

The structural model was constructed after the measurement model was developed. The goodness of fit indices of the model were cmin/df = 2.369, CFI = 0.983, GFI = 0.985, AGFI = 0.955, SRMR = 0.032, RMSEA = 0.047, and PCLOSE = 0.573 indicating that the model fits the data considerably well and the measures of fit are acceptable. The structural model is shown in Fig. 4.

Figure 4 shows that seven factors influence the "separation intention" factor ("law enforcement" factor has no effect) and five factors influence the "feeling intention" ("pollution knowledge", "government provision", and "habits" have no effect). The Fig. 4 can be interpreted as:

- The behavior of Padang citizens related to the eagerness of learning how to consistently separate the garbage well according to the rules is affected by social norms, environmental awareness, quality knowledge, pollution knowledge, government provisions, government information, and habits of citizens. Furthermore, the most influential factors on citizen behavior related to the separation intention were the "government information" factor which had highest standardized regression weight (0.37), the "government provision" factor (0.33), and the "quality knowledge" factor (0.32), followed by "environmental awareness" factor (0.19), the

Table 3 Model fitting test (of all data)

Fit index	Value of the model	Threshold value	Acceptability
Chi square/df (cmin/df)	2.317	<3 good; <5 sometimes permissible	+ (good)
p value for the model	0.000	>0.05	−
Comparative fit index (CFI)	0.933	>0.95 great; >0.90 traditional; >0.80 sometimes permissible	+ (traditional)
GFI (goodness of fit index)	0.863	>0.95	−
AGFI	0.842	>0.80	+
SRMR	0.047	<0.09	+
Root means square error of approximation (RMSEA)	0.047	<0.05 good; 0.05–1.0 moderate; >1.0 bad	+ (good)
PCLOSE	0.990	>0.05	+

Table 4 Reliability, convergent validity, and discriminant validity check of the model (of all data)

Factors	Reliability		Convergent validity		Discriminant validity			
	CR value	CR > 0.7	AVE value	AVE > 0.5	MSV	MSV < AVE	ASV	ASV < AVE
Behavior	0.90	OK	0.54	OK	0.26	OK	0.06	OK
Social norm	0.91	OK	0.58	OK	0.10	OK	0.02	OK
Separation intention	0.90	OK	0.66	OK	0.25	OK	0.06	OK
Environmental awareness	0.90	OK	0.70	OK	0.07	OK	0.04	OK
Quality knowledge	0.89	OK	0.66	OK	0.30	OK	0.06	OK
Feeling intention	0.91	OK	0.73	OK	0.26	OK	0.07	OK
Government provision	0.81	OK	0.52	OK	0.36	OK	0.06	OK
Pollution knowledge	0.92	OK	0.79	OK	0.30	OK	0.05	OK
Habit	0.89	OK	0.73	OK	0.05	OK	0.02	OK
Government information	0.86	OK	0.67	OK	0.36	OK	0.05	OK
Law enforcement	0.78	OK	0.54	OK	0.05	OK	0.03	OK

"social norms" factor (0.16), the "pollution knowledge" factor (0.10), and the "habit" factor (0.09).

- The behavior of Padang citizens related to the eagerness to increase environmental awareness, discipline, and sensitivity is affected by social norms, environmental awareness, quality knowledge, government provision, and law enforcement. In this case, the most influential factors on citizen behavior related to the intention were the "law enforcement" factor which with the highest standardized regression weight (0.22), the "government provision" factor (0.21), and the "quality knowledge" factor (0.18), followed by the "environmental awareness" factor (0.13) and the "social norms" factor (0.10).

Social evaluation

The social evaluation assessed each response of citizens toward the questionnaire by valuing the responses in assumed scales; very good (A grade) is worth 4 value, good

(B grade) is worth 3 value, fair (C grade) is worth 2 value, bad (D grade) is worth 1 value, and very bad (E grade) is worth 0 value. All responses counted were then grouped based on the factor so that the citizens' behavior can be determined according to the total value counted. Table 6 shows that "habit" factor of citizens related to waste disposal is considered to be very good, related to littering is considered to be fair, while related to waste separation is considered to be very bad. All score of "habit" factor were averaged become "2" score which means that "habit" of citizens is averagely considered to be in C grade. Other calculations in Table 6 illustrated that; "environmental knowledge" and "environmental awareness" of citizens are considered to be A grade; "social norm" of citizens or the influence of other people's behavior to oneself' is considered to be D grade; "role of government" against the waste management is considered to be E grade by citizens; "law enforcement" factor or awareness of citizens to obey the law as well as the citizens' knowledge about the law are considered to be D grade; "intention" and "behavior" of citizens toward pro-environmental behavior are considered to be B grade.

Table 5 Discriminant validity by square root of AVE (square root of AVE> inter-construct correlation) (of all data)

Factors	Discriminant Validity by Square Root of AVE (Square Root of AVE > Inter-construct Correlation)										
	Behavior	Social norm	Sep. intention	Environ. awareness	Quality knowledge	Feeling intention	Govern. provision	Pollution knowledge	Habit	Govern. information	Law enforce.
Behavior	**0.738**										
Social norm	− 0.082	**0.764**									
Sep. intention	0.357	− 0.118	**0.810**								
Environ. awareness	0.242	0.065	0.203	**0.837**							
Qual. knowledge	0.252	− 0.018	0.291	0.268	**0.815**						
Feeling intention	0.507	− 0.075	0.495	0.236	0.250	**0.852**					
Govern. provision	0.135	0.227	− 0.087	0.104	0.096	0.146	**0.723**				
Pol. knowledge	0.140	0.032	0.095	0.255	0.549	0.178	0.252	**0.889**			
Habit	− 0.077	0.052	− 0.150	− 0.170	− 0.212	− 0.075	0.029	− 0.119	**0.853**		
Govern. information	0.080	0.312	0.084	− 0.002	0.038	0.130	0.604	0.146	0.059	**0.817**	
Law enforcement	− 0.077	0.177	− 0.176	− 0.215	− 0.096	− 0.206	0.219	0.041	0.220	0.015	**0.736**

The bold sign is existed to emphasize the values of square root of AVE and show that the values are bigger than values of inter-construct correlation (the unbold characters)

Eventually, the average of total value of social evaluation is C grade.

Discussion

Findings

The hypotheses of the predictive model were supported by the result presented in Sect. 3; H1: There is a causal relationship between intention and behavior; H2: The intention degree is determined by several factors, i.e., social norms, environmental awareness, environmental knowledge, role of government, habits, and law enforcement. However, there are some differences between the results of the structural model Fig. 4 and the predictive model Fig. 1. The "intention" factor was divided into two factors named "separation intention" and "feeling intention", the "environmental knowledge" factor was divided into two factors called "quality knowledge" and "pollution knowledge", the "role of government" factor was divided into two factors named "government provision" and "government information".

Figure 4 shows that the causal relationship between intention and behavior is significant. Therefore, the behavior towards the current and possible modification (separation-based system) of the municipal solid waste system is considerably improved by the increased value of "intention". However, unique result found that the correlation coefficient between the "feeling intention" (related to the willingness to increase positive environmental feelings), and behavior (degree = 0.48) is higher than the correlation coefficient between the "separation intention" (related to waste separation) and behavior (degree = 0.14). It can be said that the positive environmental behavior of the citizens can be enhanced by increasing the positive environmental feelings rather than increasing the willingness to separate wastes. Padang citizens have not been familiar with waste separation until recently; thus the willingness to separate wastes is relatively low compared to the willingness to increase positive environmental feelings.

For the social evaluation results, Table 6 shows the average value of the pro-environmental behavior of citizens is C (fair) meaning that current social conditions are not suitable for the modification of the waste management system successfully. The "waste separation willingness" behavior was also at the C level suggesting that the modification of solid waste management system into a separation-based system has not been well accepted by citizens. If the authorities still proceed with the system modification despite citizens' dis-approval, the implementation of the system is likely to be abortive. Consequently, the government should prioritize designing a program to educate the citizens and improve their understanding and behavior
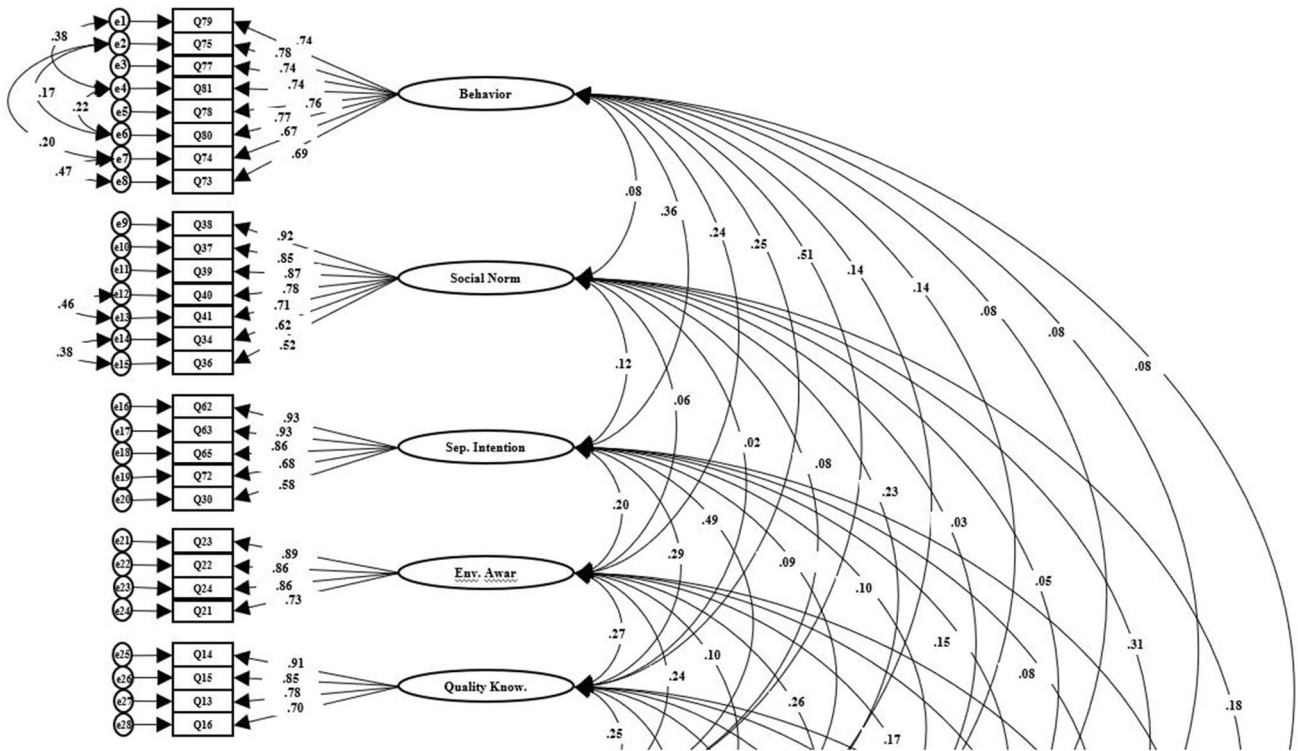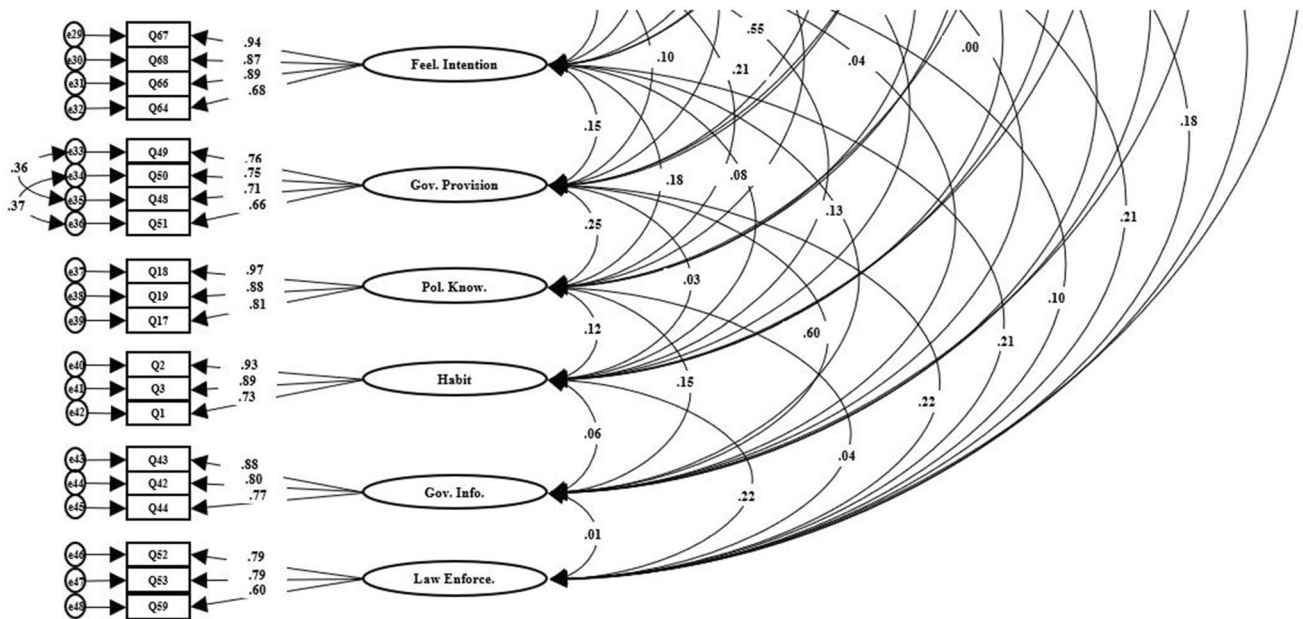
Fig. 2 Measurement model of all data part 1

Fig. 3 Measurement model of all data part 2

before modifying the waste management system for the successful implementation of future systems.

Proposed model

This study proposes an improved system to increase citizen's intention and willingness related to pro-environmental
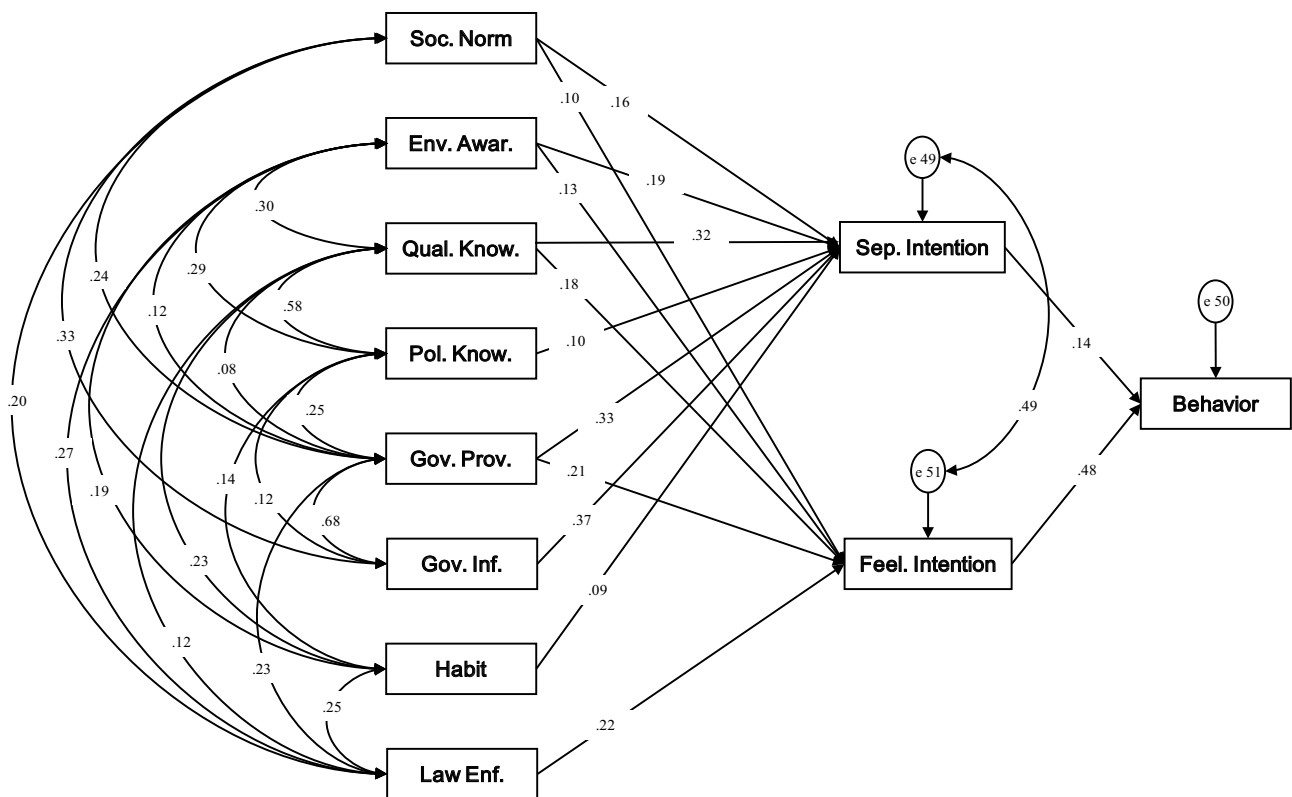
Fig. 4 Structural model of all data

behavior by establishing a system modified from the current waste separation-based system that has already exist in Padang city. From the statement of Raharjo et al. (2015) about the low effectiveness of the current SW bank programs in Padang city, it can be interpreted that current system of SW bank program is failed implementation [43]. Therefore, this study proposes an improved framework called "Waste FUN" system to solve the social constraints experienced by previous SW bank system. If we look deeper, the failure experienced by current SW bank system in Padang city might be caused by the administrator or manager. The administrator of current SW bank is private institution while the structural model found that "role of government" factor is the most influential factor for citizen's behaviors changing into pro-environmental behaviors. In other words, the best design of waste management system for Padang city's social condition is the system managed by local government to achieve the sustainable waste management in Padang city.

The proposed model designing needs to start from the three-most influential factors as a core idea. The government as an executive body of a country that has a duty to regulate the course of the law may force the citizens to obey the law (environmental related law) in a good way. The government needs to create new policy about application of waste-recycling system in Padang city's waste management through

the proposed model. Forcing the citizens in a good way can be done by creating a new waste management system which gives direct mutual benefits to citizens and government so that citizens will practice the policy with pleasure without feeling compelled.

Proposal of the new system is still including SW bank method but adding some other activities to attract citizens' participation. This "waste FUN" system has three basic elements which are "fund", "utilization", and "nurture" (FUN) and have to be built in good collaboration to empower and encourage citizens to change the previous behavior to be pro-environmental behavior. The "Fund" for economic benefits gives the citizens a chance to make profit by separating wastes to improve their standard of living, such as micro credit finance (giving loan to citizens to create new business and using separated waste as a debt payment), and waste credit card (a way to attract citizen to be a member of waste bank by giving easiness in shopping and water or electricity bills payment). The "Utilization" for the waste treatment has meaning of the process to utilize waste into valuable things for citizens, government, and environment, such as implementation of the waste bank method (recycling, recovery, reuse), convert the waste into fertilizer, plastic pellets, crafts, etc. The "Nurture" for environmental education and encouragement trains citizens to be capable of separating wastes

Table 6 Social evaluation of Padang citizens by scoring system

No.	Factor	Answer	Meaning	Average value	Score
1	Habit	1. For questions number 1–4 and 8, 85–97% of respondents gave positive answer	1. "Habit" of citizens related to waste disposal is considered to be very good (score: A)	2	C
		2. For question number 5 and 6, 67–74% of respondents gave positive answer	2. "Habit" of citizens related to littering is considered to be fair (score: C)		
		3. For question number 7, 9, and 10, only 29–43% of respondents gave positive answer	3. "Habit" of citizens related to waste separation is considered to be very bad (score: E)		
2	Environmental knowledge	95–100% of respondents gave positive answer	"Environmental Knowledge" of citizens is considered to be very good (score: A)	4	A
3	Environmental awareness	91–100% of respondents gave positive answer	"Environmental Awareness" of citizens related to discipline and sensitivity increasing to the environment is considered to be very good (score: A)	4	A
4	Social norm	33–59% of respondents gave positive answer	Influence of other people's behavior to oneself is considered to be bad or low (score: D)	1	D
5	Role of government	5–26% respondents gave positive answer	"Role of Government" against the waste management is considered to be very bad (score: E)	0	E
6	Law enforcement	1. For questions number 52, 53, 55, 57, and 59–61, 80% of respondents gave positive answer	The awareness of citizens to obey the law is considered to be good (score: B)	1.5	D
		2. For question number 54, 56, and 58, 30–49% of respondents do not know and did not get socialization about waste management law	The socialization about waste management law to citizens and the citizens' knowledge about the law is considered to very bad (score: E)		
7	Intention	1. For question number 64, 66–71, 95–99% of respondents gave positive answer	"Intention" of citizens related to waste treatment is considered to be very good (score: A)	3.5	B
		2. For question number 62, 63, and 65, 78–79% of respondents gave positive answer	"Intention" of citizens related to waste separation is considered to be good (score: B)		
8	Behavior	1. For question number 73–75,77–81, 91–99% of respondents gave positive answer	"Behavior" of citizens related to waste treatment is considered to be very good (score: A)	3.5	B
		2. For question number 62, 63, and 65, 77–81% of respondents gave positive answer	"Behavior" of citizens related to waste separation is considered to be good (score: B)		
Total				19.5	
Average				2.4375	C

1. (A: very good) is when 85-100% of respondents gave positive answer to the questions in a factor, value is 4

2. (B, good) is when 75-84% of respondents gave positive answer to the questions in a factor, value is 3

3. (C, fair) is when 60-74% of respondents gave positive answer to the questions in a factor, value is 2

and increasing environmental awareness with fun activities, such as creating a waste management website, children park, environmental events and games, environmental seminars, etc. The "Nurture" element is the most important component to run other elements for success implementation of waste FUN system because "knowledge" factor is the third-most influential factor in behavior modification after "role of government" and "law enforcement" factor.

By this proposed model, the pro-environmental behavior of citizens could be enhanced and residents would be encouraged to separate waste in their daily life. The model can empower the citizens to work with local governments to manage the municipal solid waste for the successful implementation of waste management systems. The programs in the "waste FUN" system have to be carried out continuously to form new behavior (pro-environmental behavior) in society. It might take long time to change, but Lally et al. (2009)

suggest that it takes an average 66 days (ranged from 18 to 254 days) to form a new habit [51]. Therefore, the proposed model is expected to change citizen's habits within at least one year. This proposed model has considerable potential for application to other cities in Indonesia and in other developing countries that experience similar social conditions and problems as Padang citizens do.

Conclusion

This study investigates the root cause of the problems with the waste management system in Padang city, Indonesia and takes the unique approach of examining the environmental behavior of Padang citizens to determine their social condition toward current municipal solid waste management system and level of readiness for plan of modified waste management methods for a successful implementation of the system. A survey was conducted with Padang citizens and the survey responses were analyzed using EFA and CFA to establish the structural model. SEM was used to determine the factors that influence the citizens' environmental behavior and scoring system of social evaluation was employed to describe the readiness of Padang citizens for the plan of modification of the solid waste management system which requires separating the waste at the source. Padang citizens are not yet completely ready to accept and apply the modified system in their day-to-day life. The local government as the most influential factor for behavior changing ("role of government" factor) should encourage the citizens toward adopting positive environmental behavior by increasing the effects of "law enforcement" and "environmental knowledge" before modifying the system for successful implementation.

This study proposes the "Waste FUN" system (improved version of existing SW bank system) as an idea of appropriate waste management system for citizens' social condition to improve citizens' understanding of the system and problems associated with it. The new system consists of three main components; "Fund" for economic benefits, "Utilization" for waste treatment, and "Nurture" for environmental education and encouragement. This model is expected to change the negative environmental behavior of citizens to pro-environmental behavior and make citizens accustomed to the idea of waste separation. The proposed models would be useful not only for the citizens of Padang city, but also for citizens in other developing countries.

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