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THE CHALLENGE OF THE DEVELOPMENT FOR FISHERY CULTIVATION IN BLOCK A5 DADAHUP LOWLAND IRRIGATION AREA

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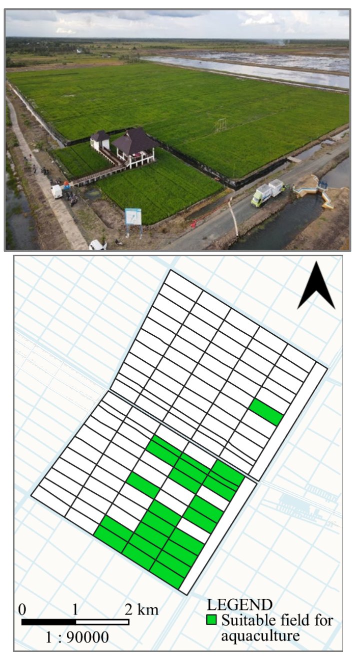
Dyah Ayu Utami[ab], Karlina[a*], Adam Pamudji Rahardjo[a], Firmelin[b]

[a]Department of Civil and Environmental Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia
[b]Directorate General Water Resources, Indonesian Ministry of Public Works and Housing, Jakarta, Indonesia

*Corresponding author
karlina.sipil@ugm.ac.id

Graphical abstract



Abstract

Dadahup Lowland Irrigation Area was part of the government's food security programs with a large potential area. However, some fields have not optimally utilized these potentials due to low elevation. Agricultural activities were difficult to carry out because it is prone to inundation. Therefore, fishery cultivation could be one of the options for potential development in this land. It is necessary to study the suitability of location for fishery based on the land conditions. The study aimed to assess land suitability and select the appropriate location for fishery cultivation. The assessment was carried out by comparing the existing condition of Block A5 with requirements stated in the Indonesian National Standard, such as land suitability, water quality, pond requirement, and water balance. The water balance was calculated by comparing water need and water availability. Storage modeling simulation using EPA-SWMM software was conducted to identify flood conditions. Furthermore, a comparison was made between water surface elevation and field elevation to determine suitable fishery cultivation locations. The results show that the study area has potential development for fishery cultivation with fulfilled land suitability and water balance requirements, but there was water quality challenge for the low pH result. Therefore, the selection of local fish species that are already adapted to acidic environments could be considered for the cultivation activities. Other than that, the water quality could be enhanced to optimize fishery cultivation. The water quality improvement could be achieved by implementing water system regulations, such as using gates to occur the leaching process. Furthermore, the liming and fertilization process also can be conducted to improve the water quality in the study area. Simulation results explained no overflow from the storage into the field with an approximate selected area for fishery cultivation ± 314.41 Ha. Therefore, the location study is potentially suitable for fishery cultivation development with 19.41% area of the total Block A5 DIR Dadahup.

Keywords: Swamp, Water balance, Flooding, EPA-SWMM, Fish culture, Land suitability

1.0 INTRODUCTION

The utilization of Dadahup Lowland Irrigation Area, known as Daerah Irigasi Rawa (DIR) Dadahup, to support the national food security program (food estate) still needs to be improved. The functional area of DIR Dadahup is 6,111 Ha out of 21,226 Ha total potential area [1]. Shrubs dominated the area of DIR Dadahup, so further development for the study area is possible. To support sustainable development by increasing food production, it is necessary to diversify land usage according to local capacity and conservation function to prevent lowlands degradation.

Before the construction of gates on the main primary channel (saluran primer utama, abbreviated SPU), land inundation became the main problem of DIR Dadahup, causing difficulties in cultivating rice and secondary crops. Based on the HEC-RAS program analysis results, water gates and pumps can reduce inundation problems in Block A5 DIR Dadahup [2]. Based on field identification, SPU gates at points L and V aim to control the upstream water supply from the Barito River to reduce the inundation problem. However, inundation can occur in several locations with very low elevations (less than 1 msl) [3]. It wasn't easy to cultivate this land, so fishery cultivation could be one of the potential development options. The ground elevation of Block A5 DIR Dadahup ranged from 0.64-1.68 (Figure 1) [4], therefore the assessment of land use based on elevation is needed.

Fishery cultivation is one of the activities that can support food security. Until recently, many types of fish have been successfully cultivated from both marine and fresh waters (rivers, lakes, and swamps), but some obstacles caused low fisheries productivity, one of which is water quality [5]. To overcome the water quality problems in acidic swampy environments, a biological approach could be used by utilizing local fish that can breathe oxygen from the air, such as Gabus (Channa striata) and Papuyu (Anabas testudineus) [6].

The demand for local fish in Kapuas District is known for the highest average consumption value per capita per week per type of fish (commodity unit) over the last five years (2018-2022) [7]. The local fish fulfillment mainly relies on wild-caught fish, leading to a decrease in the natural population [8]. Therefore, fish cultivation needs to be carried out to fulfill the demand for local fish.

Apart from the technical aspect of low pH in the lowlands, the potential for fishery cultivation can be obtained from social conditions, technology and information, as well as government support, while limited capital, appropriate prices, and management practices are still challenging for sustainable fishery cultivation [9]. Tantu, et. al. conducted a study of land suitability for shrimp aquaculture by using spatial analysis for topography, hydrology, soil condition, water quality, and climate data, that classified the suitability into four categories: highly suitable (class S1), moderately suitable (class S2), marginally suitable (class S3) and not suitable (class N) [10]. Meanwhile, the usage of hydrologic software such as EPA-SWMM for land suitability studies for fishery cultivation is still rare. Most of studies that have been conducted using EPA-SWMM focus on urban drainage system [11] and to examine the flood management from technical aspect by hydrological and hydraulic data [12].

On the other hand, the study of land suitability for fishery cultivation in lowland areas itself is still few. There is no research that discusses the potency of fishery cultivation development in DIR Dadahup. With a large potential area, field elevation differences, and the high demands for local fish consumption, it is necessary to diversify the land use based on suitability. Therefore, the study of land suitability for fishery cultivation is important to conduct as a recommendation for future development.

This study aims to assess the land suitability and select the appropriate location for fishery cultivation development in lowland area based on the Indonesian National Standard (abbreviated SNI) and assess the flood condition using the Environmental Protection Agency Storm Water Management Model (EPA-SWMM) v5.2.1 then comparing the water elevation toward field elevation to determine the suitable location.

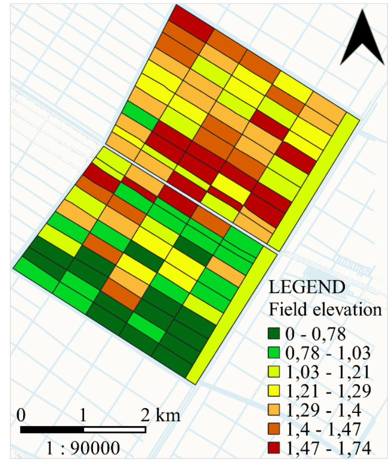


Figure 1 The field elevation of Block A5

2.0 METHODOLOGY

2.1 Location

The research was conducted in Block A5 of Dadahup Lowland Irrigation Area, Kapuas Regency, Central Kalimantan Province (Figure 2), with an approximate land area ± 1,620 Ha. The location of Block A5 is divided into right and left sides separated by a secondary channel. The left side of Block A5 was referred to "Blok A5 Kiri", while the right side was known as "Blok A5 Kanan". There are five tertiary channels in each block, so there are ten tertiary channels in the entire block.

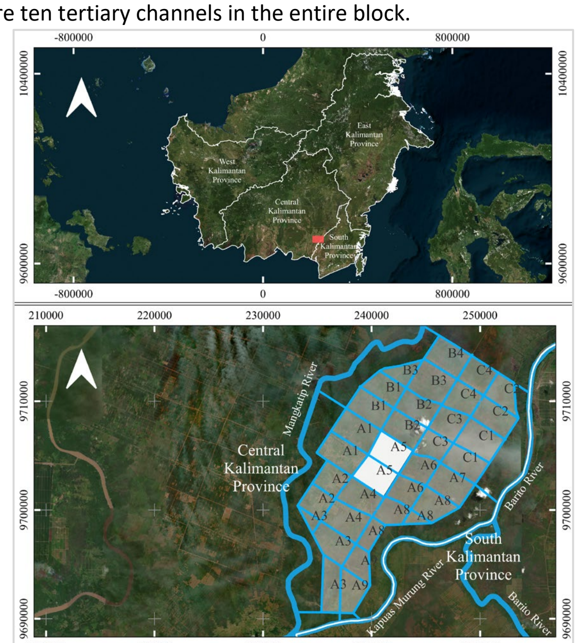


Figure 2 The location of Dadahup Lowland Irrigation Area (based map from Bing Maps)

2.2 Data Collection And Measurement

The data used in the implementation of the study are field observation, secondary data from government-owned, primary data for water and soil quality, and water level measurement.

Secondary data such as field elevations, irrigation schemes, channel elevations, channel geometry, rainfall, and peat thickness were obtained from the BWS Kalimantan II.

The locations of measurement data are indicated in Figure 7. Field measurements for primary data were conducted on February 19-25, 2023, with details as follows:

2.2.1 Water quality measurement

Water quality measurement was carried out using the Horiba Multiparameter Water Quality Meter Kit (contains of control unit and sensor probe (Figure 3) with an accuracy of two decimal places). Water quality data that can be obtained using this digital tool are temperature [°C], pH, electrical conductivity (DHL) [mS/cm], turbidity [NTU], dissolved oxygen (DO) [mg/L], total dissolved solids (TDS) [g/L], and salinity [ppt].
The measurement was taken in the morning between 08.00 and 11.00 (Figure 4). A ladle was used to collect water from the tertiary channel located near the tertiary gate (there were a total of 8 measurement locations). Next, the water was transferred to a measuring glass, then the sensor probe of water quality meter kit was dipped into the measuring glass so that the value could be displayed on the monitor screen in control unit. After that, water quality results are recorded once the screen display has stagnated. The measurement was conducted three times at each location and the sensor probe need to be rinsed using distilled water for every data collection. Finally, the data being averaged to obtain the final result of water quality data for the analysis.

Figure 3 Horiba Multiparameter Water Quality Meter Kit

Figure 4 Water quality measurement in the tertiary channel

2.2.2 Water Level Measurement

The water depth gauge boards (peil scale) was installed in the middle of tertiary channel at the same location as the water quality measurement (Figure 5). Water depth was measured by reading the peil scale in the morning, from 08.00 to 11.00. Then, the water level value was calculated based on the water depth and the correction value of elevation that has been tied to the benchmark.

Figure 5 Water level measurement in the tertiary channel

2.2.3 Soil Quality Measurement

The soil quality measurement was conducted at 7 locations in the Block A5 Kanan. The soil samples were taken using hand auger soil sampling (Figure 6). A one meter thick of soil sample was tested using soil tester to determine the soil pH value in the field.

Figure 6 Soil quality measurement in the field

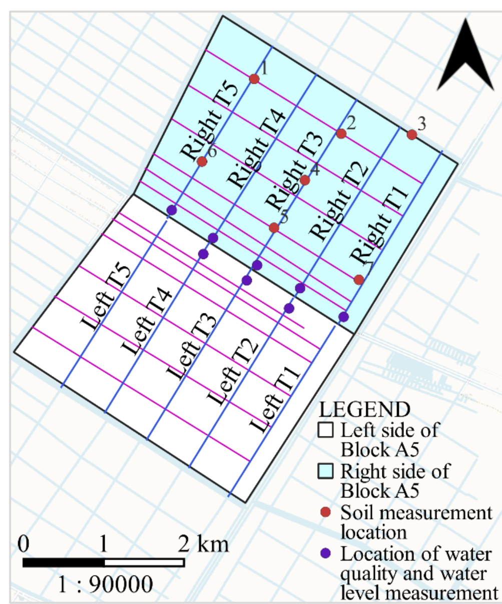


Figure 7 The location of data measurement

2.3 Methods

From the data obtained, the parameters required by the Indonesian National Standard (SNI) for fishery cultivation were analyzed. To determine the challenges for the development of fishery cultivation at the study location, there are five parameters compared to the existing conditions such as (a) land suitability, (b) water quality, (c) pond requirement, (d) water need, and (e) water availability.

Storage modeling was conducted using EPA-SWMM to identify the flood conditions. Storage modeling was chosen because the gates of the tertiary channel were closed, so there was no flow in the channel at the time of measurement. The gates were modeled as a weir, assuming the water level in the main channel (outfall) is consistently lower than the system. Supporting data such as rainfall data, water depth, water level, field elevation, channels and gates geometry were used as input for this model. In addition, a comparison was made between the simulation results of water surface elevation and field elevation data to determine the suitable location for fishery cultivation.

2.4 Indonesian National Standard (SNI)

Indonesian National Standard (SNI) was used as guidelines toward land suitability, water quality, pond requirement, water need, and water supply for fish farming in lowlands areas.

2.4.1 Land suitability

The suitable location requirements for fish farming in the lowland based on SNI 8174: 2015 Konstruksi kolam budidaya ikan di lahan gambut (Fish farming ponds construction on peatlands) [13]:

a. Following the applicable regulations;
b. Sufficient water source for the production process;
c. Not in a flood zone;
d. Peat thickness less than 1.5 m; and
e. Adequate facilities and infrastructure are available for cultivation activities.

2.4.2 Water Quality

The water quality should be following the requirements of Table 1 [14].

Table 1 Water quality requirements

No	Variable	Value/Ranges	Unit
1	Temperature	25-30	°C
2	pH	≥ 4.5	-
3	Dissolved oxygen	≥ 2	mg/l

2.4.3 Pond Requirement

The requirement for the pond is based on the regulations:

a. Strong embankment for the pond;
b. Minimum water depth 80 cm;
c. Minimum pond area 100 m^2;
d. Soil pH should be at least 4; and
e. Pond bottom slope at range (5-10) %.

2.4.4 Water Need

The water needs for fish farming are calculated based on SNI 6728.1:2015 Penyusunan neraca spasial sumber daya alam – Bagian 1: Sumber daya air (Spatially balanced formulation of natural resources - Part 1: Water resources).

Water requirements for fisheries were estimated based on the size of the pond, the type of pond, and the depth of water required. Water requirements for fisheries can be calculated using the Eq. (1) as follows:

$$Qfp = \frac{q(fp)}{1000} \times A(fp) \quad \textbf{(1)}$$

Qfp = water needs for fishery (l/s)
q(fp) = water requirement for flushing (l/s/ha)
A(fp) = fishpond area (ha)

2.4.5 Water Availability

Water availability could be calculated from dependable rainfall, in which the amount of rainfall can be reliably estimated at a given period in a field, where the risk of failure has been calculated [15]. The rainfall data was calculated and sorted then the probability value was approximated using the Weibull Method in accordance with Eq. (2) below:

$$P = \frac{m}{n+1} \times 100\% \quad \textbf{(2)}$$

P = probability
m = rank of arranged data series (large to small)
n = number of observations

2.5 EPA-SWMM

In this study, the use of EPA-SWMM was conducted to determine the impact of rainfall on the water level elevation channel modeled as storage.

EPA-SWMM is a rainfall-runoff simulation model commonly used for the simulation of runoff quantity and quality in urban areas, that able to calculate the hydrological process that produces runoff from urban areas, such as rainfall, evaporation, infiltration, and determine the flood point and calculation in runoff discharge [11]. There are visual objects used in this research to describe the field conditions (Figure 8):

a. Rain gage includes rainfall intensity data, recording time intervals, and rainfall data sources in the form of a time series.
b. Subcatchments with the principal input parameters include outlet of the subcatchment, total area, percent impervious area, average slope, characteristic width of overland flow, Manning's number for overland flow, and depression storage.
c. Junction with the principal input parameters are elevation, maximum depth, and initial depth.
d. Conduit (channel), parameters to be used are channel shape, maximum depth, length, and roughness coefficient.
e. Storage unit include elevation or altitude, maximum depth, and initial depth.
f. Weir includes shape, geometry, crest height above the inlet node invert, and discharge coefficient.

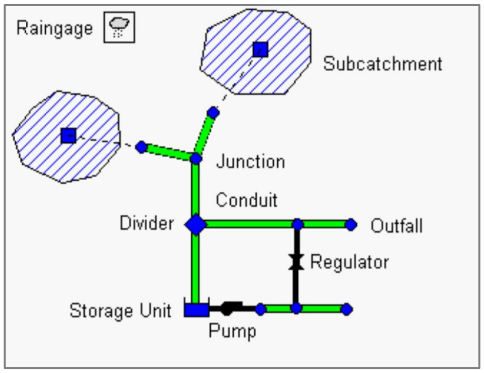


Figure 8 Visual objects in EPA-SWMM [16]

3.0 RESULTS AND DISCUSSION

3.1 Existing Condition Analyze Based On SNI

3.1.1 *Land Suitability Analysis*

Five parameters need to be done to meet the land suitability requirements, as follows:

3.1.1.1 Applicable Regulations

Commitment from the government can be pursued to follow existing regulations. The implementation of governance principles such as effectiveness and efficiency, equity, accountability, and predictability by institutions and legal frameworks can provide support for fishery cultivation [17]. The current regulations for fishery cultivation in lowland are limited to certain types of local fish such as betok/papuyu (Anabas testudineus) and catfish (Pangasianodon hypophthalmus). Based on field identification, there are other types of local fish that can live in the study location, such as snakehead (Channa striata) and three spot gourami (Trichopodus trichopterus). Several types of local fish can survive in lowlands such as betok/papuyu (Anabas testudineus), tambakan/biawan (Helostoma temminckii), sepat siam (Trichogaster pectolaris), gurame/kalui (Osphronemus gouramy), gabus/haruan (Channa striata), and toman (Channa micropeltes) [6]. Therefore, the regulations regarding requirements for various potential types of fish need to be done.

3.1.1.2 Water Availability And Water Need

Dependable rainfall was calculated using 20 years rainfall data (2003-2022) from the Sanggu Meteorological Station distanced ±114.26 km. There is a possibility that the rainfall that occurs at the research location is smaller because of orographic effects due to location differences. The calculation was done by summing each month's daily rainfall data and sorting the data from largest to smallest. Then, the probability was found by dividing the rank order by the total observations. The probability value of 80% was used to represent the dependable rainfall value (R80). Furthermore, the rainfall data was converted into discharge to calculate the water balance. The probability of rainfall as water availability is shown in Table 2.

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Table 2 Water availability

Month	R80 (mm/month)	Q (l/s)
January	179.52	210.74
February	138.58	180.11
March	221.26	259.74
April	192.52	233.53
May	139.64	163.93
June	86.16	104.52
July	83.20	97.67
August	57.80	67.86
September	27.70	33.61
October	74.96	88.00
November	236.34	286.69
December	199.80	234.55

Assuming the value of water requirement for flushing of 12 l/s/ha [18] and the estimated fishpond area of 300 ha (from the results of elevation comparison), the calculation of water need giving value of 3.60 l/s. Therefore, the water needs for fishery cultivation activities can be fulfilled monthly based on the water balance.

3.1.1.3 Flood Condition

Block A5 of DIR Dadahup is categorized into the types C and D of hydro topography classification, as rainfall for the main source of water supply [19]. EPA-SWMM storage modeling was done to determine the flood conditions used the rainfall for the water supply data. The results of the simulation showed that there was no flooding on the tertiary channels modeled as storage unit. In addition, based on the field observation the following day, there was no flooding in tertiary channels.

3.1.1.4 Peat Thickness

Based on the peat thickness map of the Dadahup Lowland Irrigation Area, there was no peat thickness exceeding 1.5 meters. Therefore, Block A5 meets the land suitability requirements in the SNI (Figure 9). Additionally, the earliest peatland regulations in 1990 stated that peatlands with a thickness of more than 3 m should be protected while those less than 3 m can be used for cultivation, more specific regulations related to peatland management are needed to restrain the rate of land conversion and peatland degradation [20].

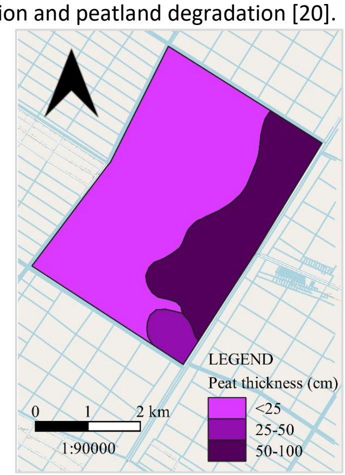

Figure 9 Peat thickness map [4]

3.1.1.5 Adequate Facilities And Infrastructure

Based on field identification of Block A5, there are road and electricity infrastructures on the main access. However, better access to the fields for cultivation activities can be reached in future development.

From the land suitability requirements, in addition to peat thickness that has met the criteria, the other requirements can be pursued at the time of planning and construction.

3.1.2 Water Quality Conditions

Water quality measurement was conducted on the 19th, 21st, 23rd, and 25th February 2023. Three parameters of water quality are analyzed: temperature, pH, and dissolved oxygen (DO).

3.1.2.1 Results of Water Temperature

The results of average temperature measurement ranged from 26.95-29.48 °C, indicating that the existing conditions of tertiary channels meet the requirements, the data shown in Table 3.

Table 3 Water temperature results (°C)

Location	Date			
	19-Feb	21- Feb	23-Feb	25-Feb
Right T1	28.95	28.59	28.29	26.15
Right T2	28.85	28.57	28.60	26.81
Right T3	30.67	28.14	28.96	27.44
Right T4	29.81	27.88	28.40	27.60
Right T5	29.11	29.52	28.02	27.20
Left T2	28.95	28.59	28.29	26.15
Left T3	28.85	28.57	28.60	26.81
Left T4	30.67	28.14	28.96	27.44
Min	28.85	27.88	28.02	26.15
Max	30.67	29.52	28.96	27.60
Average	29.48	28.50	28.51	26.95

Snakehead fish, as one of the local fish species, needs temperature variations to attain ideal conditions, for the spawning stage ranged from 27.9-31.2 °C, the rearing process requires range of 27.8-32.5 °C, and the maturation requires ranged from 26.8 to 32.1 °C [21]. Therefore, the existing water temperature condition of tertiary channel in Block A5 DIR Dadahup potentially to be used for fishery cultivation.

3.1.2.2 Results of pH

The results of average pH measurement ranged from 3.31-3.49, indicating that the existing conditions of tertiary channels do not meet the requirements, the data shown in
Table 4.

Table 4 Water pH results

Location	Date			
	19-Feb	21- Feb	23-Feb	25-Feb
Right T1	3.17	3.22	3.24	3.42
Right T2	3.44	3.39	3.32	3.45
Right T3	3.54	3.32	3.57	3.70
Right T4	3.38	3.23	3.34	3.41
Right T5	3.36	3.35	3.28	3.39
Left T2	3.17	3.22	3.24	3.42
Left T3	3.44	3.39	3.32	3.45
Left T4	3.54	3.32	3.57	3.70
Average	3.38	3.31	3.36	3.49

The low pH of the water in the channel becomes a challenge for fishery cultivation. In the previous study about one of local fish species, snakehead fish was able to live and grow well with a pH range of 4-6.3 [21]. Therefore, it is necessary to select the cultivation species using local fish that can survive and reproduce in low water pH conditions. Other than that, water management is one of the key to improving the water quality; for lowland development, there are some options such as keeping potential sulfate acid soils in submerged conditions, maintaining water surface and groundwater levels, and providing fresh water for leaching and dilution of toxicity and acidity [15]. It is possible to do some water management in the study location that already have several tertiary channels and water gates. Water system regulation using gates operation aim to prevent acidic water from entering the system and flushing when rain occurs to supply fresh water. Furthermore, water quality improvement could be achieved by adding chemicals in certain doses such as lime and fertilizer [22]. In this study location, the liming and fertilization process can be carried out as preparation before fishery cultivation activities are conducted.

3.1.2.3 Results of DO

The average dissolved oxygen (DO) measurement results ranged from 7.65-11.54 mg/l, indicating that the existing conditions of tertiary channels meet the requirements, as shown in Table 5.

Table 5 Dissolved oxygen results (mg/l)

Location	Date			
	19-Feb	21- Feb	23-Feb	25-Feb
Right T1	11.47	8.21	9.60	12.36
Right T2	6.07	8.56	10.59	10.36
Right T3	3.92	7.60	10.61	11.21
Right T4	7.86	10.32	7.73	12.19
Right T5	10.39	8.42	10.75	12.28
Left T2	11.47	8.21	9.60	12.36
Left T3	6.07	8.56	10.59	10.36
Left T4	3.92	7.60	10.61	11.21
Average	7.65	8.44	10.01	11.54

Papuyu fish have breathing apparatus so they can survive in very little water and low oxygen levels conditions [8]. At the maturation stage, snakehead fish can live and grow well with a dissolved oxygen range of 0.2-8.6 mg/L [21]. Therefore, the existing dissolved oxygen condition of tertiary channel in Block A5 DIR Dadahup potentially to be used for fishery cultivation.

Comparing existing conditions to the water quality requirements shows that the temperature and dissolved oxygen meet the requirements. In contrast, the pH value does not meet the criteria. There was the water quality challenge, so it is needed to improve the water quality for pH to meet requirements for fishery cultivation.

3.1.3 Pond Requirement Conditions

Four parameters need to be done to meet the pond requirements, as follows:

3.1.3.1 Embankment For The Pond

Excavated soil from the pond construction can be used as the embankment reinforcement by compacting, therefore the strengthening can be obtained.

3.1.3.2 Minimum Pond Area

The area of the pond can be implemented during construction. With an estimated area of each quaternary field ± 13.67 ha, the total 1000 of 100 m^2 pond area could be constructed respectively.

3.1.3.3 Minimum Water Depth

The minimum water depth in the pond for fishery cultivation activities can be maintained through the water availability from the channel.

3.1.3.4 Soil pH

Soil quality tests were conducted at 7 locations in Blok A5 Kanan, while the soil quality in Blok A5 Kiri was considered the same as the test results in Blok A5 Kanan due to similar characteristics. The following soil quality test results were obtained as shown at Table 6.

Table 6 Soil pH results

Location	Water pH in the field	Soil pH
1	5.28	6.20
2	5.37	6.10
3	4.13	6.00
4	5.67	5.90
5	5.52	5.95
6	3.35	5.95
7	3.42	6.40

The existing soil pH value of 5.9-6.4 meets the pond requirements.

3.1.3.5 Pond Bottom Slope

The value of the pond bottom slope can be implemented during construction.

In addition to soil pH requirements that have met the criteria, other technical pond requirements can be pursued at the time of planning and construction activities.

3.2 Simulation using EPA-SWMM version 5.2.1

Storage modeling simulation was carried out using EPA-SWMM to determine the impact of rainfall on the water level elevation.

3.2.1 Rainfall data

Rainfall data was obtained from the nearest station (SPU Q telemetry) to simulate existing conditions on 24 February 2023 (

Table 7 Rainfall data on 24 February 2023

Time	Rainfall intensity (mm)
20:40	36
20:45	36
20:50	84
20:55	168
21:00	132
21:05	108
21:10	144
21:15	180
21:20	144
21:25	48
21:30	24

3.2.2 Water Depth And Elevation Data

The water depth data on 24 February were measured directly, while the bed channel elevation used the secondary data, shown in Table 8.

Table 8 Water depth and elevation

Location	Elevation	Initial depth (m)
Right T1	-0.96	1.750
Right T2	-1.00	1.990
Right T3	-0.90	1.265
Right T4	-1.10	1.700
Right T5	-0.70	1.330
Left T2	-0.97	1.450
Left T3	-0.97	1.750
Left T4	-0.94	1.600

3.2.3 Simulation Model

As shown in Figure 10, the model scheme has subcatchment divided into quaternary fields. Flow direction starts from the rainfall through subcatchment, junction, conduit, storage unit, weir, and outfall. The geometry data for the channel was modeled as storage units for tertiary channels using a storage curve (Figure 11).

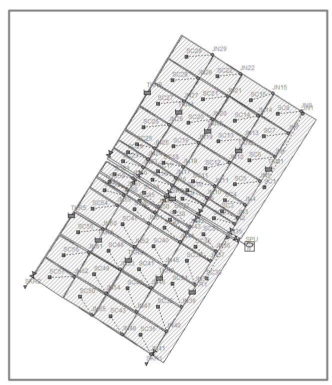

Figure 10 Irrigation scheme model in EPA-SWMM for Block A5

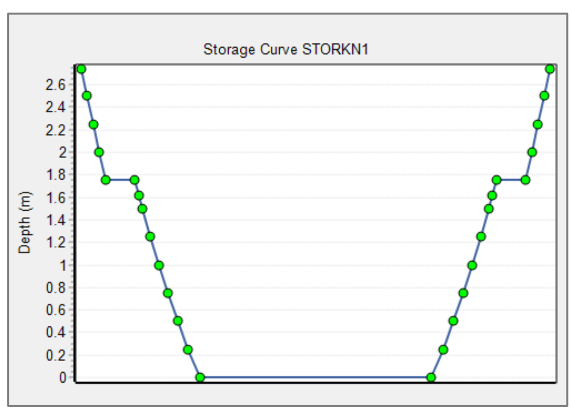

Figure 11 Storage curve for tertiary channel

3.2.4 Simulation Result

With a reasonable continuity error of less than 10% [16], results from the simulation were good, where the continuity error for surface runoff and flow routing is 0.00% and 8.99%, respectively.

The simulation results of water depth showed that there is no flooding in the node of a storage unit, with the maximum reported water depth of 2.18 m for the Right Tertiary Channels (Figure 12) and 2.06 m for the Left Tertiary Channels (Figure 13). Therefore, with 3 meters of maximum channel depth, the water level simulation results do not overflow, detailed results shown in Table 9.

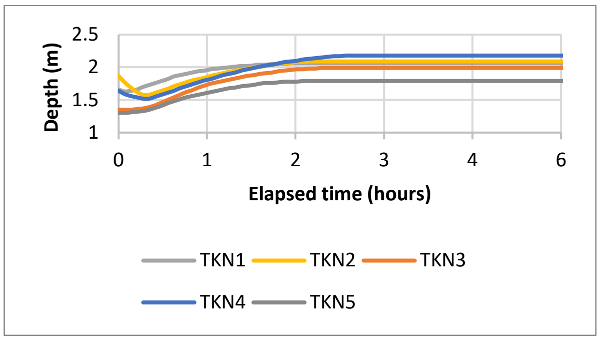

Figure 12 Simulation results of water depth graph for Right Tertiary Channels

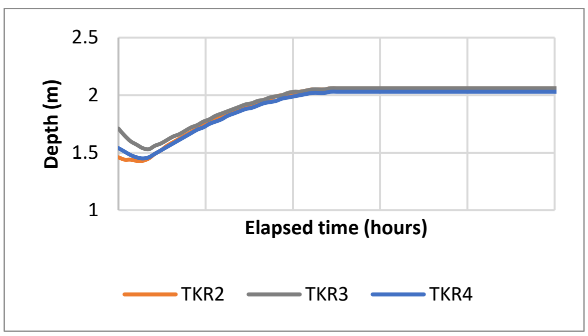

Figure 13 Simulation results of water depth graph for Left Tertiary Channels

Table 9 Results of water depth and water elevation calculation

Location	Water Depth (m)	Water surface elevation	
		Measurement	Simulation
Right T1	2.060	1.082	1.100
Right T2	2.090	1.101	1.090
Right T3	1.990	1.020	1.090
Right T4	2.180	1.147	1.080
Right T5	1.790	1.195	1.090
Left T2	2.060	1.142	1.086
Left T3	2.060	1.083	1.090
Left T4	2.030	1.115	1.088

The water surface elevation was calculated from the data of water depth simulation results. Using the Root Mean Squared Error (RMSE), the measurement data on 25 February 2023 was compared to the simulation results give value of 0.056. Therefore, the accuracy of the storage model was good with RMSE value close to zero.

3.2.5 Comparison of Elevation

Field elevation and the water surface results were compared to determine the suitable location for the development of fishery cultivation. The water surface elevation was calculated from the water depth and invert elevation values. The location for fishery cultivation was considered based on the field's elevation.

According to the results of EPA-SWMM for storage modeling, it is shown that some channels have higher water surface elevation than the fields, such as Right Tertiary 2, Left Tertiary 2, Left Tertiary 3, and Left Tertiary 4 channels. The field elevation ranged from 0.57-1.07 with an approximate area of ± 314.41 Ha could be suitable for fishery cultivation activities (Figure 14).

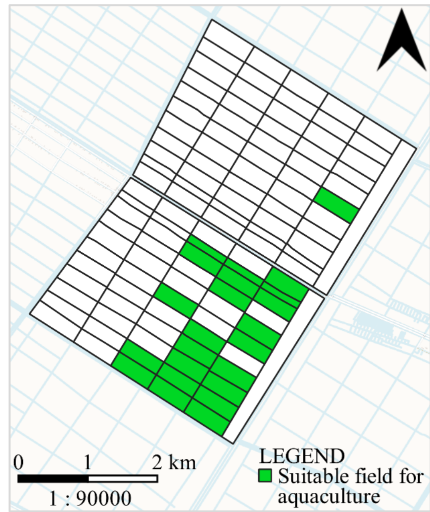

Figure 14 Suitable location for fishery cultivation based on elevation

4.0 CONCLUSION

The present study was aiming at the appropriate location for the development of fishery cultivation based on the SNI. This method has never been used before, but could be used to identify the suitability of existing conditions for fishery cultivation in lowland.

Based on the results of this research, most of the requirements for fishery cultivation in lowland areas have been met the criteria, such as applicable regulations, water quality aspects (for DO and temperature), water balance, supporting infrastructures, peat thickness, pond requirements, and flood-free conditions. However, there is a challenge regarding the water quality, specifically the unsuitably low pH level. Therefore, the selection of local fish species that are already adapted to acidic environments could be considered for the cultivation activities. Other than that, the water quality could be enhanced to optimize fishery cultivation. The water quality improvement could be achieved by implementing water system regulations, such as using gates to occur the leaching process. These regulations aim to prevent acidic water from entering the system and flushing when rain occurs to supply fresh water. Furthermore, the liming and fertilization process also can be conducted to improve the water quality in the study area.

The study has shown that there were potentially suitable fields for the development of fishery cultivation with 19.41% area of total Block A5 DIR Dadahup. Furthermore, the development should follow the regulations to obtain fish farming suitability.

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Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper

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