

# Preferences Mapping of Household Biodigester in Bandung

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**Abstract.** Bandung city government has implemented household biodigester grant 2 times in 2015 and 2016, but unfortunately, there are household biodigesters which still function well but not used. Therefore, this study is an effort to improve the acceptance of biodigester household in Bandung city. The purpose of this study is to know how preference citizens about household biodigester. The sample used in this study was obtained through the online questionnaire. Eight dimensions of Quality Garvin (1987) are used as the construct of something that may be favored by users/potential users of the household biodigester. Cluster analysis has been done and there are 3 clusters with different preferences. Interpretation and profiling of each cluster are done using Welch's ANOVA and Games-Howell Test. This study has said that the cluster with the largest number of members expressed reliability and features as the most important dimension. The cross-tabulation analysis was performed to determine the relationship between demographic and cluster formed. The implications of the results presented in the analysis are carefully discussed. The results of this study are expected to be useful for biodigester developers and also for the government in Bandung so that if biodigester household grants program will be held again, the program will become more accepted by the community in Bandung.

## 1. Introduction

The service capacity of garbage handling until now by PD Kebersihan (local waste management company) is still not optimal, only about 65% of the waste is served (1). In jabarprov.go.id, Oded M. Daniel as the vice Mayor of Bandung mentioned that the city of Bandung produces waste up to 1500 tons per day but the waste transport capacity is only about 1100 tons.

Biodigester is one of waste-to-energy based power generation. The way it works is by turning organic waste into gases and fertilizers. In February 2015, the government of Bandung held a 100 grant biodigester program with a capacity of 15 kg of organic waste for the citizens of Bandung who are interested in preparing certain requirements file (2).

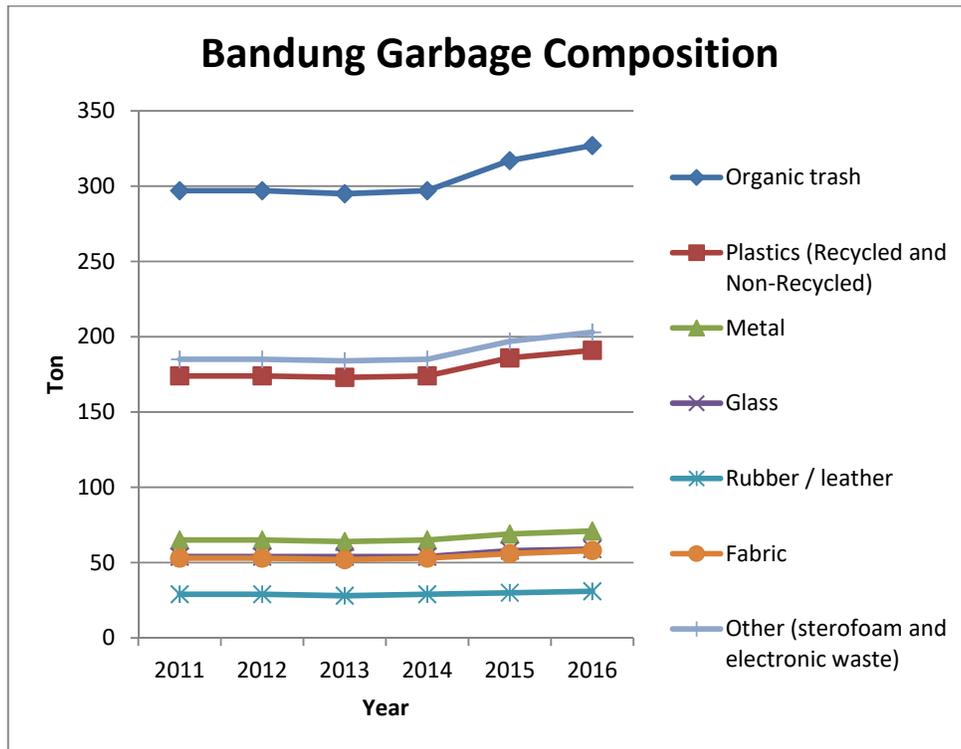


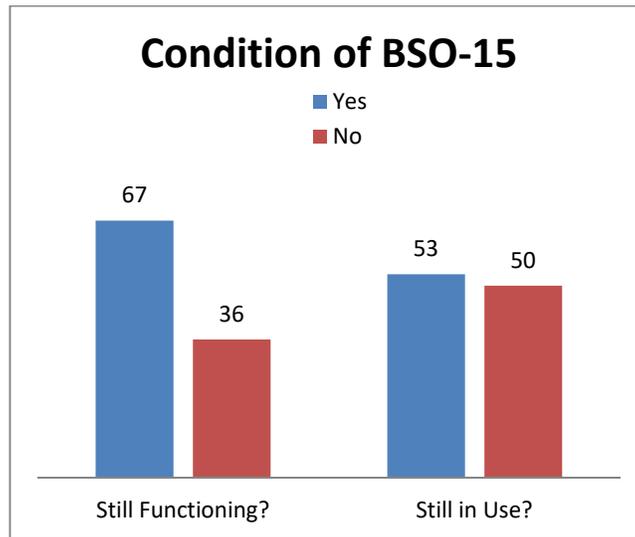
Figure 1. Bandung Garbage Composition.<sup>1</sup>

Based on figure 1, it is seen that the composition of organic waste has the highest amount of waste than any other waste in Bandung. This makes the application of biodigester became highly potential even though first of all, we need the citizens' willingness to do waste separation as early as possible. Reported from kompas.com, in 2014 Ridwan Kamil (mayor of Bandung) wants to reduce the waste that comes from the household. One way that might be applied is to use household biodigester. Hopefully, the cost of transporting garbage could be reduced because of the reduced amount of waste that must be transported to TPS.

Prior to holding a household-scale biodigester grant program, the government of Bandung has held a biodigester grant program with a larger scale of biodigester capacity that could process 250 kg of garbage. There are 14 biodigesters of 250 kg capacity granted by BPLH in Bandung, but after some time, according to survey results conducted by BPLH (3) from the use of biodigester capacity of 250 kg is considered to have a much greater risk than household biodigester.

Household biodigester has potential to be growing better, because according to the results of research that has been done by Cahyono (4) states that there is more than 50% household biodigester is distributed in the city of Bandung is still in use by the owner. Then from research conducted by Cahyono (4) also, can be seen in figure 2 below, it is known that 67 of 103 biodigesters still functioning well. From this facts, we could also obtain information that there is a difference between the term of “biodigester that is still functioning” with “biodigester which still in use”. It indicates the presence of biodigesters that are still functioning but not used.

<sup>1</sup>Surakusuma W. Permasalahan Sampah Kota Bandung dan Alternatif Solusinya. Jurnal Universitas Pendidikan Indonesia. 2012.



**Figure 2.** Condition BSO-15 in Bandung.<sup>2</sup>

Biodigester is a technology-driven product or known as push technology product, but like what Eppinger & Ulrich (5) implies, although the most decisive success of technology push products is the technology, the product developers need to pay attention to the preferences of the users/people who might become a user to increase the probability make the product becomes a successful product. Developing a new product is having a lot of risks, but by identifying customer needs, the risk can be reduced.

In a city or region, the community is a waste generation element, so the role of the community is one of the most important because the management of biodigesters is highly dependent on community participation. Therefore it is necessary to know how the hope of citizen for biodigester product to make the biodigester more accepted by society. Then according to McMillan (6), the thing that makes someone want to use something is when the product provides the benefits they want. According to Gendall and Esslemont (7) market research is unable to produce explanations of consumer behavior reliably and comprehensively, but marketing research can increase the probability of making the right decision. So this research will be mapping the preference of Bandung citizens about biodigester households to improve the acceptance of Bandung citizens of the biodigester.

## 2. Assumption and Limitation

Because biodigesters are not yet commonly known to citizens of Bandung, to increase response rate. these questionnaires are only distributed to people who have an interest in environmental preservation, environmental activists, researchers, and students who study biodigesters in their majors. So that assumption used in this research is the preference of Bandung citizen can be represented by those people. The assumption used is the preference variance between regions in Indonesia is considered same. The assumption is built because in general, the people of Indonesia have the same perception about energy. This assumption will be tested using available data using cross-tabulation (chi-square), so it can be known whether there are differences in preference between citizens of Bandung with residents other than Bandung.

## 3. Design of Collection Data

<sup>2</sup> Cahyono B. Pengalaman Penerapan Digester Pengolah Sampah Organik di Kota Bandung. Surabaya.; 2016.

The important condition for a product to succeed is that it must offer what the customer/user thinks to be a benefit (5). Therefore, in this research will be used a quality concept of Garvin (8) which divides the quality of a product into 8 dimensions, namely performance, features, reliability, conformance, durability, serviceability, aesthetics, and perceived quality.

In this study, the dimensions of conformance, aesthetics, and perceived quality are not used because they are less relevant to household biodigester products. Then the operationalization of the concept conducted by describing these dimensions into 31 indicators that are considered capable of measuring these dimensions. Indicators used are obtained from various references, such as journals, articles, theories in product development, final project, and others. In addition to the literature study, the indicators were also obtained through interviews with some biodigester users in Bandung, the results of brainstorming which was then discussed (as a form of verification/content validation) with the biodigester household product developers on the suitability of indicators identified with household biodigester products technically.

### *3.1. Scale Selection*

The scale used in this study is the ordinal scale which is considered as the interval scale because it will be processed using parametric statistics if passing the basic assumption test statistics. Type of scale used is Likert scale. This questionnaire will be made on a balanced scale because in general to get objective data scale must balance. Unbalanced scales are commonly used when data to be obtained has the possibility of abnormalities (9).

Then the scale to be used is an odd scale, i.e. a scale that has a middle value or a neutral value. Respondents are got the opportunity to choose neutral because of the indicators that there is a possibility that respondents feel neutral with these indicators. On an odd scale too, this questionnaire becomes a questionnaire that does not compel respondents because if they feel neutral about an indicator then they can choose the middle value. The scale used is 7. The scale is chosen because if the scale of 5 cannot see the difference clearly, while if the scale selected is the scale of 9, we worried to make the respondent too tired because of too many choices. Therefore the scale 7 is chosen which is the middle value of 5 and 9.

### *3.2. Questionnaire Design*

A good questionnaire should motivate respondents to be willing to contribute, feel involved, and willing to provide complete, honest and accurate answers (9). Each statement representing the indicator of this study will be marked required. This is done to avoid missing value. Although the activated feature required this questionnaire to be impressed, actually respondents should not feel threatened. First, because all indicators have been identified do not require any personal data that may be sensitive to be notified. Second, as described in the previous section, there is a neutral choice in this questionnaire which, so if the respondent feels neutral on an indicator, then he/she can choose the middle value for the indicator. Third, data retrieval will be done using typeform.com which has a user interface that is convenient for the respondent.

The questionnaire consists of two parts. The initial part of the questionnaire contains the respondents' assessment of the indicators identified. The form of the questionnaire selected is in the form of numbers 1 through 7 with information on the highest, lowest, and middle scale to facilitate the respondents to understand each scale used in the research questionnaire.

In the second part is a request for respondents to fill out the identity. Questions about demographics are deliberately placed at the end to improve the completion rate. According to Lindemann (10), there is a common practice in making questionnaires that we must begin to avoid: do not start a questionnaire with questions about the demographics of respondents. Because it will make people lazy to fill out the questionnaire thereby lowering the response rate. Preferably in a questionnaire that was first asked not in the form of personal data.

The questionnaire for this study also uses a progress bar of percentage completion. Progress bars are used because basically humans have a purpose and have a desire to achieve goals. If he does not know

how far he has stepped he might stop before finishing the questionnaire so because he does not know when the questionnaire ends. According to Zhang (11) with this progress bar, when he has completed most of the questions in the questionnaire when at the end there is a sensitive question, most likely respondent will fill it because he knows he has done a lot by looking at the progress bar. So with the design of such questionnaires, indirectly respondents are forced to provide personal data. Type of progress bar selected is the percentage because if the progress bar shows the number of questions that have been filled, then from the beginning to open the questionnaire, respondents already know the number of questions very much in the questionnaire of this study so it is feared respondents become lazy and immediately close the questionnaire without completing it first. It will be different if the progress bar is used as a percentage, then the respondent will not know the number of questions but he will have a picture of how far he has done in the questionnaire that is being filled.

### 3.3. Validity and Reliability Test

Great data is data obtained by valid and correct way, what is measured according to what you want to measure. In this research, we have collected data for validity and reliability test 3 times with each test using about 30 respondents. The validity test used is construct validity and the results of all indicators are valid convergent. The reliability test performed is internal consistency reliability with the calculation method of Cronbach's Alpha. According to (9), a dimension is reliable if the alpha value more than 0.6. From the calculation result is concluded that all dimensions used are reliable because all dimensions have alpha value more than 0.6.

**Table 1.** Reliability Test.

<b>Dimensions</b>	<b>Cronbach's Alpha</b>	<b>Reliable</b>
<i>Performance</i>	0.6945	Yes
<i>Features</i>	0.7340	Yes
<i>Reliability</i>	0.9010	Yes
<i>Durability</i>	0.7063	Yes
<i>Serviceability</i>	0.8739	Yes

## 4. Data Collection and Method

After the questionnaire proved to be valid and reliable, data collection was done and obtained 146 respondents. According to Zhao (12), the respondent required in a study is 5x the number of variables used or at least 100 respondents. After data collection, outlier test is done using Grubbs Test and result there are 3 outliers. Outlier removal due because of unusual filling. After that also done the basic assumption test that is normality test, heteroscedasticity test, linearity test. The result states that the data used pass the linearity test but cannot be assumed to be normal and heteroscedasticity. In this research, autocorrelation test is not conducted because the data used is not a time series data so it is not necessary to do autocorrelation test (13).

The tools used in this research are cluster analysis and also use ANOVA along with its post hoc test to know the preference of each cluster, and also use cross tabulation to find the demographic relation with the cluster formed. According to Malhotra & Birks (9), cross tabulation is a statistical technique that describes two or more variables simultaneously and generates a table that reflects a combination of two or more variables that have a number of different categories or values. In this research is used chi-square calculation to know the relation of demography variable with cluster formed.

Based on Santiago (14) some testing tools are considered "robust" against normality assumptions, such as the t-test, Analysis of Variance (ANOVA), Regression, and Design of Experiment (DOE). According to Glen (15), although ANOVA requires normality assumptions, we can still use this test if the sample size is large enough (usually more than 20), but if the sample size is very small then it is better to use nonparametric testing. The sample (without outlier) used in this study was 143 samples because the number of samples is quite a lot then ANOVA testing will be used.

Considering one of the assumption test results that the data obtained for this study cannot be assumed to have the same variance, and then in this study cannot use classic ANOVA. In processing the heteroscedasticity data, Welch's ANOVA and Kruskal-Wallis (nonparametric) can be an alternative data processing. Liu (16) has conducted a study to compare what is likely to be a lower type I error and which has higher power between Welch's ANOVA and Kruskal-Wallis Test. And from the results of his research concluded that Welch's ANOVA gives the best performance in the appeal of Kruskal-Wallis, and then in this study will be used Welch's ANOVA.

The post-hoc test that will be used is Games-Howell Test. According to Shingala & Rajyaguru (17), the Games-Howell (GH) procedure is the equivalent of the Tukey Kramer Test. The GH method provides the best results for pairwise comparison. Then according to Hilton and Armstrong (18), the Games-Howell test is one of the robust methods among the latest methods. With Games-Howell, pairwise comparison can be performed although there are differences in the number of samples being compared, with the data being heterogeneously variable, and when the data does not meet the assumption of normality.

## 5. Processing and Analysis of Data

### 5.1. Selection of Clustering Variables

Cluster analysis is one type of multivariate analysis aimed to categorize objects (such as respondents, products, and others) based on the characteristics they have (19). In this study, cluster analysis is used to determine whether there are different groups in a population. This is important because by understanding the preferences of groups in society, people's preferences can be understood in more detail and in depth. There are several steps in cluster analysis which are choosing cluster variable, determining optimal cluster number, cluster validation, outlier analysis, and profiling the cluster.

An ideal clustering variable is a variable that is not correlated with other variables. However, because in this study there are no variables that really do not correlate with other variables so then the selected cluster variable is the variable with the least number of correlations. Based on the calculation of the number of correlations between variables, it is found that the selected cluster variable (to represent every dimension) can be seen in table 2 below.

**Table 2.** Clustering Variables.

Dimensions		Variables
<b>Performance</b>	X1	Biodigester is able to convert waste into gas that can be used for cooking
<b>Features</b>	X8	There is a monthly incentive for the person who operates the biodigester
<b>Reliability</b>	X19	The stove can still be used even when the power (electricity) is off
<b>Durability</b>	X20	The biodigester-generated gas has the same quality in every operation of biodigester
<b>Serviceability</b>	X24	There is a regular meeting with biodigester engineers for the users

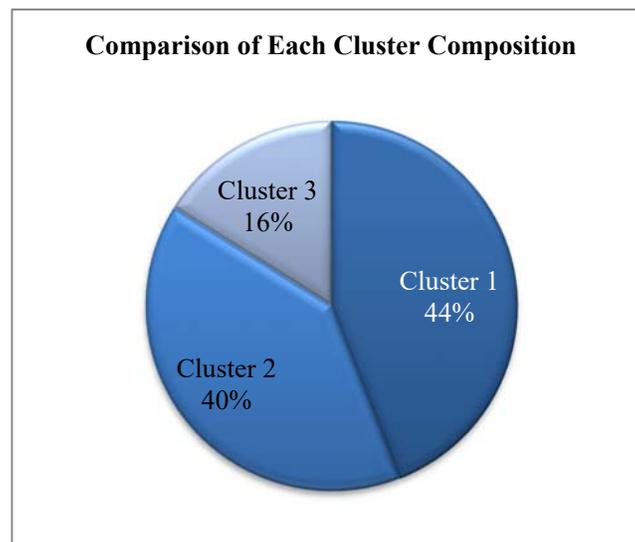
### 5.2. Agglomeration Method

The most optimal number of clusters is the number of clusters that most explain the differences between the clusters that are formed. To determine it, the tools used are hierarchical cluster using SPSS 20. The hierarchical method used is agglomerative method. This method is a grouping method that is bottom up that is done by cluster number as much of number of samples then samples are grouped one by one based on their similarity to finally form one cluster.

**Table 2.** Determination of Optimal Cluster.

Number of Clusters	Difference of Coefficient	Changes in Coefficient Difference	Difference in Changes
1	<i>Emptied</i>	<i>Emptied</i>	<i>Emptied</i>
2	152.68	108.3%	<i>Emptied</i>
3	79.02	56.4%	51.8%
4	74.78	53.8%	2.6%
5	51.75	37.5%	16.3%
6	28.64	20.9%	16.6%
7	28.13	<i>Emptied</i>	<i>Emptied</i>

The optimal number of clusters depends on the stopping rule. The cluster formation must stop when there is the biggest change in the value of heterogeneity. From table 5.12 above can be seen that the spike occurs in cluster 3, it can be concluded that the best cluster is 3 because the highest heterogeneous change spike is in the difference of cluster 2 to cluster 3 that is 51.8% then done the clustering of respondents into 3 clusters. The methods used are the same as those done when determining the optimal number of clusters using Ward's Method, distance measurement using Squared Euclidean Distance, and standardization of data using Z-score (variable). This grouping is done using Minitab 17. The proportion of members of each cluster formed can be seen in Figure 3 below.



**Figure 3.** Comparison of Each Cluster Composition.

### 5.3. Validity Test

To test the validation of the clusters formed, cluster analysis with other methods (K-Means) was performed. It is known that 78.38% of the cluster members generated by K-Means are the same as cluster members generated through hierarchical methods. The minimum standard validity of a cluster is 75%

(19), it can be concluded that the cluster results that have been done in this study have passed the validation test.

#### 5.4. Interpreting and Profiling Cluster

The process of interpreting and profiling clusters is done using Welch's ANOVA, Games-Howell Test, and cross-tabulation. From the results of cross-tabulation test, proved that there is no difference or no relationship between preference citizens of Bandung and residents outside the city of Bandung, thus the assumptions used in this study proved. But, because of this result too, in this research, we cannot describe who the member of the entire cluster is. And then, to know about what the most important dimension of every cluster, we use the Welch's ANOVA and Games Howell Test. The result can be seen in the table 4 below.

**Table 3.** The Most Important Dimensions.

Cluster	The Most Important Dimensions
1	Reliability Features
2	Durability Reliability
3	Performance Durability Reliability

After that, Welch's ANOVA and Games Howell Test have performed again on the indicators of each dimension clustered by each cluster and the summary of the results can be seen in Table 4 below.

**Table 4.** Summaries of Preferences.

Cluster	The Most Important Dimensions	The Most Important Indicator	The Most Important Indicator of Clustering Variables
1	Features and Reliability	X14 Biodigester not easy to leak	X19 The stove can still be used even when the power (electricity) is off
		X16 Gas pipes to the stove are not easily broken	X8 There is a monthly incentive for the person who operates the biodigester
2	Durability and Reliability	X14 Biodigester not easy to leak	X20 The biodigester-generated gas has the same quality in every operation of biodigester
		X20 The biodigester-generated gas has the same quality in every operation of biodigester	
		X19 The stove can still be used even when the power (electricity) is off	
		X17 Gas distribution pipes are not easily clogged	X19 The stove can still be used even when the power (electricity) is off

Cluster	The Most Important Dimensions	The Most Important Indicator		The Most Important Indicator of Clustering Variables	
		X16	Gas pipes to the stove are not easily broken		
		X15	Not easily damaged if hit by a hard object collision		
3	Performance, Durability, and Reliability	X16	Gas pipes to the stove are not easily broken	X1	Biodigester is able to convert waste into gas that can be used for cooking
		X14	Biodigester not easy to leak		
		X4	The resulting gas does not have a stinging smell when it is used for	X20	The biodigester-generated gas has the same quality in every operation of biodigester
		X17	Gas distribution pipes are not easily clogged		
		X3	Biodigester can reduce organic waste	X19	The stove can still be used even when the power (electricity) is off

## 6. Conclusion and Recommendation

### 6.1. Conclusion

Based on the cluster analysis along with the tests that have been done, it can be concluded that there are 3 clusters of citizens' preference for household-scale biodigester, i.e. people who emphasize dimensions of features and reliability, people who emphasize durability and reliability, and people who emphasize dimensions of performance, reliability, and durability.

If we compared to other clusters, cluster 1 contained in the data used in this study has the largest proportion than other clusters. This can be an illustration that the size of the cluster in the population is the cluster with the largest members as well. So, if the biodigester of this household scale will be commercialized, from the 3 clusters formed, cluster 1 is a potentially interesting target market because the population is considered large enough. In addition, the dimensions clustered by cluster 1 is quite easy to implement because the cluster-centered indicator is not so much that household biodigester developers can focus more on the indicator. The cluster's main indicator is that the biodigester is not easy to leak and the pipes that deliver gas to the stove are not easily broken.

If the grant program will be held again by the government of Bandung, then the mayor city of Bandung might provide guarantees of a warranty for these indicators to make members of the cluster prefers the biodigester. Regarding the variables used for cluster analysis, the most important clustering variables for cluster 1 are stoves that can still be used even though the electricity is not on and there is an incentive every month for those operating the biodigester. So, for biodigester developers could be more concerned about how to make this could be implemented on household biodigester, and how much the right amount of incentives to be given to biodigester operator, so they continue to have the drive to operate biodigesters.

### 6.2. Recommendation

The main stakeholder in this problem is the government of Bandung. In this section, the managerial implication will be arranged. Based on this study, it is known that there is difference within citizen's

preference of household biodigester. Therefore, to increase the residents' acceptance of biodigester, it is better for the Bandung City Government to design policies that match the preferences of citizens and provide household biodigesters to citizens with appropriate preferences.

In the previous sections, it has been explained that the recommended cluster is cluster 1 which is the cluster that emphasizes dimension of features and reliability. And then, the most important thing by cluster 1 is the biodigester is not easy to leak and the gas distributor to the stove is not easily broken. By utilizing these findings, biodigesters should be granted with a warranty of two things: the warranty that biodigester is not easy to leak and warranty that the connecting pipe is not easily broken.

Development of household biodigester can also be done based on the most important variables among the variables used for cluster analysis. This is done because the clustering variable has a function as a differentiating variable between the clusters formed. Therefore, the use of clustering variables for the development of household biodigester is expected to make biodigester more appropriate to the preference of the selected segment. In cluster 1, the most important of clustering variable is a stove that can still be used even though the electricity is off and there is an incentive for those who operating the biodigester. Based on this finding, Bandung City Government should provide incentives for people who are willing to operate household biodigester. Then the Bandung City Government should also ask the manufacturer (or find a capable producer) to produce household biodigesters that can be operated when the power goes out.

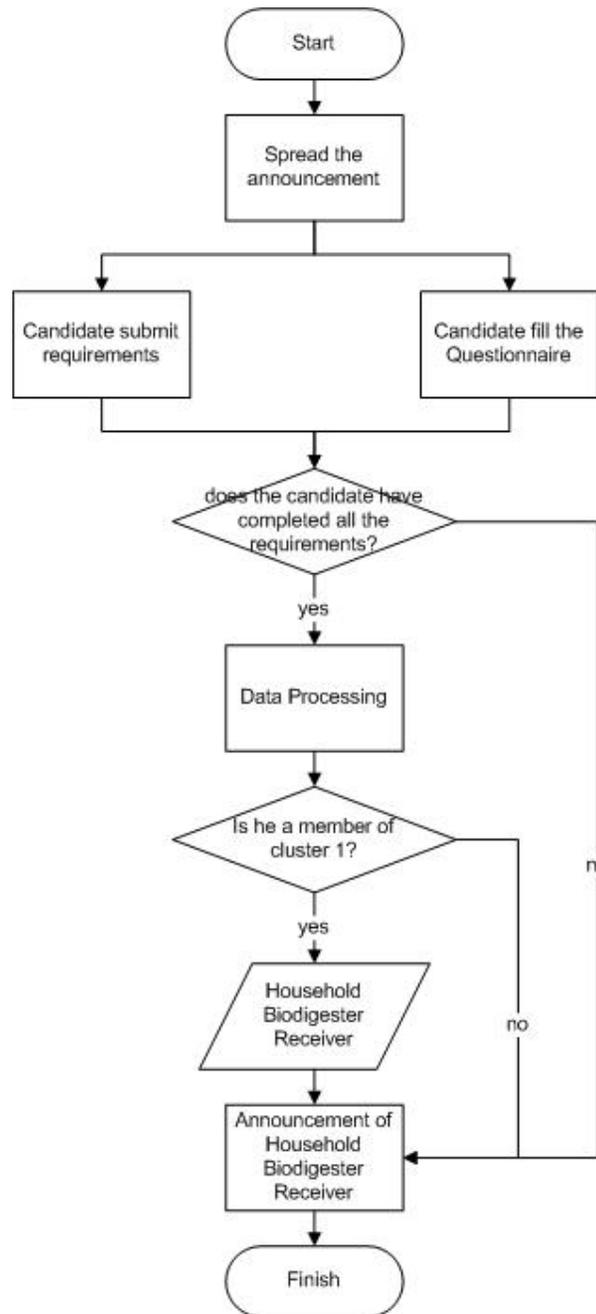
Then, to reach people who are the member of cluster 1 can be done by asking prospective recipients of household biodigester to fill out the same questionnaire as the questionnaire used in this study. Then the result of the questionnaire is processed (by testing ANOVA and Post Hoc Test on clustering variable and on the indicators of the important dimension). After that, the results are compared with the cluster results formed in this study, is the respondent a member of clusters 1, 2 or 3? If the result states that the potential recipient of this biodigester belongs to cluster 1, then he may be the next beneficiary of the biodigester grant.

Then the process of spreading of information about the biodigester program should be done through forums of environmental activists. This is recommended because most of respondents used in this study are people who have more concern for environmental sustainability. Therefore, it is possible that the preferences generated by this study will be more appropriate to those participated in the forums of environmental activists. However, the distribution of information through local officials (such as heads of sub-districts, heads of RWs. etc.) should be done too. So that the dissemination of information on biodigester grants can be spread to rural areas of Bandung. It is recommended also because there are some respondents who are ordinary citizens. Therefore, the predicted preference of this study is estimated to be still in accordance with the preferences of citizens in general. For the next biodigester grant program, the recommendation of the biodigester recipient search path can be seen in Figure 4.

When spreading the information about household biodigester grant programs, warranties and additional features existing in biodigester are not mentioned. This is intended to anticipate potential biodigester grant recipients who try to relate the biodigester condition with the assessment that it will fill into the questionnaire. Thus, respondents can fill out the questionnaire honestly, according to their natural preferences.

Any citizen who wishes to be a biodigester grantee will be required to submit the requirement files to the Bandung City Government office (or to a specified place) directly (not by courier). Then the person who is willing to accept and maintain the household biodigester is asked to fill out the online questionnaire using the gadget provided. Biodigester recipients fill out questionnaires and the organizers waiting for him so that the prospective recipients can fill out the questionnaire as well as possible.

By using this flow, Bandung City Government can find the right biodigester household recipients. Therefore, the risk of product failure caused by the product is not used can be suppressed. Non-used biodigester is a disadvantage because the procurement of biodigester requires a lot of money.



**Figure 4.** Recommendation of The Biodigester Recipient Search Path.

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