ISSN 2541-223X

EVALUATION OF MODEL DEVELOPMENT OF URBAN ECO-DRAINAGE IN REGION SCALE

Sih Andayani[1*], Bambang. E.Yuwono[1]

[1]*Department of Civil Engineering, Faculty of Civil Engineering and Planning, Trisakti University, Jakarta, Indonesia*

ABSTRACT

Drainage problems in urban area have been even more complicated and need to be handled immediately. People in urban areas often experience flood and spatial puddles of water in rainy season lately, drought in dry season, as well as pollution on drainage water by liquid and solid waste (i.e. garbage). These conditions may disturb their activities and inflict them both moral and financial loss. The flood occurs because the river overflows, while puddle occurs because the flow of surface water that comes from the local rain water and wastewater from the surrounding area could not be accommodated by the drainage network. Drought occurs because of declining supplies of surface water and groundwater at the time of the dry season. Moreover, drainage water pollution occurs because of the lack of both Government and community roles. The problems of flooding, puddles, and drought in urban areas, which have been described previously cannot be solved with the old concept of urban drainage system, they can be overcome with the new concept instead. The old concept of urban drainage is to drain rainwater runoff into a nearby channel or water body as soon as possible, as for the new concept of drainage system is an Urban Eco-Drainage System where runoff rainwater will partially be detained first in the headwater, from then it will partially be permeated into the ground. The new concept of drainage system is also integrated with liquid and solid waste management, which is known as eco-drain. Therefore, eco-drainage system is expected to gain benefit for the environment sustainability. Guidelines and related researches on urban drainage performance assessment are available to access, as well as the concept of urban eco-drainage. In fact, identification process has been done on allegedly factors which can be used as key factors in evaluating whether an urban drainage system in one area has been in accordance with ecological concept of drainage system. From the previous research, it concluded that the key factors are: (1) technical management, and (2) non-technical management. Technical management consists of five key factors, such as (1) infiltration system, (2) drainage channel system, (3) complementary building systems, (4) storage system and (5) pump system. Non-technical management consists of two key factors, such as (1) the role of Government and (2) community participation. At this stage, the research aimed to acquire the indicator and the key factors that are most influential in the Eco-Drainage System. Analysis tool used for that purpose is the Partial Least Square (PLS) through the SMART PLS application version 3.00. The best factor in establishing Technical Management variable is the Storage System with the highest Significance Weight of 82.192. The best indicator in establishing the Non-Technical Management variable is the Government role with the highest Weight significance of 39,460. The best indicator in establishing variable on Eco-Drainage System Key Factor is Technical Management with the highest Weight significance of 39,460.

Keywords : Drainage; Eco-drain; Evaluation; Factor; Key; Model

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*Corresponding author's email: sandajani23@gmail.com , bey_trisakti@yahoo.com

1. INTRODUCTION

Drainage problems in urban area have been even more complicated and need to be handled immediately. People in urban areas often experience flood and spatial puddles of water in rainy season lately, drought in dry season, as well as pollution on drainage water by liquid and solid waste (i.e. garbage). These conditions disturb their activities and inflict them both moral and financial loss. The flood occurs because the river overflows, while puddle occurs because the flow of surface water that comes from the local rain water and wastewater from the surrounding area could not be accommodated by the drainage network. Drought occurs because of declining supplies of surface water and ground water at the time of the dry season. Moreover, drainage water pollution occurs because of the lack of both Government and community roles. The problems of flooding, puddles, and drought in urban areas, which has been described above cannot be solved with the old concept of urban drainage system, but can be overcome with the new concept.

The old concept of urban drainage is to drain rainwater runoff into a nearby channel or water body as soon as possible, as for the new concept of drainage system is an Urban Eco-Drainage System where runoff rainwater will partially be detained first in the headwater, from then it will partially be permeated into the ground. The new concept of drainage system is also integrated with liquid and solid waste management, which is known as eco-drain.

Therefore, eco-drainage system is expected to gain benefit for the environment sustainability. Guidelines and related researches on urban drainage performance assessment are available to access, as well as the concept of urban eco-drainage. In fact, identification process has been done on allegedly factors which can be used as key factors in evaluating whether an urban drainage system in one area has been in accordance with ecological concept of drainage system.

In the early result of research, Andayani and Endro Yuwono (2015) have determined the indicators and key factors which can be used to evaluate whether an urban drainage system in one area has been in accordance with ecological concept of drainage system. Those results are acquired from review study on the previous researches as well as guidelines published by the Ministry of Public Works.

To outline the aspects which allegedly can describe whether an urban eco-drainage system of region scale has been in accordance with ecological concept, are: (1) technical management, and (2) non-technical management. Technical management consists of five key factors, such as (1) infiltration system, (2) drainage channel system, (3) complementary building systems, (4) water basin system, and (5) water pump system. Non-technical management consists of two key factors, such as (1) government participation and (2) community role.

However, the research result has not been included the testing phase to test whether those factors are valid and they have not been brought in the weighing value of each factor. So the proposed research question was about what factors and how heavy is each of key factor that can be used in the evaluation model of region-scaled urban eco-drainage.

2. METHODOLOGY/ EXPERIMENTAL

Methods used in this research are:

1. Developing the questionnaire to test all factors and indicators which allegedly can describe whether an urban eco-drainage system of region scale has been in accordance with ecological concept or not.
2. Conducting a comprehensive survey by spreading questionnaires to all related parties to get the determining factors of urban eco-drainage system performance. Related parties who were involved in this research are various government agencies related to urban drainage management, industrial society that utilizes drainage channels (the industrial community, the public), urban drainage observers (profession bodies, NGOs), and universities.
3. Conducting test on the determining factors of urban eco-drainage system performance at region scale, so both factors and indicator are obtained in order to identify which urban drainage has been in accordance with ecological concept by using Partial Least Square Analysis.

3. RESULTS

At this stage, the research was aimed to acquire the indicator and the key factors that are most influential in the Eco-Drainage System. Analysis tool used for that purpose is the Partial Least Square (PLS) through the SMART PLS application version 3.00. Another method used in this research is Confirmatory Factor Analysis. By using this tool, existing indicators can be proven that they are able to explain a variable. The purpose of this measurement model is to describe how well the indicators in this research can be used as a measurement instrument for the latent variables.

Evaluation on validity of measurement model can be done by looking at the loading factors estimation results. A variable can be labeled as valid (to its latent variable) when its standard loading factor (LF) is higher or equal to 0.50 (≥ 0.50); and/or T-value of loading factor is bigger than the critical value (≥ 1.96). Moreover, evaluation on reliability of measurement model in PLS can be done by using Average Variance Extracted (AVE) higher or equal to 0.50 and Composite Reliability (CR) higher or equal to 0.70.

In order to find out which factors have more important role, it can be done by looking at the highest Loading Factor score, as for the most decisive indicator can be seen from the highest Weight Significance score. The recapitulation of evaluation results on validity and reliability evaluation can be seen in Table 1 and 2.

Tabel 1. Stage 1 of Measurement Model Evaluation (1st Order Outer Model) Before Elimination

Indicator	Factor	Convergent Validity LF≥ 0.5=valid			AVE≥0.5=valid	
		LF	Notes	Rank	AVE	Notes
Infiltration System (A1)	*A1.1*	*0.361*	*Not valid*	*7*	*0.462*	*Not valid*
	A1.2	*0.462*	*Not valid*	*6*		
	A1.3	0.703	Valid	5		
	A1.4	0.851	Valid	2		
	A1.5	0.845	Valid	3		
	A1.6	0.899	Valid	1		
	A1.7	0.781	Valid	4		
	A1.8	*0.028*	*Not valid*	*8*		
Drainage Channel System (A2)	*A2.1*	*0.429*	*Not valid*	*7*	*0.383*	*Not valid*
	A2.2	*0.552*	Valid	*6*		

Indicator	Factor	Convergent Validity LF≥ 0.5=valid			AVE≥0.5=valid	
		LF	Notes	Rank	AVE	Notes
	A2.3	0.560	Valid	5		
	A2.4	0.743	Valid	3		
	A2.5	0.702	Valid	4		
	A2.6	0.825	Valid	1		
	A2.7	0.755	Valid	2		
	A2.8	*0.277*	*Not valid*	*8*		
Comple Mentary Building System (A3)	*A3.1*	*0.378*	*Not valid*	*7*	*0.486*	*Not valid*
	A3.2	0.708	Valid	5		
	A3.3	0.775	Valid	3		
	A3.4	0.825	Valid	2		
	A3.5	0.738	Valid	4		
	A3.6	0.850	Valid	1		
	A3.7	0.527	Valid	6		
Storage System (A4)	*A4.1*	*0.244*	*Not valid*	*8*	*0.418*	*Not valid*
	A4.2	*0.363*	*Not valid*	*7*		
	A4.3	0.666	Valid	4		
	A4.4	0.890	Valid	1		
	A4.5	0.634	Valid	5		
	A4.6	0.821	Valid	3		
	A4.7	0.836	Valid	2		
	A4.8	*0.474*	*Not valid*	*6*		
Pump System (A5)	A5.1	0.681	Valid	4	*0.394*	*Not valid*
	A5.2	*0.500*	*Not valid*	*6*		
	A5.3	0.568	Valid	5		
	A5.4	0.781	Valid	2		
	A5.5	*0.491*	*Not valid*	*7*		
	A5.6	0.770	Valid	3		
	A5.7	0.827	Valid	1		
	A5.8	*0.291*	*Not valid*	*8*		
The Role of Government (B6)	*B6.1*	*0.487*	*Not valid*	*11*	*0.486*	*Not valid*
	B6.2	0.765	Valid	2		
	B6.3	0.788	Valid	1		
	B6.4	0.613	Valid	7		
	B6.5	*0.366*	*Not valid*	*13*		
	B6.6	*0.304*	*Not valid*	*14*		
	B6.7	0.757	Valid	3		
	B6.8	0.595	Valid	8		
	B6.9	0.569	Valid	9		
	B6.10	0.645	Valid	6		
	B6.11	0.720	Valid	4		
	B6.12	0.72	Valid	4		
	B6.13	0.549	Valid	10		
	B6.14	*0.39*	*Not valid*	*12*		
	B6.15	*-0.011*	*Not valid*	*15*		

Indicator	Factor	Convergent Validity LF≥ 0.5=valid			AVE≥0.5=valid	
		LF	Notes	Rank	AVE	Notes
Community Participation (B7)	B7.1	0.717	Valid	3	0.504	Valid
	B7.2	0.627	Valid	7		
	B7.3	0.655	Valid	5		
	B7.4	0.815	Valid	2		
	B7.5	0.819	Valid	1		
	B7.6	0.637	Valid	6		
	B7.7	0.689	Valid	4		

Table 2 Stage 1 of Reliability Evaluation *(1st Order Outer Model)* Before Elimination

Variabel Latent	Indicator	Composite Reliability CR≥0.7=Reliable	
		CR	Notes
Technical Management (A)	Infiltration System (A1)	0.847	Reliable
	Drainage Channel System (A2)	0.819	Reliable
	Complementary Building System (A3)	0.862	Reliable
	Storage System (A4)	0.834	Reliable
	Pump System (A5)	0.827	Reliable
Non-Technical Management (B)	The Role of Government (B6)	0.867	Reliable
	Community Participation (B7)	0.890	Reliable

According to Table 1 and 2 above, we can know that several Loading Factor (LF) scores are ≥ 0.50 except on factors like A1.1, A1.2, A1.8, A2.1, A2.8, A3.1, A4.1, A4.2, A4.8, A5.2, A5.5, A5.8, B6.14, B6.15, B6.5, B6.6, B6.9, and most of indicators have AVE scores < 0.50.

It can be concluded that validity of all manifest variables towards latent variable is not good. As for reliability calculation, results show that all Composite Reliability (CR) results are ≥ 0.70. Because there are several factors which stated as invalid, the testing was repeated by considering some factors which are considered inappropriate to be followed up in the next research.

Upon this matter, the researcher considered to remove factors which have low weight factor value or do not reach good validity standards. The researcher reduced measurement indicators by removing the factors that tilted italics until the retesting results produced LF, AVE and CR value, which are in accordance with the standard of measurement model evaluation criteria. Analysis results in detailed are given in Table 3 and 4.

Table 3. Stage 1 of Measurement Model Evaluation (1st Order Outer Model) After Elimination)

Indicator	Factor	Convergent Validity LF≥ 0.5=valid			AVE≥0.5=valid	
		LF	Notes	Rank	AVE	Notes
Infiltration System (A1)	A1.3	0.668	Valid	5	0.696	Valid
	A1.4	0.873	Valid	2		
	A1.5	0.857	Valid	3		

Indicator	Factor	Convergent Validity LF≥ 0.5=valid			AVE≥0.5=valid	
		LF	Notes	Rank	AVE	Notes
	A1.6	**0.916**	**Valid**	**1**		
	A1.7	0.834	Valid	4		
Drainage Channel System (A2)	A2.3	0.510	Valid	5	0.541	Valid
	A2.4	0.742	Valid	3		
	A2.5	0.721	Valid	4		
	A2.6	**0.841**	**Valid**	**1**		
	A2.7	0.817	Valid	2		
Complementary Building System (A3)	A3.2	0.681	Valid	5	0.557	Valid
	A3.3	0.776	Valid	3		
	A3.4	0.836	Valid	2		
	A3.5	0.756	Valid	4		
	A3.6	**0.854**	**Valid**	**1**		
	A3.7	0.526	Valid	6		
Storage System (A4)	A4.3	0.611	Valid	4	0.616	Valid
	A4.4	**0.895**	**Valid**	**1**		
	A4.5	0.677	Valid	5		
	A4.6	0.830	Valid	3		
	A4.7	0.870	Valid	2		
Pump System (A5)	A5.1	0.659	Valid	4	0.567	Valid
	A5.3	0.519	Valid	5		
	A5.4	0.834	Valid	2		
	A5.6	0.810	Valid	3		
	A5.7	**0.882**	**Valid**	**1**		
The Role Of Government (B6)	B6.2	0.769	Valid	2	0.521	Valid
	B6.3	**0.782**	**Valid**	**1**		
	B6.4	0.646	Valid	7		
	B6.7	0.759	Valid	3		
	B6.8	0.581	Valid	8		
	B6.9	0.711	Valid	9		
	B6.10	0.733	Valid	6		
	B6.11	0.766	Valid	4		
	B6.12	0.720	Valid	4		
Community Participation (B7)	B7.1	0.717	Valid	3	0.520	Valid
	B7.2	0.586	Valid	7		
	B7.3	**0.828**	**Valid**	**5**		
	B7.4	0.818	Valid	2		
	B7.5	0.664	Valid	1		
	B7.6	0.699	Valid	6		
	B7.7	0.705	Valid	4		

ISSN 2541-223X

Table 4 Stage 1 of Reliability Evaluation *(1st Order Outer Model)* After Elimination

Variable Latent	Indicator	Composite Reliability CR≥0.7=Reliable	
		CR	Notes
Technical Management (A)	Infiltration System (A1)	0.919	Reliable
	Drainage Channel System (A2)	0.852	Reliable
	Complementary Building System (A3)	0.881	Reliable
	Storage System (A4)	0.887	Reliable
	Pump System (A5)	0.864	Reliable
Non-Technical Management (B)	The Role of Government (B6)	0.896	Reliable
	Community Participation (B7)	0.882	Reliable

Based on Table 3 and 4 above, it can be seen that all Loading factor values are ≥ 0.50, and all AVE values are ≥ 0.50. Therefore, it can be concluded that validity of all manifest variables to their latent variables are good. The reliability measuring result shows that all latent variables have good reliability result.

4. DISCUSSION

The key factor which dominantly contributes to latent construct is as follows:

1. Factor that is good in establishing **InfiltrationSystem** Indicator **(A1)** is **A1.6** (sediment handling in infiltration system) with the highest loading factor of **0.916**.
2. Factor that is good in establishing **Drainage Channel System** Indicator **(A2) is A2.6** (sediment handling in drainage system) with the highest loading factor of **0.841**.
3. Factor that is good in establishing **Complementary Building Systems** Indicator **(A3)** is **A3.6** (Wild vegetation handling on the complementary building) with the highest loading factor of **0.854**.
4. Factor that is good in establishing **Storage Systems** Indicator **(A4)** is **A4.4** (Waste handling in reservoir building) with the highest loading factor of **0.895**.
5. Factor that is good in establishing **Pump Systems** Indicator **(A5)** is **A5.7** (Wild vegetation handling in pump building) with the highest loading factor of **0.882**.
6. Factor that is good in establishing **Government Role** Indicator **(B6)** is **B6.3** (Determination of O & P Workforce Amount) with the highest loading factor of **0.782**.
7. Factor that is good in establishing **Community Participation** Indicator **(B7)** is **B7.3** (Community Participation in Reporting of any Puddles) with the highest loading factor of **0.828**.

Table 5 Stage 2 of Measurement Model Evaluation (2nd Order Outer Model)

Variable Latent	Variable Manifest	Significance Weight	Rule of Thumb	Notes	Rank
Technical Management (A)	Infiltration System (A1)	3.853	1.96	Valid	5
	Drainage Channel System (A2)	11.957	1.96	Valid	4
	Complementary Building System (A3)	15.271	1.96	Valid	3

Variable Latent	Variable Manifest	Significance Weight	Rule of Thumb	Notes	Rank
	Storage System (A4)	**82.192**	**1.96**	**Valid**	**1**
	Pump System (A5)	15.781	1.96	Valid	2
Non Technical Management (B)	The Role of Government (B6)	**64.276**	**1.96**	**Valid**	**1**
	Community Participation (B7)	37.153	1.96	Valid	2

According to Table 5 above, it can be seen that all Weight Significance values are ≥ 1.96. It leads to a conclusion that validity of all manifest variables towards their latent variables is good. The best indicators in establishing Technical management variable (A) are **Storage System (A4)** with the highest Weight Significance of **82.192**. The best indicators in establishing Non-Technical management variable (B) are **Government Role (B6)** with the highest Weight Significance of **64.276**.

Tabel 6 Stage 3 of Measurement Model Evaluation (3rd Order Outer Model)

Variable Latent	Variable Manifest	Significance Weight	Rule of Thumb	Notes	Rank
Key Factor of Urban Eco-Drainage	Technical Management (A)	39.460	1.96	Valid	1
	Non-Technical Management (B)	18.550	1.96	Valid	2

According to Table 6 above, it can be seen that all Weight Significance values are ≥ 1.96. It leads to a conclusion that validity of all manifest variables towards their latent variables is good. The best indicator in establishing the variable of Urban Eco-Drainage System Key Factor is **Technical Management (A)** with the highest Weight Significance of **39.460**.

Thus statistical-based recommendation stated that when the authorities want to improve the result of Eco-Drainage System value, then they can prioritize the increase of **Technical Management (A).**

The reasons to prioritize that variable is because it was statistically stated to have the highest Weight value of **39.460**, which the best indicator in need of improvement is **Management Techniques** variable **(A)** with the indicator of **Storage System (A4)** with the highest Significance Weight value of **82.192**. As for dominant key factor in giving contribution to **Storage System (A4)** is **A4.4** factor (Waste handling in reservoir building) with the highest loading factor of **0.895**. See also Figure 1 and 2.

ISSN 2541-223X

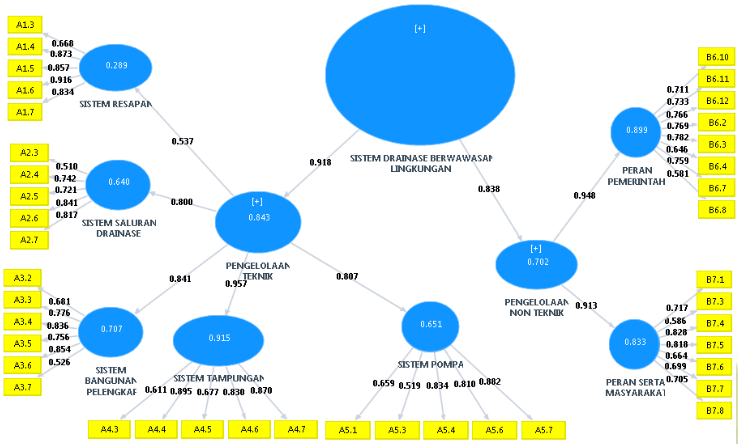

Figure 1 Diagram of Stage 1 of Measurement Model Evaluation (1st Order Outer Model)

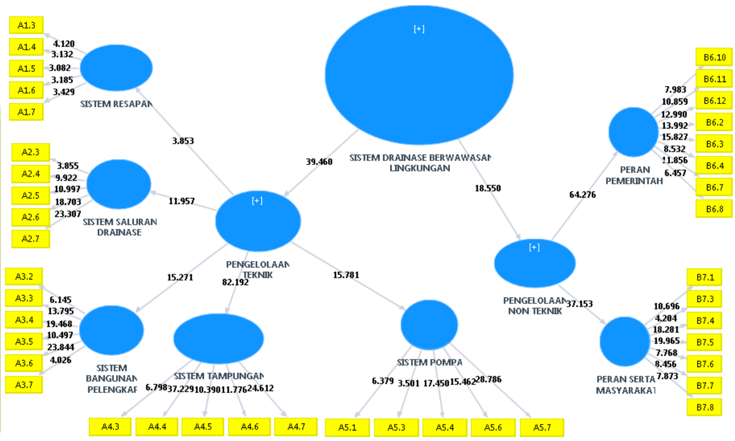

Figure 2 Diagram of *Significance Weight* of Stage 2 and 3 of Measurement Model Evaluation

5.CONCLUSION

It can be concluded that the validity of all the manifest variables to the latent variable is good. The most dominant key factors in contributing to the latent construct are as follows:

1. The best factor in establishing an **Infiltration System** indicator **(A1)** is **A1.6** (sediment handling in the infiltration system) with the highest loading factor of **0.916.**
2. The best factor in establishing a **Drainage Channels System** indicator **(A2)** is **A2.6** (sediment handling in the drainage channels) with the highest loading factor of **0.841.**
3. The best factor in establishing a **Complementary Building System** indicator **(A3)** is **A3.6** (Wild vegetation handling on the complementary building) with the highest loading factor of **0.854.**
4. The best factor in establishing a **Storage Systems** indicator **(A4)** is **A4.4** (Waste handling on the complementary building) with the highest loading factor of **0.895.**
5. The best factor in establishing a **Pump Systems** indicator **(A5)** is **A5.7** (Wild vegetation handling on the pump systems) with the highest loading factor of **0.882.**

6. The best factor in establishing **Government Role** indicator **(B6)** is **B6.3** (Determination of O & P Workforce Amount) with the highest loading factor of **0.782.**
7. The best factor in establishing **Community Participation** indicator **(B7)** is **B7.3** (Community role in reporting of any puddles) with the highest loading factor of **0.828.**

The best factor in establishing Technical Management (A) variable is the **Storage System (A4)** with the highest Significance Weight of **82.192.** The best indicator in establishing the Non-Technical Management (B) variable is the **Government role (B6)** with the highest Weight significance of **39.460**.

The best indicator in establishing variable on Eco-Drainage System Key Factor is **Technical Management (A)** with the highest Weight significance of **39.460**.

When the authorities want to improve the result of Eco-Drainage System value, then they can prioritize the waste management on the Reservoir building. Statistically, **Technical Management (A)** variable has the highest Weight significance of **82.192** with the key factor which dominantly gives contribution to **Reservoir System (A4)** is waste management on reservoir building **(A4.4)** factor with the highest loading factor of **0.895**.

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