International Journal on
Advanced Science
Engineering
Information Technology

Vol.10 (2020) No. 5
ISSN: 2088-5334

Adoption Model of Water Filter by The Society of Lake Water Users in Dry Land Area, Gresik, East Java, Indonesia

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***Abstract*— North Gresik is a dry land area. The primary water source is lake water. The analysis result showed that lake water contained the contamination of ammonia, iron, manganese, organic matter, and a coliform total exceeding standard quality. This condition could endanger local societies. A water process was needed to remove water contamination and improve water aesthetics. In this study, the researchers were choosing a water filter as Water treatment tool. This tool used three media; manganese greensand, zeolite, and active carbon. This tool had an excellent performance to reduce lake water contamination, practical to use and affordable price. This research built Structural Equation Modeling (SEM) to identify the factors and variables which were influencing water filter adoption by societies. Data collection was conducted by distributing questioners to 248 respondents. The finding showed that the behavior of tool accepting was the most take positive effect to tool adoption (path coefficient = 0.320), following governments' role path coefficient = 0.276) and infrastructure (path coefficient = 0.157). Behavior acceptance was a tool as mediate the relationship of society's perception to tool adoption and to mediate the relationship between institutional and tool adoption. The resulting model was included moderate because it was able to explain about 36.7% from variable variants in tool adoption. The variables, finding which influenced tool adoption in positive and significant effect, both directly and indirectly, were input, for the decision-maker (government) and local lake water process in making policies and developing work programs for sustainable water supply.**

***Keywords*— water filter adoption; active carbon; manganese greensand; structural equation modeling; zeolite.**

I. INTRODUCTION

Several studies have found that water sources in some locations contained contamination exceeding the WHO maximum standard [1]–[7]. Contaminated water sources were also occurring in Gresik. Lake water, which was consumed by local societies, was contaminated by ammonia, iron, manganese, organic matter, and coliform total [8], [9]. However, the contamination could able to reduce the water lake contamination if there were processes in lake water. Several processing methods could be conducted to reduce the contents of water lake contamination. One of the effective methods to reduce the content of water contamination was filtration [10], [11].

Filtration is a process of solid separation from liquids in physics. The function of filtration media like manganese greensand, zeolite, and active carbon, was reducing solid from fluids, heavy metal with not too high level, and organic compounds [12]–[14]. Some studies have proved if water filtration was equipment which was able to reduce the content of pollutants by practical use, easy to maintain, and affordable price. However, the societies were not necessarily accepting this information. Although the factors could influence several studies and literature have explained societies' decision to adopt water treatment equipment or technology.

Previous research explained that societies could be encouraged to adopt water treatment equipment if they were dissatisfied with water quality that they consumed, and this dissatisfies illustrated the wrong perception of water quality [6]. Societies' perception of the water quality which they consumed, it was influenced by few perceptions; organoleptic, health risks, and economic assessments of water quality [15]. Although the societies were able to assess water quality organoleptically, the actual water quality needed to be tested because organoleptic perception has not necessarily appropriated with the actual weather conditions

[5]. Determining the appropriate water treatment method and designing the equipment which would be adopted as a needed test to the actual water quality.

The definition of adoption was a stage of someone's acceptance to the new idea which has been used continuously on a border scale. The adoption occurred after it has passed a few stages; awareness, interest, assessment, and experiment [16]. The stage toward adoption was also refined into a few stages; introduction, persuasion, decision, application, and confirmation [17]. Furthermore, the adoption process could also be divided into some stages. They were awareness, attention, evaluation, trial, adoption, confirmation [18]. Adoption was also defined as a process of changing the knowledge, attitude, and someone's skill, which manifests in behavior-changing after they got socialization. The attitude and behavior formed were influenced by perception [19], [20]. Then, adoption meant a mental process that occurred to someone when they heard about innovation for the first time until they decided to do adoption [21].

Adoption was an action that was included in the third behavior domain after knowledge and attitude. Adoption was an action at the highest level after guiding practice and mechanism practice. The attitude, which was the second domain of behavior, was not necessarily continued with the action. To change the attitude into action needed another factor; facility or infrastructure [22]. The attitude was influenced by the first domain of behavior, namely, knowledge. The attitude was a part of close behavior. Closed behavior happened when the humans' response to the stimulus was still closed. Responses to the stimulus were still in the forms of attention, awareness, perception, knowledge, and attitude [23]–[25].

This study examined the finding which explained knowledge, desires, perceptions and attitudes, experiments, and applications. Confirmations were stages that passed in the adoption process. So, these stages were estimated as variable and indicator which influenced tools adoption [6], [20], [26], [27]. This study was also testing the finding, which explained that the attitudes could change actively if there would have facility or infrastructure [22].

The policy of providing infrastructure was implemented by the local government [28]. Based on that statement, the adoption in this study would be expected to influence the governments' role. The spearhead of the adoption process was the lake water management institution called the Association of Drinking Water Users. The local community managed this institution, so the active role of the community was needed to improve the performance of this institution [29]. Then, the excellent performance of the institution was estimated to influence the community's decisions to adopt water treatment equipment.

This study tested the relation between the variables of the public's perception of the tool, infrastructure, governments' role, institution, behavior acceptance of tool, and tool adoption. This study used SEM methods to analyze the relation of several variables directly because it could assess different relations between different variables simultaneously [15], [30]. The findings from this research could be used as a basis of model development for adopting water treatment devices as well as the development of other technological innovation adoptions [31].

II. Material and Method

A. Hypothesis and Research Conceptual Framework

The first step in building a model was drawing up a conceptual, as shown in Fig. 1 and a hypothesis for research.

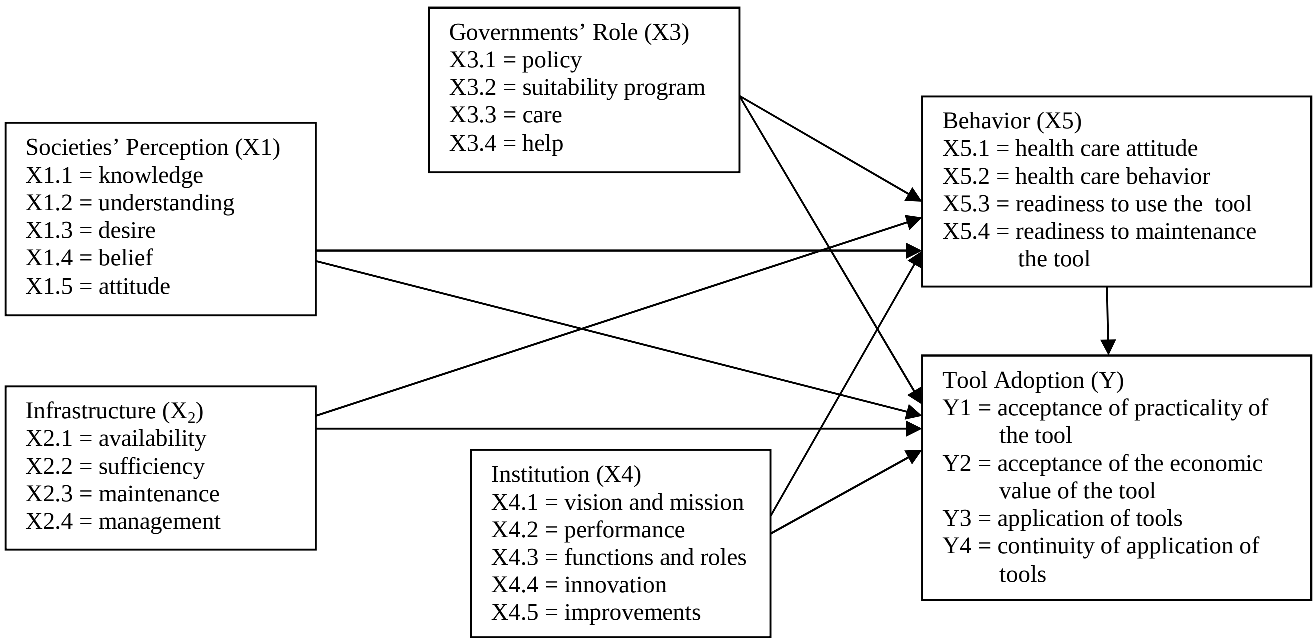

Fig. 1 Research conceptual framework

Fig. 1 showed that in a conceptual framework, there were four exogenous variables; society's perception of the tool (X1), infrastructure (X2), governments' role (X3), and institution (X4), and there were two endogenous variables; tool acceptance behavior (X5) and tool adoption (Y). Each variable was explained into three to five indicators. Each indicator was explained in one to three items. These items were developed into questions in the questionnaire. Then, there were 9 hypotheses which would be tested in this study, as followed:

H1 : Society's perception of the tool positively influenced tool adoption

H2 : Tool adoption was positively influenced by infrastructure

H3 : Governments' role positively influenced tool adoption

H4 : The institution positively influenced tool adoption

H5 : The acceptance behavior of the tool positively influenced tool adoption

H6 : Society's perception positively influenced the acceptance behavior of the tool

H7 : The acceptance behavior of the tool was positively influenced by infrastructure

H8 : Governments' role positively influenced acceptance behavior of the tool

H9 : The institution positively influenced the acceptance behavior of the tool

B. Samples

The population for this study included the people in Beijing District, Gresik Regency, Indonesia, who consumed lake water in 10 months a year more than 3 levels of headings should be used. Three villages consumed water lake in 10 months a year: Metatu, Sirnoboyo, and Kalipadang Village as shown in Fig. 2.

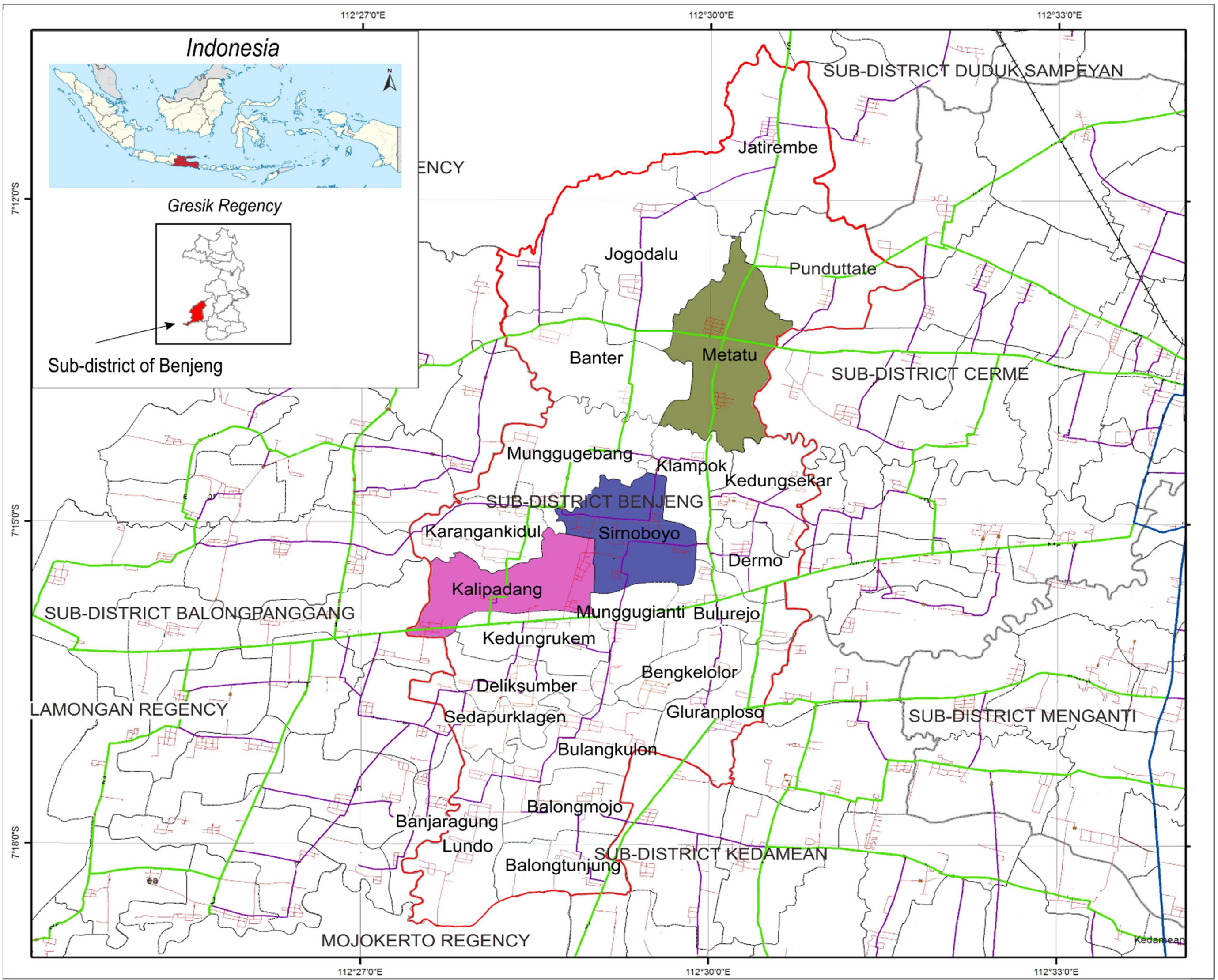

Fig. 2 The research location included three villages: Metatu (green), Sirnoboyo (blue), and Kalipadang (pink)

A total of 250 sets of questionnaires was distributed, and 248 returned. It was because the research location was quite extensive, which included three villages, so the sampling was taken randomly based on the village area (Cluster Random Sampling). The samples of 250 respondents were chosen from three villages. There were 90 people from Metatu Village, 80 people from Kalipadang Village, and 80 people from Sirnoboyo Village. Two sets of questionnaires were distributed in Metatu Village, and it did not return. The water filter has been socialized to the respondents before they filled the questioners. The water filter contained three media, namely manganese greensand, zeolite, and activated carbon. The researchers tested filter performance in reducing lake water contaminant content. So, this lake water met the Health Minister Standard of the Republic of Indonesia and the World Health Organization. Processing was needed to add chlorine capsule to reduce the content of biological contaminants. The water filter scheme is shown in Fig. 3.

C. Measurement

Questionnaires techniques to collect quantitative data have been implemented in many studies [5], [6], [15]. This study used the same method to test the hypotheses in research regarding variables that influenced tool adoption. Questionnaires were developed based on literature about adoption, behavior, perception, governments' role, and infrastructure, which was modified to fit into the context in this research [5], [6], [15]–[17], [20]–[22], [27].

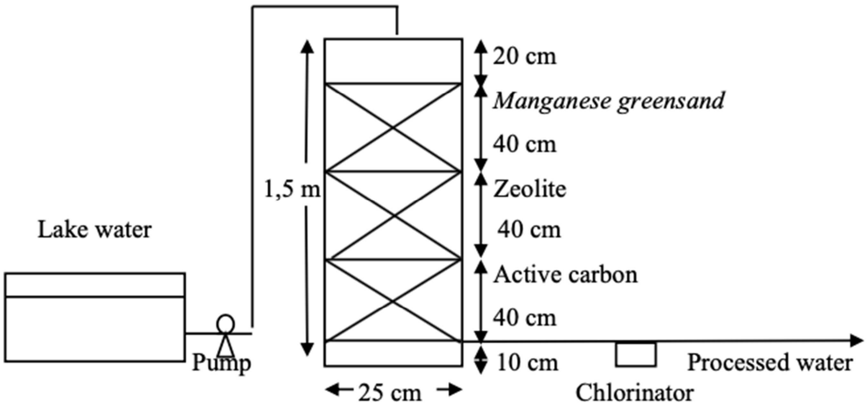

Fig. 3 Socialized water filter scheme

The five variables were measured using *Likert Scale* ranging from 1 (strongly disagree) to 5 (strongly agree). Each construct was measured using three to five indicators. This research was conducted pre-test to the questionnaire to ensure the validity and reliability of every questionable item. Validity test ensured developed items could measure something well while reliability testing ensured that the items were consistent in doing the measurement. The validity and reliability test of items were conducted by software SPSS version 20. The item was declared valid if the Pearson rxy Correlation coefficient was more significant than the cut off value of 0.1381, while items were declared reliable if Cronbach's alpha was bigger than 0.60 [32]. A pre-test was conducted on the questionnaire result from 30 respondents from Metatu Village. After all, the question items are declared valid and reliable, so the researchers were doing a measurement model to evaluate.

The evaluation of the measurement model was carried out after 248 sets of questionnaires were redistributed. The evaluation was conducted by SEM-PLS and PLS 3.0 smart software. The evaluation included constructing validation items, convergent validation items, discrimination validation item, item of constructing reliability, the indicators of validation and reliability to the variables, multicollinearity test, determination coefficient (R2), and predictive relevance (Q2). This research was confirmatory, so the instrument was valid if the load factor was more significant than 0.7 and AVE was more significant than 0.5. The instrument would be valid based on discrimination validation if the cross-loading value in an indicator or corresponding variable were more significant than the item correlation value of other variables or indicators. The instrument would be reliable or consistent if the value of Cronbach's Alpha were more significant than 0.6 and the value of Composite Reliability was more significant than 0.7 [32], [33].

Furthermore, in the SEM-PLS model should not be occurring multicollinearity symptoms or the existence of a strong relationship between independent variables in the model. The model would be declared that there were no multicollinearity symptoms if the variance inflation factor (VIF) value were smaller than 10 [34]. This research also examined the ability of endogenous variables in explaining the diversity of the exogenous variable stated in the determination coefficient (R2). The R2 value was 0.67 showed a robust model; 0.33 showed a moderate model, and 0.19 showed a weak model [33]. Then, the observation value was produced by the model, and the parameter estimated was measured by predictive relevance value (Q2); if the value were bigger than zero, the model would say to be quite good [33]. After the model was quite good, so it would be done the hypothesis test. Exogenous variables influenced endogenous variables significantly if T statistics were bigger than T table (T table = 1.96) while the P-value is less than 0.05 (alpha 5%).

III. Results and Discussion

A. Measurement Model

The measurement model showed that all items were valid to measure the indicators because the loading factor was 0.708 – 1.000. All indicators were valid to measure the variables because AVE was 0.592 - 1,000, while the evaluation of discriminant validity showed that all items from indicators were valid. So, each question could measure latent variables that correspond to the indicators [32], [33]. The measurement model was also shown that all the reliable items in measuring the indicators because Cronbach's Alpha was 0.706 - 1.000, and stable composite was 0.847 - 1.000. All of the reliable indicators were able to measure the variables because Cronbach's Alpha was 0.627 - 0.828 and the stable composite was 0.769 - 0.878, while the instruments would be said reliably if Cronbach's Alpha was more significant than 0.6 and Reliability Composite was more significant than 0.7 [32], [33].

The multicollinearity test showed that the variance inflation factor (VIF) in all variables was smaller than 10; it was 1.391 - 1.707. So, in this model, there was no multicollinearity symptom, or there was no relation between independent variables [34]. Test of the determination coefficient showed that R2 tool adoption variable was 0.367. It explained that the variables of infrastructure, government role, and accepting the behavior of tool could explain the diversities of tool adoption variable were 36.7%. Then, R2 tool adoption variable was 0.365. It showed that variables of tool perception, infrastructure, government role, and institution could explain the diversities of variable behavior acceptance tools were 36.5%.

The model included moderate because R2 approached 0.33 [33]. The relevance predictive test showed that Q2 of tool adoption variable was 0.123, and Q2 of the behavior variable of tool acceptance was 0.214. Q2 value showed how well the observation value which was produced by the model and its parameter estimation. The model could be said quite well because the Q2 value was more significant than zero [33].

B. *Hypotheses Testing*

Table 1 showed that H2, H3, H5, H6, H 7, H8, and H9 met the requirement, but H1 and H4 did not meet the requirement. The variable of tool adoption (Y) was influenced directly and positively by the infrastructure variable (X2), Governments' role (X3), and the behavior acceptance of the tool (X5). Among these three variables, the behavior variable of tool acceptance had the most significant influence (path coefficient = 0.330), which followed by governments' role variable (path coefficient = 0.249) and infrastructure (path coefficient = 0.194).

TABLE I
THE RESULT OF HYPOTHESES TESTING BASED ON T STATISTIC VALUE

Hypotheses	Variants Influence	Original Sample (O)	T Statistics (|O/STDEV|)	P Values	Conclusion
H1	X1 → Y	-0.096	1.347	0.178	Insignificant
H2	X2 → Y	0.194	2.900	0.004	Significant
H3	X3 → Y	0.249	2.808	0.005	Significant
H4	X4 → Y	0.088	1.181	0.238	Insignificant
H5	X5 → Y	0.330	4.676	0.000	Significant
H6	X1→ X5	0.307	5.306	0.000	Significant
H7	X2 → X5	0.185	2.724	0.007	Significant
H8	X3 → X5	0.175	2.346	0.019	Significant
H9	X4 → X5	0.201	3.011	0.003	Significant

H1 and H4 did not meet the requirement because society's perception variable regarding the tool and institutions could influence indirectly and positively to the tool adoption, mediated by the variety of tool acceptance. The behavior variable of tool acceptance (X5) was the most influential tool adoption (Y). This variable was influenced directly and positively by society's perception variable about the tool (X1), infrastructure (X2), governments' role (X3), and institution (X4). Among these variables, society's perception about the tool was the most influential the accepted behavior of the tool (path coefficient = 0.307), followed by institutional variables (path coefficient = 0.201), infrastructure (path coefficient = 0.185) and governments' role (path coefficient = 0.175). Model improvement was conducted by removing two non-significant pathways, namely the influence of society's perception about the tool to tool adoption (H1) and institution influence on tool adoption (H4). The effect of removing those two pathways was that the path coefficient changed slightly as presented in Table 2.

TABLE II
HYPOTHESIS TESTING BASED ON T STATISTIC VALUE AFTER MODEL IMPROVEMENT

Hypothesis	Variables Affect	Original Sample (O)	T Statistics (|O/STDEV|)	P Values	Conclusion
H2	X2 → Y	0.157	2.533	0.012	Significant
H3	X3 → Y	0.276	3.896	0.005	Significant
H5	X5 → Y	0.320	4.753	0.000	Significant
H6	X1→ X5	0.296	5.152	0.000	Significant
H7	X2 → X5	0.206	2.855	0.004	Significant
H8	X3 → X5	0.171	2.232	0.026	Significant
H9	X4 → X5	0.197	3.147	0.002	Significant

Besides, significance testing of the variables was also influencing like in hypotheses. Significance testing of the effect of indicator of the variables was also explaining that T statistics of all indicators were bigger than 1.96 and P values were smaller than 0.01. So, all indicators were influencing its variability significantly. Then, the structural model adoption model of water treatment tool based on path coefficient was shown in Figure 4.

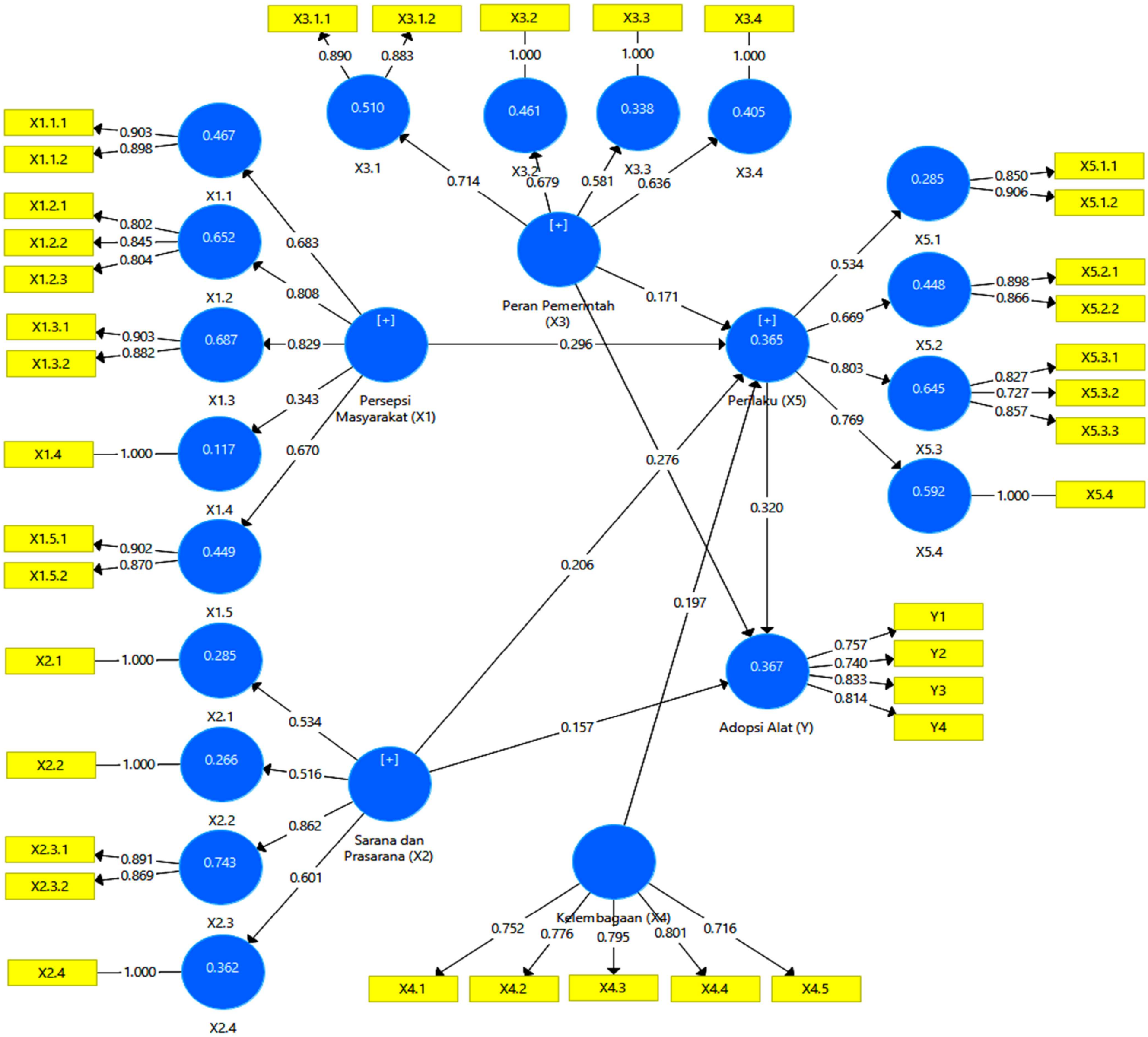

Fig. 4 Structural model of water treatment tool adoption based on path coefficient (blue : variable, yellow : indicator)

Fig. 4 showed that the perception variable (X1); the most influential variable was the desire for healthy living (X1.3). Then, the smallest influence indicator was the assessment of equipment performance (X1.4). While infrastructure variable (X2), the most important hands were water source and tool maintenance (X2.3), and the coefficient was 0.862. The coefficient of operational management tool (X2.4) was 0.601, the coefficient of water lake availability (X2.1) was 0.534, the sufficiency of electricity, roads, water distribution facilities (X2.2) with a coefficient of 0.516

Furthermore, governments' role variable (X3), the most important indicators were water supply and distribution (X3.1) and the coefficient was 0.714, the coefficient of an appropriate program with the societies' need (X3.2) was 0.679, coefficient of providing infrastructure assistance (X3.4) was 0.636, and efficient of concern to the society (X3.3) was 0.581. The most influence for instituting variable (X4) was a water treatment innovation (X4.4) and the coefficient was 0.801, coefficient of the function and role (X4.2) was 0.776, coefficient of vision and mission (X4.1) was 0.752, and coefficient of perfecting performance (X4.5) was 0.716. Tool acceptance behavior (X5), the most important indicators were the readiness to use the tool (X5.3) and the coefficient was 0.803, coefficient of readiness to tool maintenance (X5.4) was 0.769, the efficiency of health care behavior (X5.2) was 0.669, and efficiency of health care attitude (X5.1) was 0.534. The most influence for tool adoption variable (Y) was the tool application (Y3) which had coefficient 0.833, coefficient of the continuity of tool application (Y4) was 0.814, efficient of tool practically acceptance (Y1) was 0.757, and the acceptance of economic tool value had an efficiency of 0.740.

The result, finding of this study reinforces previous theories which explained that attention, awareness, perception, knowledge, and attitude were closed behavior and have not come to action form yet [27]. Changing attitude into actions needed to be supported by the existence of additional factors, such as facility and infrastructure. Adoption included the highest action [27]. This study also found that governments' role was significant enough to encourage adoption. The governments played a vital role to provide the infrastructure (such as roads and electricity). Besides, the governments were a policymaker and program maker of sustainable water supply for the society. Governments' role could be seen since the establishment of a lake water management institution, namely the Association of Drinking Water Users, whom establishment required permission from local government. This study showed that many factors must be considered to make the adoption could be realized.

IV. CONCLUSION

This study produced the structural model of water treatment tool adoption had a valid and reliable construct, and it did not show multicollinearity symptoms. The model included moderate in explaining the variance in tool adoption (36.7%) and variance in tool acceptance (36.5%). Some variables are not discussed in this model, such as respondents' characteristics, counseling, tools urgency, tools procurement, and assistance. Furthermore, variance in each indicator, which was shown in a model, varies from 11.7% - 74. 3%. The smallest variance was in the performance appraisal of tool indicator (X1.4) in the variety of society's perception of the tool (X1). In comparison, the most significant variance was found in the indicator of water source and tool maintenance (X2.3) in the infrastructure variables (X2). The limitation of variables in explaining the variance of tool adoption was the opportunities to develop this model.

The model had a limitation in explaining the variance, which was influencing it, but the model was good enough in observation and estimated the parameters. The model showed infrastructure variable (X2), governments' role (X3), and acceptance tool behavior (X5) were influenced directly and positively to the tool adoption (Y). Variables of society's perception of the tool (X1) and institutions (X4) were influencing indirectly and positively to the tool adoption (Y) mediated by tool acceptance behavior (X5). The most influence variable to the adoption was tool acceptance behavior, governments' role, and infrastructure. The practical application of the finding in this study was the need for the active part of the government in mobilizing stakeholders to realize the adoption of the water filter tool by the societies that used lake water. The government could embrace community leaders, Corporate Social Responsibility Companies, Non-Governmental Organizations, the private sector, experts from universities, and other stakeholders in funding and technical assistance. The real program could be carried out, such as intensive socialization about the quality of lake water, contaminant hazards, performance, and economic value of the tool. The next program after socializing was the tool procurement and assistance with the adoption process.

ACKNOWLEDGEMENT

This research was funded by the Education Fund Management Agency under the Ministry of Finance of the Republic of Indonesia and supported by the Regional Government of Gresik Regency and Brawijaya University, Indonesia.

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