International Journal on Advanced Science Engineering Information Technology

Vol.14 (2024) No. 3
ISSN: 2088-5334

Performance Evaluation of Jakarta Polder Based on the Sustainable Urban Polder Model (SUPM)

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Abstract—**Although economic and institutional reports have yielded relevant insights, they have not been linked to the polders' performances since the Jakarta flood control study 2004. As a result, two crucial shortcomings have arisen: the absence of an integrated conclusion and a deficiency in model assessment. The Sustainable Urban Polder Model (SUPM) was developed to integrate Technical, Financial, and Institutional (TFI) aspects to address this gap. This research addresses two core questions: First, what is the structure of the SUPM? Second, what insights can be gleaned regarding the Polder Boards? This research aims to formulate SUPM and investigate the Polder Board's impact on Pluiton Pulo Mas and Pantai Indah Kapuk (PIK) Polders. The formulation of SUPM is conducted using the Partial Least Squares- Structural Equation Model (PLS-SEM). Further, the PLS-SEM's i) R^2 is utilized as model validation and ii) the weight-value to describe the impact of inter TFI. The sustainable management construct's R^2 of Pluit, Pulo Mas, and PIK attain 49.2%, 35.9%, and 96.2 %, respectively. The polder's technical construct's R^2 towards inundation in Pluit, Pulo Mas, and PIK Polders, respectively, attains R^2 = 68.3%, R^2 =94.5% and R^2 = 26.0%. The pathway of Sustainable Management towards Open Water reveals that PIK Polder has a positive contribution (+0.606) due to its operational management. Conversely, Pluit and Pulo Mas Polders exhibit negative weight values (-0.396 and -0.866, respectively), indicating the risk of inability to maintain the open water storage. Consequently, establishing Polder Boards is essential for these polders.**

Keywords— **Polder Board; partial least squares; structural equation model; polder management; flood risk**

Manuscript received 17 May. 2023; revised 29 Jan. 2024; accepted 15 Apr. 2024. Date of publication 30 Jun. 2024.

I. INTRODUCTION

During 2004-2005, Consulting Service for Drainage Management for Jakarta: Strategic Action Program Development (DKI 3-9) conducted the capacity building report, which led to the Polder Management Organization (OPP), which consisted of strategic and executing levels with some duties. The first duty is the management of the system under the concept of partnership. The second duty is the defrayal of the system by society's retribution. The third duty is business strategy and service [1]. Further, an economic report was also released, consisting of a feasibility analysis and a comparison between the project's budget requirement and Governmental budget availability for a specific implementation period, usually five years [2]. In addition, a community empowerment report was also prepared, which contained the project's social impact and the community's perception and response towards land acquisition, relocation, and organization of drainage management and funding [3].

During 2007-2009, the four volumes of urban polder guidelines, i.e., general [4], institutional [5], technical [6], and case study of Banger [7], were produced under MoU between the Indonesian Ministries of Public Works and the Netherlands Ministries of Transport, Public Works and Water Management, and of Spatial Planning, Housing and Environment. Those volumes described the polder development aspects in an integrated way; for instance, the technical guidelines report was not limited to the sections of design and construction but also included the socio-economic analysis on poverty level and the importance of urban polder to minimize the impact towards the weak and the poor and to create mutualism between rural and urban areas [8].

In 2009, a project to Review the Master Plan (MP) of flood mitigation and urban drainage system in Jakarta also conducted a socio-economic analysis under preliminary [9] and final reports [10]. MP 2009's initial report, The Study on Comprehensive River Water Management Plan in Jabotabek (MP 1997), stated that understanding the foundation and its causes must be common knowledge among stakeholders, including laypeople [11]. Moreover, in the final report, the socio-economic analysis covered population, educational facilities, infrastructures, and *Pendapatan Asli Daerah* (Original Local Government Revenue). Population analysis was orientated to inform about household quantities, population density, the number of house members, and melancholy and population growth. Despite those scopes, the final was the absence of a conclusion and recommendations, which either stemmed from socioeconomics or impacted the flood control.

The preceding reports, from 1997 to 2009, suggested that Polder's aspects were not limited to technical but included socioeconomics and institutional. There were relationships among Polder's aspects that interacted towards the good/sustainable polder condition. It is also noticeable that due to an unestablished model to utilize them in an integrated way, the data processing might be limited to concentrate on the technical aspect, as in MP 2009. This situation creates the demand for modeling the integrated aspects of the polder to ensure its sustainability.

A. *Literature Review: Formulation of the Sustainable Urban Polder Model (SUPM)*

1) Sustainability: Sustainability has been adopted as an indicator for Indonesia's sustainable infrastructure development, mainly through the Triple Bottom Line (TBL) [12], which consists of profit, people, planet (3Ps) [13] or 3 pillars of social, environment and economy [14]. Polder development is classified as infrastructure development; hence the 3Ps apply. However, this has not yet been reflected in practice because urban polder guidelines were published in 2009. Therefore, it becomes necessary to formulate a sustainable urban polder model that reflects the 3Ps.

2) Considerations: A broad spectrum of polder aspects, data, and objectives create multitudes of urban polder's integrated aspects model. To prioritize the relevant model structure, the process must consider governance, what is already certain, priority, and method. Firstly, governance means that the Ministry of Public Works (MPW)/Pussosekling (Research Center for Social, Economic, and Environment) has been mandated to enhance the urban polder guidelines since 2008 [15]. Following that, the various aspects of Polder were grouped into technical, financial, and institutional (TFI) aspects with respected coverage as follows:

- Design, construction, operation and maintenance.
- Sources of financing (private partnership [16], polder fee, other sources), schemes, and components to be financed.
- Polder board, management, partnership, community participation [17], [18].

This TFI of the polder is an approach after the standard for integrated aspects of infrastructure analysis. Secondly, what is already specific means that the Polder Board is the designated Indonesia polder management organization; hence, this entity, with its financial characteristics of revenue generating and polder fee retribution, is elemental in a polder model [19]–[21]. Further, the polder is experiencing decremental factors such as sea level rise (SLR) [22]–[24], land subsidence [25]–[28], and squatters [29]–[32]**.** Thirdly, priority means that setting up a Polder Board and community participation in the Polder fee becomes a priority between 2010-2030. This has been proposed by the DKI 3-9 study, the urban polder guidelines and recently in 2009 by the Academic Draft of RTRW 2010-2030 [33]. Finally, by *method*, the selected method needs to address the TFI relationships and sound governance principles, particularly transparency and participatory [34] in terms of being easily perceived by untrained participants and the ability to simulate the scenario of improvements.

*3) TFI variables***:** Following the TFI approach and its coverages, both the Financial and Institutional aspects may have hierarchical relationships in which the institutional aspect (polder board and management function) precedes the financial aspect. In addition, apart from legal and organizational structure, the polder board can be represented by its management function. This impacts the structure of SUPM, i.e., management shall be a construct measured by the financing function: share responsibilities among the Government, the business sector, and the community [35]. Moreover, the Polder Board shall have a vision of polder management that decides the technical aspect; hence, the management variable shall impact the technical aspect.

In terms of technical aspects, the Academic draft of RTRW DKI Jakarta 2020-2030 advises the open water storage (retention capacity) -pumping capacity graph (Fig.1) [36]**.** Open water storage may include an urban drainage system with a retention basin. Financially, pumping and retention basin and urban drainage consumed 23% (typical) to 82% of the total polder costs [37]. Hence, reducing the storage capacity and triggering the demand for a larger pumping capacity are among the risks that could burden the financial, institutional, and technical aspects.

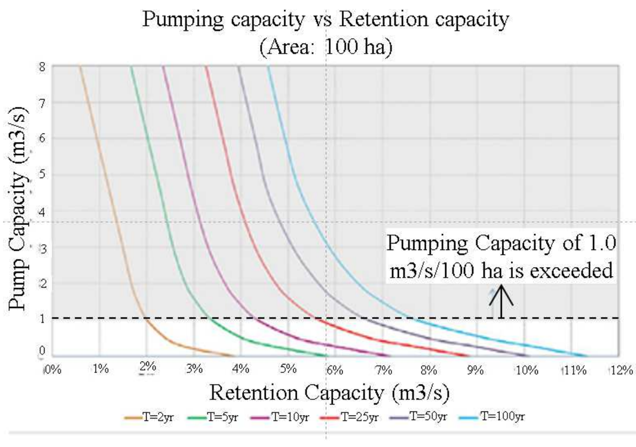

Fig. 1 Retention capacity and pumping capacity

Open water storage-pumping capacity aims to attain the *SPM* (Minimum Service Standard) in the drainage sector, which is to prevent inundation of more than 30 cm longer than 2 hours or more than two times annually [38]. The open water storage, pumping capacity, and inundation create a three-tracked relationship that must be analyzed in one package.

Moreover, the technical aspect of polders in DKI Jakarta has been experiencing several challenges, e.g., Sea Level Rise, land subsidence [39], and illegal occupation (squatter). As those factors determine the performance of polders and could be a test of the Polder Board, they would be beneficial to be included as variables in SUPM.

4) Method for model development: In terms of method, at least statistical correlation, composite index, and Partial Least Squares-Structural Equation Model (PLS-SEM) have been evaluated, which led to the latter as the most suitable method [40], [41]. The utilization of a Covariance-Based (CB) Structural Equation Modelling (SEM) in flood protection and control research can be traced back to 2012 when SEM was applied to formulate the model of the index of urban drainage service, which consisted of 4 non-technical variables (10 indicators) and 5 technical variables (28 indicators) [42]. This model was developed to provide a tool to evaluate the drainage service performance as mandated by Ministry of Public Works Regulation Number 14/PRT/M/2010. Moreover, in 2018, SEM was applied to formulate the urban drainage network's service index modeling, consisting of 3 technical variables and 5 non-technical variables [43].

In 2020, PLS-SEM was applied to develop the index model of the polder system. This publication appeared as follows:

- A doctoral research grant that combined 4 technical variables of 13 indicators and 4 non-technical variables of 11 indicators [44].
- Conference papers that combined 17 technical indicators and 15 non-technical indicators [45].
- Journal paper which combined 17 technical indicators and 15 non-technical indicators [46].
- A doctoral dissertation that combined 4 technical variables and 5 non-technical variables [47].

Those publications formulated the equation model for the service index of the polder, which contained technical and non-technical indicator performances. Moreover, all case studies were conducted for polders within the DKI Jakarta Province administration. The PLS-SEM was further implemented as doctoral research on the performance index model of river and infrastructure, which combined 8 variables of 51 indicators [48].

SEM, either i) CB-SEM for average distribution data with AMOS software or ii) PLS-SEM for non-normal distribution data with SmartPLS software, has been implemented for drainage, river, infrastructure, and the polder topics, which combine technical/non-technical variables and indicators. In this research, PLS-SEM could combine the TFI by combining the technical/non-technical variables and indicators.

TABLE I
TFI IMPLEMENTATION IN SUPM

Aspects	**Structure**		
	Constructs	**Variables**	**Measured indicators**
Financial and Institutional	Sustainable Management		Illegal settlement (households)
			Polder fee (IDR)*
		Community Partnership Potentiality (CPP)	Regional Minimum Wage (% households above regional minimum wage)
		Partnership Potentiality (PaPo)	Small Medium Enterprises (enterprises)
		Government budget for drainage and flood protection (Flood_bdg)	Government budget for drainage and flood protection (IDR)
Technical	Polder technical performance‡		none
		Open Water	Open water storage (m^2)
		Pumping Capacity	Pumping capacity (m^3/s)
		Inundation	Inundation (cm)
Technical	Decremental Rate		Paved and unpaved area (m^2)
		Squatter	Illegal settlement (households)
		Sea Level Rise	Mean Sea Level rise (cm)
		Land subsidence	Land subsidence (m)

*: measured indicator for private project developer polder
‡: not appear in the model due to PLS-SEM's paths limitation rule

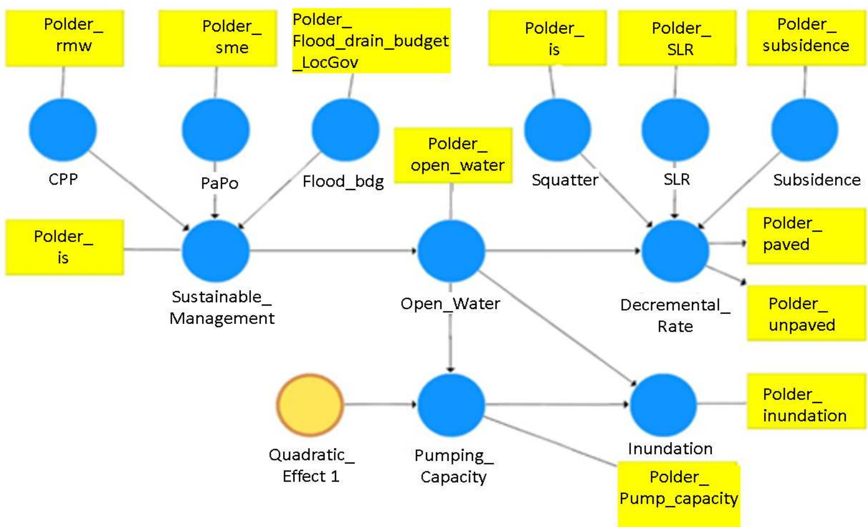

Fig. 2 PLS-SEM format' structure of Sustainable Urban Polder Model

II. Materials and Method

A. Materials

Material for this analysis comes from the polders of Pluit, Pulo Mas, and Pantai Indah Kapuk (PIK) (Fig.3). Both Pluit and Pulo Mas polders are public polders and have not yet established their Polder Board. PIK is a project developer polder and has its operational polder management. The dataset of measured indicators is listed in Table II and was collected from 2009 to 2013 (5 years).

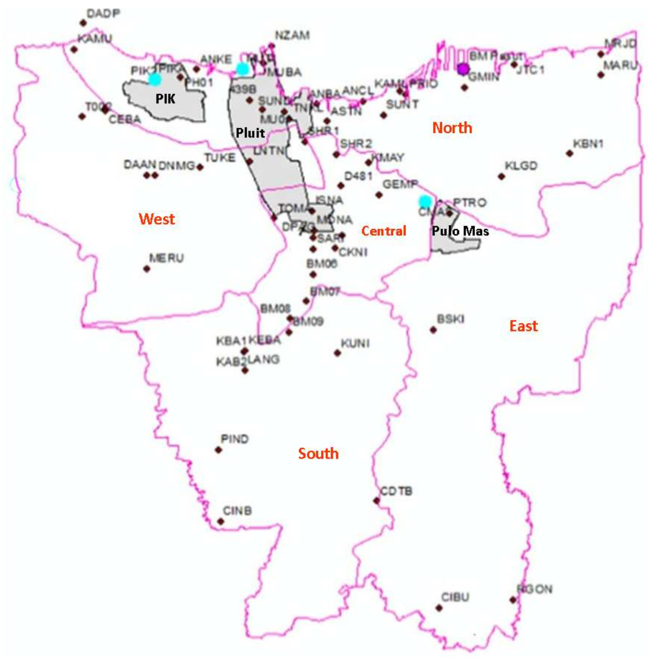

Fig. 3 Polder case studies

Legend
- ● : GNSS point
- ● : BM *Pasut (*Tidal Gauge Station Benchmark*)*
- ● : Polders' GNSS point
- — : DKI Jakarta administrative boundary
- ▢ : Area of polder case studies

TABLE II
MEASURED INDICATORS AND SOURCES

Measured indicators	**PLS-SEM code**	**Source**
Illegal settlement (households)	Polder _is	Survey
Government budget for flood protection and drainage control (IDR)	Polder_flood_drain_budget_LocGov	http://data.jakarta.go.id/dataset?q=anggaran&tags=APBD
Households whose wages are above the Regional Minimum Wage (% households)	Polder _rmw	Survey
Small and Medium Enterprises (enterprises)	Polder _sme	Author's survey with BPS DKI Jakarta in 2012 and 2014
Open water storage (m^2)	Polder_Open_water	Image classification using Landsat 7 and 8
Pumping capacity (m^3/s)	Polder_Pump_capacity	DUFLOW simulation based on flood event on January 17th 2013 under T-25 = 146 mm/day
Inundation (cm)	Polder_inundation	HEC-RAS simulation based on flood event on January 17th 2013 under T-25 = 146 mm/day
Paved and unpaved area (m^2)	Polder_Paved Polder_Unpaved	Image classification using Landsat 7 and 8
Mean Sea Level rise (cm)	Polder _SLR	MSL projection, which is based on MSL data 1925-2005 regression [49]
Land subsidence (m)	Polder_Subsidence	Global Navigation Satellite System (GNSS) trendline equation [50]

TABLE III
PLUIT POLDER'S DATASET

Measured indicator	**2009**	**2010**	**2011**	**2012**	**2013**
PL_flood_drain_budget_LocGov (IDR x 10^8)	8.00	7.50	1.50	118.5	39.38
PL_sme(enterprises)	478	481	489	489	486
PL_rmw(% households)	99.4	99.7	99.6	99.4	99.4
PL_is (households)	90.1	90.2	90.3	60	0
PL_fee_exp (IDR x 10^5)	5.31	5.47	5.85	6.23	6.22
PL_Pump_capacity (m^3/s)	53.3	53.4	53.3	53.2	53.3
PL_inundation (x10 cm)	18.61	18.68	18.67	18.62	18.60
PL_SLR (cm)	0.117	0.116	0.115	0.120	0.116
PL_Subsidence (m)	0.1	0.1	0.2	0.3	0.3
PL_Paved (x 10^6 m^2)	19.2	18.4	18.5	18.5	14.3
PL_Unpaved (x 10^6 m^2)	1.04	1.41	1.40	2.23	4.98
PL_Open_water (x 10^6 m^2)	1.79	2.31	2.17	1.32	2.83

TABLE IV
PULO MAS POLDER'S DATASET

Measured indicator	**2009**	**2010**	**2011**	**2012**	**2013**
PM_flood_drain_budget_LocGov (IDR x 10^8)	23.0	5.50	13.0	0.50	17.5
PM_sme(enterprises)	158	158	174	174	179
PM_rmw(% households)	78.1	78.1	74.7	78.6	78.6
PM_is (households)	4,006	3885	3930	3,930	3870
PM_fee_exp (IDR x 10^5)	1.60	1.59	1.66	1.73	1.70
PM_Pump_capacity (m^3/s)	7.40	7.46	7.48	7.49	7.50
PM_inundation (x10 cm)	16.7	16.0	16.8	16.7	16.6
PM_SLR (cm)	0.117	0.116	0.115	0.120	0.116
PM_Subsidence (m)	-0.013	0.64	0.05	0.35	0.35
PM_Paved (x 10^6 m^2)	3.74	3.44	3.74	3.89	1.61
PM_Unpaved (x 10^6 m^2)	0.721	0.719	0.633	0.515	0.242
PM_Open_water (x 10^6 m^2)	0.150	0.459	0.238	0.215	0.586

TABLE V
PANTAI INDAH KAPUK (PIK) POLDER'S DATASET

Measured indicator	2009	2010	2011	2012	2013
PIK_flood_drain_budget_LocGov (IDR x 10^6)	350	0	500	12,850	2,663
PIK_sme (enterprises)	390	433	486	486	582
PIK_rmw (% households)	80.4	79.4	79.4	80.0	80.0
PIK_is (households)	0.7	0.8	0.1	0.2	0
PIK_fee_exp (IDR x 10^3)	570	54.8	597	646	745
PIK_Pump_capacity(m^3/s)	7.3	7.2	7.36	7.39	7.4
PIK_inundation (cm)	0.1	0.1	0.2	0.9	0.4
PIK_SLR (cm)	0.117	0.116	0.115	0.120	0.116
PIK_Subsidence (m)	0.2	0	0.2	0.2	0.34
PIK_Paved (m^2 x 10^4)	351	252	245	220	242
PIK_Unpaved m^2 x 10^4)	191	125	135	168	120
PIK_Open_water (m^2 x 10^4)	36.5	33.2	30.9	23.2	49.4

B. Method

The method to develop and evaluate the DKI Jakarta Polders is the Sustainable Urban Polder Model (SUPM) in PLS-SEM format. SUPM is an exploratory model using the formative mode [51]. Formative mode quality is tested through the Variance Inflation Factor (VIF) while the Coefficient of Determination (R2) gauges model validity, which is categorized as weak (19%), moderate (33%), and substantial effects (>67%) [52]. Moreover, the PLS-SEM sign of weight value shall be used to examine the impact of sustainable management as a representative of the Polder Board function. This sign of weight values shall be compared with the ideal or expected sign of weight value.

III. RESULTS AND DISCUSSION

A. Formative Mode Quality

VIF results of the SUPM's formative mode show that collinearity issues are still acceptable (< 5), as in Table VI. This means that the SUPM is qualified for further inference.

TABLE VI
VIF RESULTS

Pluit Polder	
Measured indicators	VIF
PL_Pump_capacity	1.000
PL_SLR	1.000
PL_flood_drain_budget_LocGov	1.000
PL_inundation	1.000
PL_is	1.000
PL_open_water	1.000
PL_open_water*PL_open_water	1.000
PL_paved	1.005
PL_rmw	1.000
PL_sme	1.000
PL_subsidence	1.000
PL_unpaved	1.005
PL_is	1.000

Pulo Mas Polder	
Measured indicators	VIF
PM_Pump_capacity	1.000
PM_flood_drain_budget_LocGov	1.000
PM_inundation	1.000
PM_is	1.000
PM_open_water	1.000
PM_open_water*PM_open_water	1.000
PM_paved	1.372
PM_rmw	1.000
PM_sme	1.000
PM_subsidence	1.000
PM_unpaved	1.372
PM_is	1.000

PIK Polder	
Measured indicators	VIF
PIK_Pump_capacity	1.000
PIK_SLR	1.000
PIK_flood_drain_budget_LocGov	1.000
PIK_inundation	1.000
PIK_open_water	1.000
PIK_open_water*PIK_open_water	1.000
PIK_paved	1.122
PIK_rmw	1.000
PIK_sme	1.000
PIK_subsidence	1.000
PIK_tax_exp	1.000
PIK_unpaved	1.122

B. Results: SUPM Results Validation

Through computing the dataset (Table III, IV, V) into SUPM in PLS-SEM format, the weight values and coefficient of determination (R^2) of each polder are produced (Fig.4,5,6).

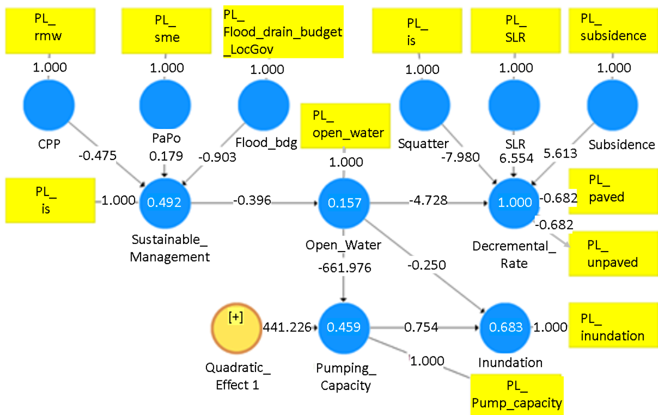

Fig. 4 Sustainable Urban Polder Model of Pluit Polder

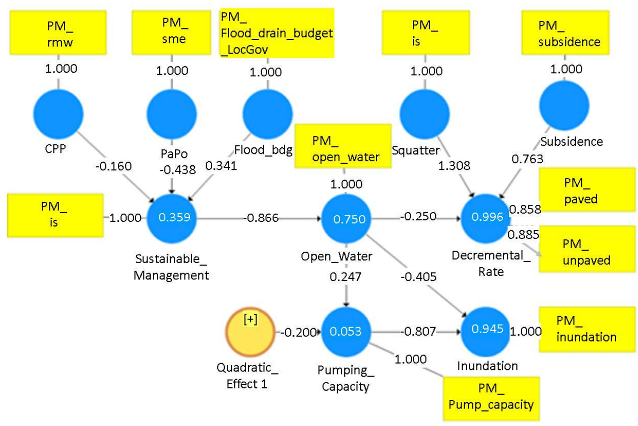

Fig. 5 Sustainable Urban Polder Model of Pulo Mas Polder

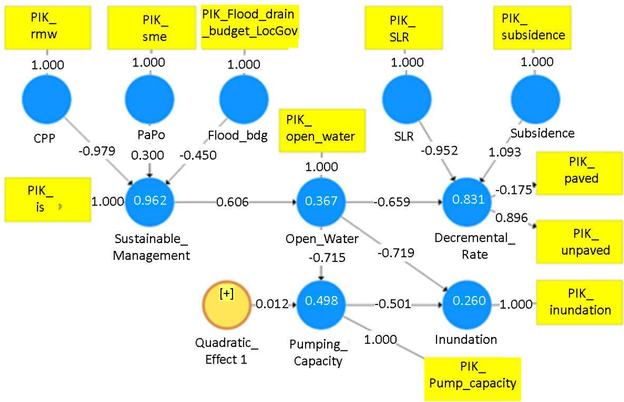

Fig. 6 Sustainable Urban Polder Model of PIK Polder

1) Construct of Sustainable Management: Its constituting variables are derived from shared responsibilities among the Government, the business sector, and the community. By accommodating the CPP, PaPo, and Flood_bdg as derivatives of that concept, it is, in fact, sufficient to validate the model (Table 1). In addition, statistics validation finds that the coefficient of determination (R^2) of those 3 variables is at the level of moderate to substantial effect (Table VII).

TABLE VII
CONSTRUCT OF SUSTAINABLE_MANAGEMENT'S R^2

Polder	CPP	PaPo	Flood_bdg	R^2 (%)
Pluit	-0.475	0.179*	-0.903	49.2
Pulo Mas	-0.160	-0.439	0.341*	35.9
PIK	-0.979	0.300*	-0.450*	96.2

*: it matches with the expected positive sign

2) Construct of polder technical performance: Polder technical performance does not appear as a construct in SUPM due to the limitation of path development as data merely 4 years. Another reason was that the constituting variables and objective of technical performance are as follows: storage (retention capacity)-pumping capacity graph, and the *SPM* (Minimum Service Standard) in the drainage sector to prevent inundation of more than 30 cm. Following that, the priority is not to assess the construct, as it has already been cleared about its constituting variables, but to measure the relationships among the three tracks of storage-pumping capacity-inundation.

Following that, the expected sign of weight-value of the three-tracked is negative. The results find that i) PIK's three-tracked all match with the expected sign of weight-value with moderate R^2 (26.0%), ii) Pluit's three-tracked are matched in two paths with substantial R^2 (68.3%), and iii) Pulo Mas' three-tracked are matched in two paths with substantial R^2 (94.5%) (Table VIII).

TABLE VIII
THREE-TRACKED RELATIONSHIPS PERFORMANCES

Path	Pluit	Pulo Mas	PIK
Open_Water towards Pumping_Capacity	-661.976*	0.247	-0.715*
Open_Water towards Inundation	-0.250*	-0.405*	-0.719*
Pumping_Capacity towards inundation	0.754	-0.807*	-0.501*
Open_Water towards Inundation and Pumping_Capacity towards inundation	R^2 = 68.3%	R^2 =94.5%	R^2 = 26.0%

* : it matches with the expected negative sign

3) Construct of Decremental Rate: Its constituting variables are derived from the factors which have been affecting polders as in section B.1. Statistics validation finds that the R^2 of those 3 variables are at the level of substantial effect (Table IX).

TABLE IX
CONSTRUCT OF DECREMENTAL_RATE'S R^2

Polder	Squatter	SLR	Subsidence	R^2
Pluit	-7.980	6.544	5.613	100%
Pulo Mas	1.308	n.a.	0.763	94.5%
PIK	n.a.	-0.952	1.093	83.1%

C. Discussion

1) Evaluation regarding the necessity to set up The Polder Board: The impact of the Polder Board can be assessed through the path Sustainable_Management towards Open_Water (Table X). The SUPM finds that Pluit and Pulo Mas polders have negative weight values. It means that the constituting variables under sustainable management, as a construct representing the Polder Board, have not positively contributed to the open water storage. On the other hand, PIK Polder has a positive weight value, which indicates that polder management contributes positively towards open water storage.

TABLE X
POLDER MANAGEMENT IMPACT

Polder	Sustainable_Management towards Open_Water	R^2 (%)
Pluit	-0.396	15.7%
Pulo Mas	-0.866	75.0%
PIK	+0.606	36.7%

From 2009 to 2013, Pluit and Pulo Mas Polders did not have a Polder Board-type institution, and open waters tended to decrease due to illegal settlements (Tables III and IV). In 2013, the retention ponds in both polders were cleared of illegal settlements.

In Pluit Polder, one (PaPo) out of three of the constituting variables of sustainable management are matched with the expected signs (Table VII), and two out of three-tracked relations are matched with the expected negative signs (Table VIII). Those statistics reflect that the management function has not yet attained effective integration towards maintaining the retention pond size as planned. Finally, this produces the negative weight value for the path of Sustainable_Management towards Open_Water

In Pulo Mas Polder, one (Flood_bdg) out of three of the constituting variables of sustainable management are matched with the expected signs (Table VII), and two out of three-tracked relations are matched with the expected negative signs (Table VIII). Those statistics reflect that the management function has not yet attained effective integration towards maintaining the retention pond size as planned. Finally, this produces the negative weight value for the path of Sustainable_Management towards Open_Water

On the other side, in PIK Polder, two (PaPo and Flood_bdg) out of three constituting variables of its sustainable management are matched with the expected positive signs (Table VII), and all three-tracked relations are matched with the expected negative signs (Table VIII). Those statistics reflect the operational polder management to work on the management function and the maintenance of retention pond size as planned. Finally, this produces the positive weight value for the path of Sustainable_Management towards Open_Water

2) Evaluation in terms of inundation control: The performance of polders' technical aspect in terms of inundation control is assessed through paths: i) Open_Water towards Pumping_Capacity, ii) Open Water towards Inundation and iii) Pumping_Capacity towards inundation. In Pluit Polder, the first path matches the expected negative sign, which indicates the normal condition (Table VIII). Further, the combined second and third paths have only 1 path, which matches the expected negative sign. This indicates that the unmatched path (Pumping_Capacity towards inundation) is getting less effective not because of the decreasing open water storage. This finding seems coherent with the field fact during the 17 January 2013 flood in which Pluit's pumps were submerged due to flood and defective due to garbage [53], [54].

In Pulo Mas Polder, the first path is unmatched with the expected negative sign, which indicates the non-normal condition. However, the combined second and third paths are simultaneously matched with the expected negative sign, which means both open water storage and pumping capacity must be improved towards the ideal ratio. In the PIK Polder, the first path matches the expected negative sign, which indicates the normal condition. Further, the combined second and third paths match the expected negative sign, suggesting that open water storage and pumping capacity contribute effectively to inundation.

IV. Conclusion

The social, economic, and institutional reports have been part of DKI Jakarta flood control studies since 2004. Despite some relevant findings and recommendations, the relationships of those reports with the polders' components' performances are unclearly modeled, hence leading to the absence of an integrated conclusion and deficiency in model assessment. The Sustainable Urban Polder Model (SUPM) is a model that was developed by integrating the polders' technical, financial, and institutional (TFI) aspects under the PLS-SEM format.

In terms of model validation, this research reveals some findings. The construct of Sustainable_Management shows that all constituting variables in all polder case studies have a substantial effect. This concludes that all variables could be kept in future applications of SUPM. The construct of technical performance shows that the three-tracked open water storage-pumping capacity-inundation can emulate the performance of PIK Polder's components as all results match the expected negative sign of weight values. This research also found that Open_water and Pumping_capacity can explain the inundation data variability at the level of moderate-substantial effect.

The construct of Decremental_rate shows that all indicated decremental factors have substantial R^2. However, when the three-three tracked relationships are applied towards inundation control, the findings in Pluit Polder may need additional information, outside the SUPM's measured indicators, to explain the match/unmatched values, e.g., defective pumps during flood, causes of defective pumps which could be garbage or electricity issues, and probably the retention pond sedimentation. This concludes that it is vital to record this information and that it could enhance the Decremental_rate variables in future SUPM refinement.

In terms of DKI Jakarta polders evaluation, SUPM finds that PIK Polder, as a polder whose management function is operational, has a positive contribution to maintaining both its open water storage and the three-tracked relationships of open water storage-pumping capacity-inundation in normal conditions. Moreover, Pluit and Pulo Mas Polders have a risk of being unable to maintain their open water storages; hence, the Polder Boards need to be established. The TFI relationships can be modeled and visualized using SUPM, which helps integrate the TFI-related reports towards polder sustainability.

Acknowledgment

We thank the Netherlands Fellowship Program (NFP) for funding this research.

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