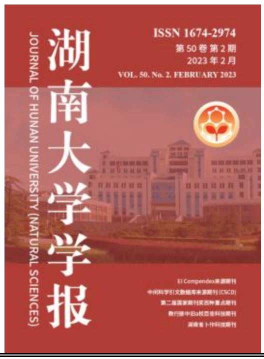


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# The Limiting Indicator of Variables in the Performance Index Modeling for Simple Waterworks

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**Abstract:** This research intends to evaluate a variable scheme based on the condition of a simple waterworks system in the Brantas river area to obtain the variables that influence each other. This research was conducted in 30 water sources that are distributed in the Brantas river area such as Batu, Malang Regency, Blitar Regency, Jombang Regency, Kediri Regency, Nganjuk Regency, and Tulungagung Regency. The methodology consists of identifying the affected variables to the bron-capturing and to evaluate the indicators that are influenced the variables, then to conduct the statistic test of the indicators to the variables. The research indicators about the performance index model of simple waterworks are obtained through the partial least square (PLS) method. The PLS method is used for evaluating the influenced relationship among the variables that are used in this research, such as the variables of technical, social, and management aspects. The technical aspect consists of physical infrastructure, service, operation, environment damage, and maintenance; the social aspect consists of economy and socio-culture conditions; the management aspect consists of water management institutions, human resources, and monetary aspect. Based on the $t_{calculated}$ analysis of the inner model, where t variable statistic of the technical aspect is 11.632, the social aspect is 3.017, and management aspect is 4.665, each variable has the $t_{calculated}$ higher than $t_{critic}$ (1.682) due to the level of significance ($\alpha$) = 0.05 or the p value of 0.000, and it is less than the critic value (0.05). Based on the regression analysis, it can be concluded that the technical aspect has the most effect (72.1%) on the performance index model of simple waterworks in the Brantas river area. The second biggest effect is the management aspect (26.7%) in influencing the performance index model of simple waterworks in the Brantas river area. Then, the lowest effect is the social aspect (15.1%) in affecting the performance index model of simple waterworks in the Brantas river area. This result is necessary for supporting the performance index modeling of simple waterworks.

**Keywords:** indicator, variable, bron-capturing, waterworks.

# 简易自来水厂性能指标建模中的变量限制指标

**摘要：**本研究拟基于布兰塔斯河流域一个简单水厂系统的条件对变量方案进行评估，以获得相互影响的变量。这项研究是在分布在布兰塔斯河地区的 30 个水源地进行的，如巴图、玛琅摄政区、勿里达摄政区、琼邦摄政区、吉迪里摄政区、干竹摄政区和图隆加贡摄政区。该方法包括识别影响捕获的变量和评估影响变量的指标，然后对变量进行指标的统计检验

。通过偏最小二乘法(求助)得到简易自来水厂性能指标模型的研究指标。求助方法用于评估本研究中使用的变量之间的影响关系，例如技术、社会和管理方面的变量。技术方面包括物理基础设施、服务、运营、环境破坏和维护；社会方面包括经济和社会文化条件；管理方面包括水管理机构、人力资源和资金方面。基于内模型的计算分析，其中技术方面的吨变量统计量为 11.632，社会方面为 3.017，管理方面为 4.665，由于水平的原因，各变量的吨计算值均高于批评的（1.682）显着性(α) = 0.05 或 p 值为 0.000，且小于临界值(0.05)。基于回归分析可以得出结论，技术方面对布兰塔斯河流域简易自来水厂性能指标模型的影响最大（72.1%）。第二大影响是管理方面（26.7%）对布兰塔斯河地区简易水厂绩效指标模型的影响。然后，影响最低的是社会方面(15.1%)在影响布兰塔斯河地区的简单水厂性能指标模型。该结果对于支持简单水厂性能指标建模是必要的。

**关键词：**指标，变量，布朗捕获，自来水厂。

# 1. Introduction

Water is an important component in the ecosystem for life continuity of all creatures in the world [1], [2], it is due to that water is as the natural resources that cannot be replaced [3]. As a renewable resource, water is critical for supporting the biological processes [4], [5], providing the habitat for water creatures and in the water’s edge [6], supporting the development of vegetation and the creatures in the land and water [7], and facilitating the active distribution of water organisms [8].

The increasing in water resource demand, which is limited, is due to the happening of climate change, population growth, and the increasing in urbanization that causes a big challenge to the waterworks system, mainly in the developing country [6], [7]. The water resource systems in several areas in the world experience difficulty in fulfilling the need for drinking water and basic sanitation, even there is a water resource system in an area that has unable to support and maintain the toughness biodiversity ecosystem [4]. Loucks and van Beek mentioned some typical reasons for the disability of water resource system to fulfill the variety of water needs, caused by the inaccuracy, unsuitability, damaged infrastructure, withdrawal of the river flow in a bigger amount, systemic changes in water flow and sediment, etc. Inability of water resource systems to fulfill the water need often reflects the failure in design, management, and decision-making.

The performance index system [9], [10] of simple waterworks is an important part in waterworks [11], [12], mainly in the regions not reached by the PDAM service. The performance index is needed for obtaining a simple waterworks system to operate and give the service in the percentage value form for the assessment of the feasibility condition of a simple waterworks system; then, it can become the basis for the management of a simple waterworks system. This research intends to evaluate the variable scheme based on the condition of a simple waterworks system [13] in the Brantas river area to obtain the variables influencing each other and supporting modeling the performance index of simple waterworks systems.

# 2. Materials and Method

### 2.1. Research Location

The Brantas river area has a vital function for East Java Province for supplying the clean water for an amount of city and along the river flow. The Brantas river area is as a unit area of water resource management and the area is 1,410,300 ha that consists of 220 watersheds, including the biggest watershed, four little watersheds in the northern part, estuaries in the Java sea, 216 small watersheds in the southern part, and estuaries in the Samudera Hindia [14]. The research was conducted in a city and six regencies that have a water source in the Brantas watershed: Batu, Malang Regency, Blitar Regency, Jombang Regency, Kediri Regency, Nganjuk Regency, and Tulungagung Regency.

The simple waterworks system is an alternative of raw water preparation for some areas that do not obtain the services and are not reached by the PDAM, such as the residence near the water source in the Brantas river area. Several residences’ areas near the water source in the Brantas river area are reached by the PDAM network because the population in the areas is spread unevenly, and the location is not easily reached because they are located in the back country and hills. Based on the Ministry Rule (PUPR) No. 04/PRT/M/2015, the Brantas river area is one of the national strategic rivers, the area unity of water resource management, and the area of 1,410,300 ha, and the regulation is under the central government authority. The performance of a simple waterworks system can be evaluated using three parameters: technical aspect, social aspect, and management aspect.

### 2.2. Theoretical Foundation on the Performance Index Model of a Simple Waterworks System

From the previous studies, we can collect some parameters that support and dominantly influence the simple waterworks system, to be used as the basis for determining the variables of simple waterworks systems. The variables are classified into the technical, social, and management aspects, as presented in Table 1.

Table 1 Indicator of the performance index model of the simple waterworks system in the Brantas river area (Own study)

| No. | Variable | Dimension | Symbol | Indicator | |
|---|---|---|---|---|---|
| A | Technical aspect | Physic infrastructure | $T_1$ | 1 | Water source |
| | | | | 2 | Bron-capturing |
| | | | | 3 | Channel pipe (Bron-cap to Tank) |
| | | | | 4 | Water tank |
| | | | | 5 | Distribution pipe to society |
| | | | | 6 | Sediment filtering |
| | | | | 7 | Water quality (*Coliform*) |
| | | Service | $T_2$ | 8 | Technical service scope |
| | | | | 9 | Customer growth per-year |
| | | | | 10 | Complaint solving level |
| | | | | 11 | Customer of water domestic per-customer KK |
| | | Operational | $T_3$ | 12 | Efficiency of production (Production usage factor) |
| | | | | 13 | Service operation hour |
| | | | | 14 | Leakage in the bron-capturing tank (PMA) |
| | | | | 15 | The suitability of the existing bron-capturing tank (PMS) |
| | | | | 16 | Service water meter unit |
| | | | | 17 | Leakage in the service unit piping |
| | | | | 18 | Water pressure/Manometer |
| | | | | 19 | Monitoring of water quality in the service unit |
| | | Environment damage | $T_4$ | 20 | Natural factor |
| | | | | 21 | Human factor |
| | | Maintenance | $T_5$ | 22 | Monitoring of the piping network periodically |
| | | | | 23 | Checking the water quality periodically/ draining the water tank periodically |
| | | | | 24 | Updating the human resources knowledge periodically/updating the information to customer |
| B | Social aspect | Economy | $S_1$ | 25 | Prophesy |
| | | | | 26 | Society income |
| | | Socio-culture of society | $S_2$ | 27 | Education |
| | | | | 28 | Human activity |
| | | | | 29 | Society care to infrastructure |
| | | | | 30 | Society local wisdom/traditional culture |
| C | Management aspect | Water management institution | $M_1$ | 31 | Legal entity |
| | | | | 32 | Institution performance |
| | | Human resources | $M_2$ | 33 | Ratio of number of employee/1,000 customers |
| | | | | 34 | Ratio of employee training |
| | | Monetary | $M_3$ | 35 | Rentability |
| | | | | 36 | Activity |
| | | | | 37 | HIPPAM manager income |
| | | | | 38 | HIPPAM economy independence |
| | | | | 39 | The ability of HIPPAM to develop asset/ budget from HIPPAM for infrastructure need |

## 3. Results and Discussion

### 3.1. Variable and Indicator

The technical aspect criteria comprise five dimensions: (1) Physical infrastructure, with seven indicators ($T_{11}$-$T_{17}$); (2) Service, with four indicators ($T_{21}$-$T_{24}$); (3) Operational, with eight indicators ($T_{31}$-$T_{38}$); (4) Damage, with two indicators ($T_{41}$–$T_{42}$); (5) Maintenance, with three indicators ($T_{51}$–$T_{53}$).

The social aspect criteria comprise two dimensions: (1) Economy condition, with two indicators ($S_{11}$-$S_{12}$); (2) Socio-cultural condition of society, with four indicators ($S_{21}$-$S_{24}$).

The management aspect criteria comprise three dimensions: (1) Water management institution, with two indicators ($M_{11}$-$M_{12}$); (2) Human resources, with two indicators ($M_{21}$-$M_{22}$); (3) Monetary, with three indicators ($M_{31}$-$M_{32}$).

Based on the criteria of research variables, there are three variables with 10 dimensions, and 37 indicators, as presented in Table 2.

Table 2 Research variables (Own study)

| No. | Variable | Dimension | Symbol | Indicator | | Symbol |
|---|---|---|---|---|---|---|
| A | Technical aspect | Physical infrastructure | $T_1$ | 1 | Water source | $T_{11}$ |
| | | | | 2 | Bron-capturing | $T_{12}$ |
| | | | | 3 | Channel pipe (Bron-cap to Tank) | $T_{13}$ |
| | | | | 4 | Water tank | $T_{14}$ |
| | | | | 5 | Distribution pipe to society | $T_{15}$ |
| | | | | 6 | Sediment filtering | $T_{16}$ |
| | | | | 7 | Water quality (*Coliform*) | $T_{17}$ |
| | | Service | $T_2$ | 8 | Technical service scope | $T_{21}$ |
| | | | | 9 | Customer growth per-year | $T_{22}$ |
| | | | | 10 | Complaint solving level | $T_{23}$ |
| | | | | 11 | Customer of a domestic water per-customer KK | $T_{24}$ |
| | | Operational | $T_3$ | 12 | Efficiency of production (production usage factor) | $T_{31}$ |
| | | | | 13 | Service operation hour | $T_{32}$ |
| | | | | 14 | Leakage in the bron-capturing tank (PMA) | $T_{33}$ |
| | | | | 15 | The suitability of the existing bron-capturing tank (PMS) | $T_{34}$ |
| | | | | 16 | Service water meter unit | $T_{35}$ |
| | | | | 17 | Leakage in the service unit piping | $T_{36}$ |
| | | | | 18 | Water pressure/Manometer | $T_{37}$ |
| | | | | 19 | Monitoring of water quality in the service unit | $T_{38}$ |
| | | Environment damage | $T_4$ | 20 | Natural factor | $T_{41}$ |
| | | | | 21 | Human factor | $T_{42}$ |
| | | Maintenance | $T_5$ | 22 | Monitoring of the piping network periodically | $T_{51}$ |
| | | | | 23 | Checking the water quality periodically/ draining the water tank periodically | $T_{52}$ |
| | | | | 24 | Updating the human resources knowledge periodically/updating the information to customer | $T_{53}$ |
| B | Social aspect | Economy | $S_1$ | 25 | Prophesy | $S_{11}$ |
| | | | | 26 | Society income | $S_{12}$ |
| | | Socio-culture of society | $S_2$ | 27 | Education | $S_{21}$ |
| | | | | 28 | Human activity | $S_{22}$ |
| | | | | 29 | Society care for the infrastructure | $S_{23}$ |
| | | | | 30 | Society local wisdom/traditional culture | $S_{24}$ |
| C | Management aspect | Water management institution | $M_1$ | 31 | Legal entity | $M_{11}$ |
| | | | | 32 | Institution performance | $M_{12}$ |
| | | Human resources | $M_2$ | 33 | Ratio of number of employee/1,000 customers | $M_{21}$ |
| | | | | 34 | Ratio of employee training | $M_{22}$ |
| | | Monetary | $M_3$ | 35 | Rentability | $M_{31}$ |
| | | | | 36 | Activity | $M_{32}$ |
| | | | | 37 | HIPPAM manager income | $M_{33}$ |
| | | | | 38 | HIPPAM economy independence | |
| | | | | 39 | The ability of HIPPAM to develop asset/ budget from HIPPAM for infrastructure need | |

In this research, irrigation that is used as test sampling includes 21 districts: Junrejo, Doko, Wonotirto, Kesamben, Gandusari, Panggungrejo, Wlingi, Wonosalam, Puncu, Ngantang, Tumpang, Pujon, Gedangan, Nglayu, Kertosono, Bandung, Canpur Darat, Sendang, Kalidawir, Puncanglaban, and Pagerwojo. This survey is conducted for obtaining the criteria value of each variable and index such as criteria of the technical, social, and management aspects.

### 3.2. The Results of SEM-PLS

#### *3.2.1. Validation Test Results*

The analysis result for each research indicator is as follows:

a) The outer loading value of 5 rest indicators in the physical infrastructure variable ($T_1$) that consist of water quality ($T_{1.2}$), distributed pipe to society ($T_{1.3}$), water source ($T_{1.4}$), connection pipe/bron-cap to the tank ($T_{1.6}$), and bron-capturing ($T_{1.7}$), which all of them have a loading factor value > 0.5, so the 5 rest indicators can be continued to the next stage of research analysis.

b) The outer loading value of two indicators in the service variable ($T_2$), scope of technical service ($T_{2.2}$) and water domestic consumption by a per-customer/KK ($T_{2.3}$), has a loading factor value > 0.5, so the three indicators can be continued to the next stage of research analysis.

c) The outer loading value of 3 indicators in the operational variable ($T_3$) that are: leakage in the service unit piping ($T_{3.1}$), monitoring water quality in the service unit ($T_{3.2}$), and leakage in the tank of bron-capturing (PMA) ($T_{3.3}$) have a loading factor value > 0.5, so the two indicators can be continued to the next stage of research analysis.

d) The outer loading value of two rest indicators in the environment damage variable ($T_4$) that are: natural factor ($T_{4.1}$), and human factor ($T_{4.2}$), have a loading factor value > 0.5, so the two rest indicators can be continued to the next stage of research analysis.

e) The outer loading value of 3 rest indicators in the Maintenance variable ($T_5$) that are: monitoring the piping network periodically ($T_{5.1}$), controlling the water quality periodically/ to drain the water tank periodically ($T_{5.2}$), and update the human resources knowledge periodically/update the information to society ($T_{5.3}$) have a loading factor value > 0.5, so the three rest indicators can be continued to the next stage of research analysis.

f) The outer loading of two rest indicators in the economy variable ($S_1$) that are: prophesy ($S_{1.1}$), and society income ($S_{1.2}$) have a loading factor > 0.5, so the two rest indicators can be continued to the next stage of the research analysis.

g) The outer loading value of two indicators in the society socio-culture ($S_2$) that are: society care to the infrastructure ($S_{2.3}$), and society local wisdom/ society culture traditional ($S_{2.4}$), have a loading factor > 0.5, so the two indicators can be continued to the next stage of research analysis.

h) The outer loading value of 2 rest indicators in the water management institution variable ($M_1$) that are: legal entity ($M_{1.1}$), and institution performance ($M_{1.2}$), have a loading factor > 0.5, so the two rest indicators can be continued to the next stage of research analysis.

i) The outer loading value of 2 rest indicators in the human resources variable ($M_2$) that are: ration number of employer/1000 customers ($M_{2.1}$), and ratio of employer training ($M_{2.2}$), have a loading factor value > 0.5, so the two rest indicators can be continued to the next stage of research analysis.

j) The outer loading of three rest indicators in the monetary variable ($M_3$) that are: administrator income of HIPAM ($m_{3.3}$), economy independence of HIPAM ($m_{3.4}$), and ability of HIPAM to develop asset/ budget from HIPAM for infrastructure need ($m_{3.5}$) have a loading factor value > 0.5; the three rest indicators can be continued to the next stage of research analysis.

*3.2.2. Results of the Reliability Test*

The reliability test of data is carried out for measuring the stability consistence of data that is score in the form of a measurement scale in an instrument which in further can be used for measuring the certain concept and helping the goodness value of a measurement instrument. The quality test of data is carried out by seeing the composite reliability value that is produced using SmartPLS of the research variable: Physical infrastructure ($T_1$), Service ($T_2$), Operational ($T_3$), Environment damage ($T_4$), Maintenance ($T_5$), Economy ($S_1$), Society socio-culture ($S_2$), Water management institution ($M_1$), Human resources ($M_2$), and Monetary ($M_3$).

The composite reliability value can be said to be good if the composite reliability value: $\rho c > 0.8$, so it is said that the construct has the high reliability or reliable and $\rho c > 0.6$ is said to be reliable enough and the Average Variance Extracted (AVE) value is good if > 0.50. The result of the reliability test for the whole variables is presented as in Table 3.

Table 3 Reliability test (Own study)

| **No.** | **Variable** | **Average Variance Extracted (AVE)** | **Composite Reliability** |
|---|---|---|---|
| **(1)** | **(2)** | **(3)** | **(4)** |
| 1 | Physic infrastructure ($T_1$) | 0.608 (reliable) | 0.885 (high reliability) |
| 2 | Service ($T_2$) | 0.635 (reliable) | 0.776 (high reliability) |
| 3 | Operational ($T_3$) | 0.704 (reliable) | 0.877 (high reliability) |
| 4 | Environment damage ($T_4$) | 0.726 (reliable) | 0.842 (high reliability) |
| 5 | Maintenance ($T_5$) | 0.707 (reliable) | 0.878 (high reliability) |
| 6 | Economy ($S_1$) | 0.838 (reliable) | 0.912 (high reliability) |
| 7 | Socio culture of society ($S_2$) | 0.709 (reliable) | 0.829 (high reliability) |
| 8 | Water management institution ($M_1$) | 0.816 (reliable) | 0.899 (high reliability) |
| 9 | Human resources ($M_2$) | 0.681 (reliable) | 0.810 (high reliability) |
| 10 | Monetary ($M_3$) | 0.612 (reliable) | 0.825 (high reliability) |

The results of the reliability test above show that all research variables are the fit measurers that the reliability test can use as the criteria: average variance extracted (AVE) or composite reliability (CR).

Based on the result in the table above, all variables that are researched from all of question items that will be used are generally having good reliability.

*3.2.3. The Value of the Inner and Structural Models*

The hypothesis test is based on the value in the analysis of the structural model; a significant level of path coefficient is obtained from the $t_{calculated}$ value and the standardized path coefficient value. The value limitation of the hypothesis test is the value of $t_{calculated}$ of the loading factor has to be more than the critical value (≥ 1.682) due to the level of significant (α) = 0.05. Table 4 presents the coefficient of the path.

Table 4 Path coefficient (Own study)

| No. | Path Coefficient | Original Sample | Sample Mean | T Stat | p Values |
|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) |
| 1 | Technical aspect → Performance index model of waterworks system in the Brantas river area | 0.721 | 0.718 | 11.632 | 0.000 |
| 2 | Social aspect → Performance index model of waterworks system in the Brantas river area | 0.151 | 0.138 | 3.017 | 0.003 |
| 3 | Management aspect → Performance index model of waterworks system in the Brantas river area | 0.267 | 0.273 | 4.665 | 0.000 |

Based on the result of the structural model test that is in the table of path coefficient above, it can be concluded that: 1) Technical aspect consists of physical infrastructure (water quality/coliform, distributed piping to society, water source, connection pipe/bron-cap to the tank, and bron-capturing), service (technical service scope and domestic water consumption per-customer), operational (leakage in the service unit piping, monitoring of water quality in service unit and leakage in the tank bron-capturing/PMA), environment damage (natural factor and human factor), maintenance (usage of piping network periodically, controlling the water quality periodically/to drain the water tank periodically, update the human resources knowledge periodically/update the information to customer). 2) Social aspect consists of economy (prophesy and society income), socio-culture condition (society care to infrastructure, and society local wisdom/traditional culture), 3) Management aspect consists of water management institutions (legal entity, institution performance), human resources (ratio number of employer/1,000 customers and ratio employer training), monetary (HIPAM administrator income, HIPAM economy independence, the ability of HIPAM to develop asset/budget from HIPAM for infrastructure need) has a positive and significant effect on the performance index model of a simple waterworks system in the Brantas river area. It can be seen based on the $t_{calculated}$ in the analysis of the inner model, which the t statistic of the technical aspect is 11.632, the social aspect is 3.017, and the management aspect is 4.665. Each variable has the $t_{calculated}$ higher than the critical value (≥ 1.682) due to the significance level of (α) = 0.05 and/or p value of 0.000; it is lower than the critical value (≤ 0.05).

# 4. Conclusion

The composite reliability value can be said to be good if the composite reliability value: ρc > 0.8, so it is said that the construct has the high reliability or reliable and ρc > 0.6 is said to be reliable enough and the average variance extracted (AVE) value is good if > 0.50. The results of the reliability test above show that all research variables are the fit measurers that the reliability test can use as the criteria: average variance extracted (AVE) or composite reliability (CR). Based on the result in the table above, all variables that are researched from all of question items that will be used are generally having good reliability.

This research intends to evaluate the variable scheme based on the condition of a simple waterworks system in the Brantas river area to obtain the variables influencing each other and supporting modeling the performance index of simple waterworks systems.

Based on the result of the structural model test that is in the table of the path coefficient above, it can be concluded that: the ability of HIPAM to develop asset/budget from HIPAM for infrastructure need) has a positive and significant effect on the performance index model of the simple waterworks system in the Brantas river area. It can be seen based on the $t_{calculated}$ in the analysis of the inner model, where the t statistic of the technical aspect is 11.632, the social aspect is 3.017, and the management aspect is 4.665. Each variable has the $t_{calculated}$ higher than the critical value (≥ 1.682) due to the significance level of (α) = 0.05 and/or p value of 0.000; it is less than the critical value (≤ 0.05).

Based on the regression analysis, it can be concluded that the technical aspect has the most effect (72.1%) on the performance index model of simple waterworks in the Brantas river area. The second biggest effect is the management aspect (26.7%) in influencing the performance index model of simple waterworks in the Brantas river area. Then, the lowest effect is the social aspect (15.1%) in affecting the performance index model of simple waterworks in the Brantas river area.

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