WATER MANAGEMENT SERVICE FEE FOR OPTIMAL OPERATION AND MAINTENANCE OF CANAL SYSTEMS IN TIDAL LOWLANDS CASE STUDY TELANG I, SOUTH SUMATERA

FRAIS DE GESTION DE SERVICES DE L'EAU POUR UN FONCTIONNEMENT OPTIMAL ET MAINTENANCE DES SYSTEMES DE CANAL DANS LES PLAINES BAS MAREE
ÉTUDE DE CAS TELANG I, SUD SUMATRA

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ABSTRACT

Sufficient budget is an important condition for achieving adequate operation and maintenance of canal systems. This also applies to the success of agricultural exploitation of reclaimed tidal lowlands in Indonesia, which, among others, depends on good functioning water management systems. The effectiveness of such water management systems is largely determined by how well these systems are operated and maintained, which in turn determines the resource requirements for operation and maintenance. Therefore an important question is what would be an optimal level of operation and maintenance? This is what has been explored in the case study of Telang I in South Sumatera, which is one of the large reclaimed tidal lowlands under the development programme of the Indonesian Government. By focusing on potential tradeoffs, this research has examined an optimum level of operation and maintenance of the canal systems by analyzing the present condition of the canal systems, the expected average annual damage due to yield reduction and the required activities and budget to keep the systems in the envisaged condition. Based on hydraulic modelling, economic assessments and analysis of the existing rules, an optimal level of operation and maintenance is recommended. The results can also be useful in support of the preparation of policies for sharing the operation and maintenance costs among the Indonesian Government and farmers.

KEY WORDS: tidal lowlands, operation and maintenance, canal systems, water management service fee.

SYNTHÈSE ET CONCLUSIONS

Budget suffisant est une condition importante pour la réalisation du fonctionnement adéquat et la maintenance de systèmes de canalisation. Ceci s'applique également à la réussite de l'exploitation agricole des plaines bas récupérées marée en Indonésie, qui, entre autres, dépend le bon fonctionnement des systèmes de gestion de l'eau. L'efficacité de tels systèmes de gestion

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de l'eau est largement déterminée par la façon dont ces systèmes sont exploités et entretenus, ce qui détermine les ressources nécessaires pour le fonctionnement et l'entretien. Par conséquent, une question importante est ce que serait un niveau optimal d'exploitation et d'entretien? C'est ce qui a été explorée dans l'étude de cas, je Telang dans le sud de Sumatra, qui est l'une des grandes plaines de marée récupérés dans le cadre du programme de développement du gouvernement indonésien. En se concentrant sur les compromis possibles, cette recherche a examiné un niveau optimal d'exploitation et la maintenance du réseau de canaux en analysant l'état actuel du réseau de canaux, les dommages prévus en moyenne annuelle en raison de la réduction de rendement et les activités nécessaires et le budget pour maintenir les systèmes dans l'état prévu. Sur la base de la modélisation hydraulique, les évaluations économiques et de l'analyse des règles en vigueur, un niveau optimal d'exploitation et d'entretien est recommandée. Les résultats peuvent aussi être utiles à l'appui de l'élaboration des politiques pour le partage des coûts d'exploitation et d'entretien entre le gouvernement indonésien et les agriculteurs.

MOTS CLÉS: les plaines bas de marée, le fonctionnement et la maintenance, des systèmes de canalisation, des frais de service de gestion des eaux.

INTRODUCTION

Population growth will result in a reduced area per person to support his/her living conditions. In addition there is a continuous loss of existing fertile agricultural lands to residential, industrial and other forms of land use. Indonesia, which is expected to have approximately 270 million people in 2025, needs a well defined strategy to cope with this problem. In light of these developments marginal areas like the tidal lowlands become more important for the future of agricultural development (Suryadi, 1996). Therefore in the recently formulated policy of the Indonesian Government, one of the main objectives is tidal lowland development and management to contribute to the required increase in food production in order to maintain self-sufficiency in food, especially in Rice (Schultz, 2006).

The success of reclaimed tidal lowlands for agriculture depends to a large extent on the functioning of the water management system that is applied. To achieve a proper and sustainable functioning, operation and maintenance (O&M) of the canal systems are of major importance. Sufficient budget is an important condition for achieving adequate operation and maintenance of the canal systems. Based on hydraulic modelling, economic assessments and analysis of the existing rules, this paper recommends an optimal level of operation and maintenance, as well as how such a level can be achieved.

PROBLEM DEFINITION

Large scale reclamation of South Sumatera tidal lowland by the Indonesian government for transmigration purposes started in 1969. One of the schemes is Telang I (26,680 ha), located in the coastal swamp plains north of Palembang in South Sumatera Province. Administratively, Telang I is located in the Muara Telang Sub District in Banyuasin District (Figure 1). It is bordered by the Musi (East), Selat Jaran and Sebalik (South), Anak Telang and Telang rivers (West and North).

The water management systems (irrigation and drainage) of Telang I, consisting of primary, secondary and tertiary canals, are generally provided with water control structures in several of the secondary and tertiary canals. However, not all parts of the area have sufficient structures. In addition, there are some water control structures and also some canals found in poor condition. Insufficient funding is an obstacle for proper O&M of the canal systems.

RESEARCH OBJECTIVES

The objectives of this research were:

- to analyze the required activities and budget for O&M of the canal systems in Telang I;
- to analyze the capability of water users associations (farmers) in funding of, or contributing to the O&M cost in Telang I;
- to recommend a water management service fee (WMSF) for optimum O&M of the water management systems in Telang I.

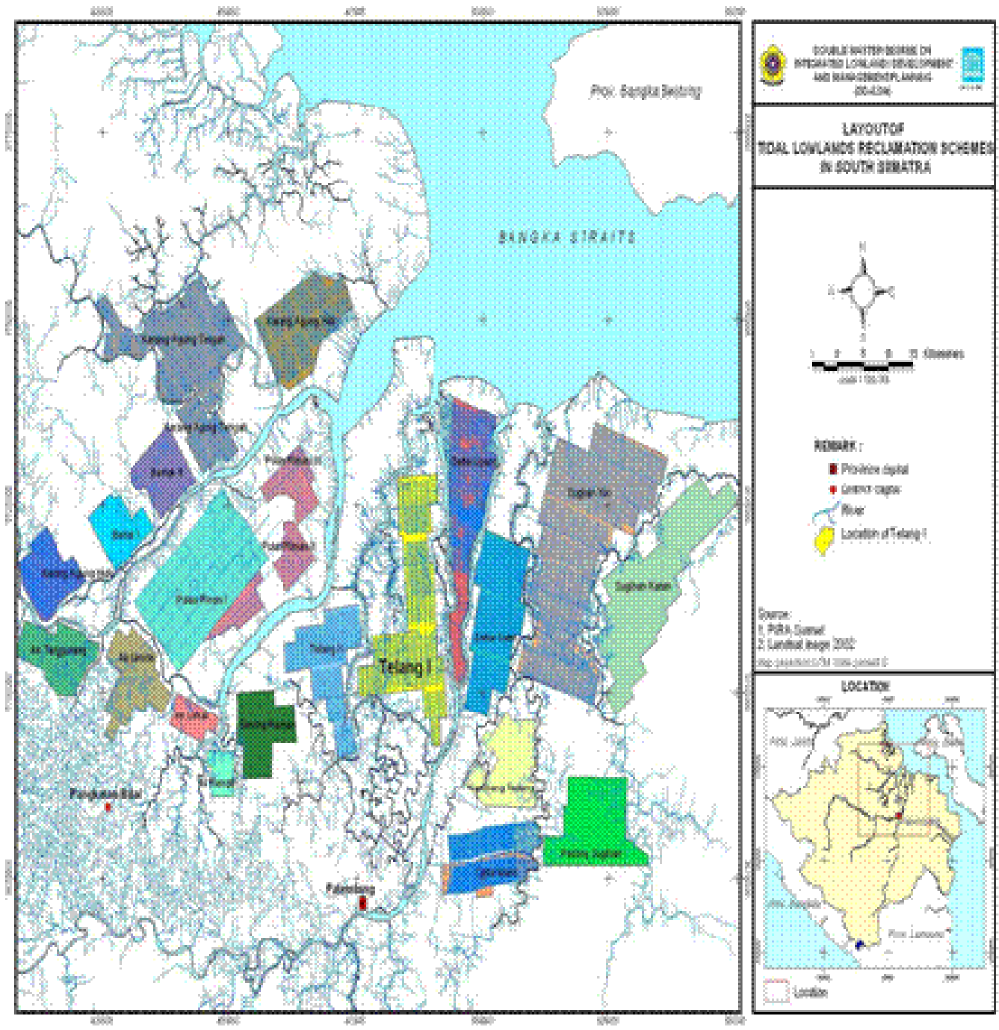


Figure 1. Tidal lowlands schemes in South Sumatra

METHODOLOGY

Figure 2 shows the methodology that has been used in this study. All data and information collected during the fieldwork were analyzed and evaluated to identify the real condition of the canal systems and to determine the required budget for O&M in the present situation. Government budget for funding O&M in the present situation was analyzed and followed by a capability analysis of the farmers in contributing to the O&M cost.

The level of service was determined based on the expected damage (damage cost) in each secondary block. The expected damage itself was determined by the relationship between relative yield decrease (1-Ya/Ym) and number of days of submergence with clear water for Rice. In the formulae Ya = actual yield and Ym is maximal yield.

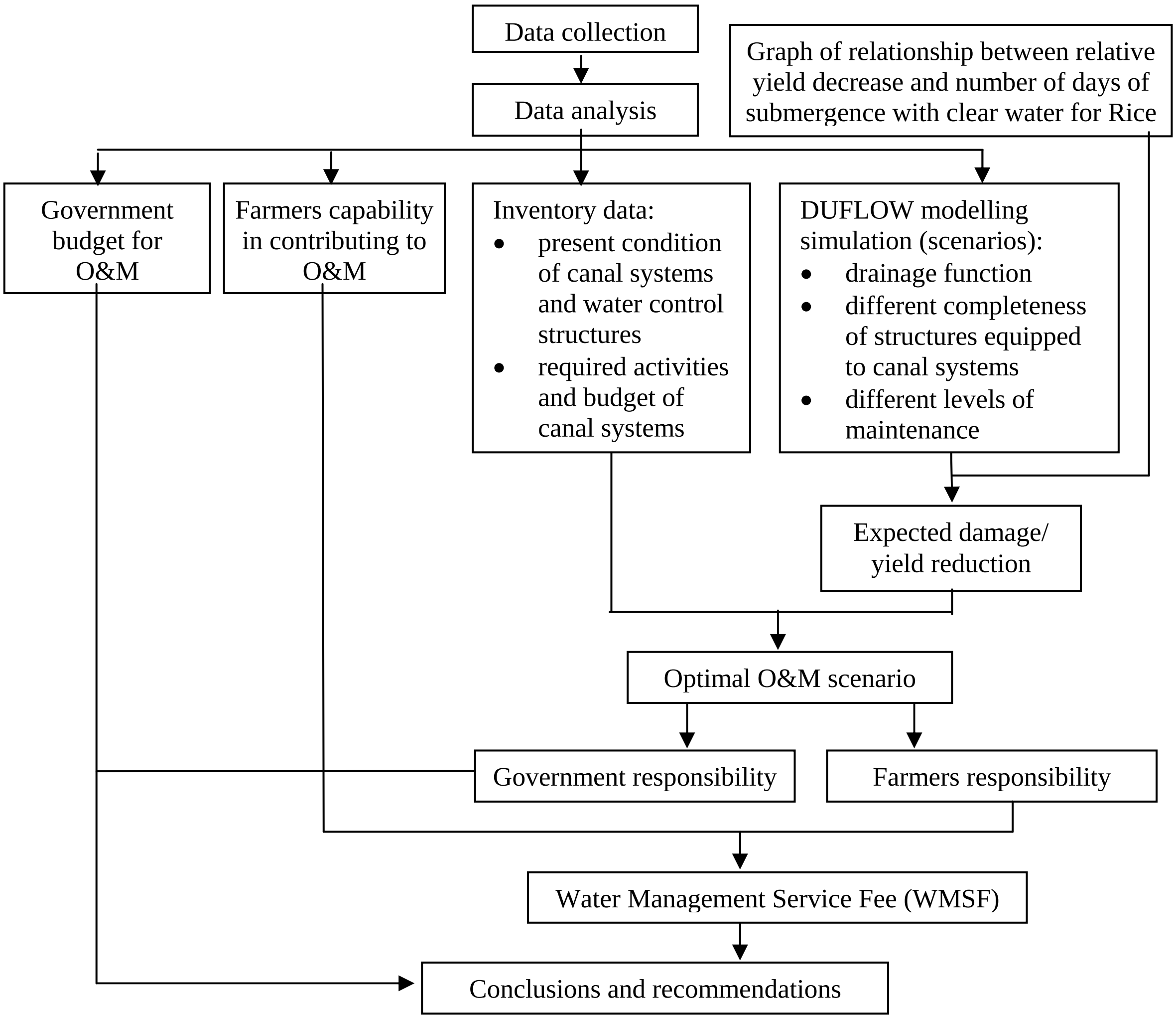


Figure 2. Methodology of the study

The canal system was modelled with DUFLOW to simulate the submergence related to the drainage function. DUFLOW is a hydraulic model for the simulation of non-steady flow. The drainage function was chosen instead of the supply function because in this particular research area, water supply is not a problem, since there is a combination of high tide and high rainfall. The main problem is how to keep the water level as needed, which requires a proper functioning of the drainage system to avoid deep and long inundation and to get rid of the excess water due to high tide and high rainfall (Joint Working Group, 2006a). The results of those analyses were formulated in level of service, followed by how and how much the farmers would have to be charged for water management service fee.

RESULTS AND DISCUSSION

Present condition of the canal systems and water control structures in Telang I

As a whole, for this study, the area of Telang I has been categorized as listed in Table 1. The level of production was determined based on secondary data from the projects Land and Water Management Tidal Lowlands (LWMTL) and Strengthening Tidal Lowland Development (STLD) and interviews with farmers (Hartoyo Suprianto et al., 2010).

Table 1. Categories of areas based on the existing hydraulic infrastructure in Telang I

Category	Remark	Sampling area (secondary block)	Paddy rice yield (tons/ha)
I	• flap gate in the secondary canal • flap gates in the tertiary canals • tertiary canal interval = 200 m	P6-3N	7
II	• no flap gate in the secondary canal • flap gates in the tertiary canals • tertiary canal interval = 200 m	P8-12S	5.5
III	• no flap gate in the secondary canal • flap gates in the tertiary canals • tertiary canal interval = 400 m	P8-9S	4.5
IV	• no flap gate in the secondary canal • no flap gates in the tertiary canals • tertiary canal interval = 400 m	P6-3S	3.5

DUFLOW model simulation

DUFLOW model simulation was undertaken to show the drainage function of the canal system in regard with the different scenarios of O&M and the different level of completeness of the hydraulic infrastructure. Table 2 shows the scenarios that were simulated with the DUFLOW model. In Table 2 complete structures means that the secondary canal (SPD) and tertiary canals are provided with flap gates. Half structures means that the flap gates are only in the SPD canal or only in the tertiary canals and no structures means open connections of all canals (Figure 3).

Table 2. Scenarios that were simulated with the DUFLOW model

O&M scenario	Resistance (Chezy) value for cross-section in secondary and tertiary canals		
	Complete structures	Half structures	No structures
100%	40	40	40
75%	25	25	25
50%	20	20	20

In these simulations, the condition of 100%, 75% and 50% O&M of the canal system was represented by the roughness (resistance value) of the cross-section and also of the flap gates. The 100%, 75% and 50% represent the different levels of maintenance frequency, which was proportionally decreased based on the Technical Guidelines of Tidal Lowland Development (Joint Working Group, 2006b). By expert judgement, the resistance values of 100%, 75% and 50% O&M conditions were chosen as respectively 40, 25 and 20. However, since the 17 tertiary canals in the simulations are grouped into 3 bigger tertiary canals, the values of resistance in tertiary canals and tertiary gates were adjusted to represent the conditions as shown in Table 3.

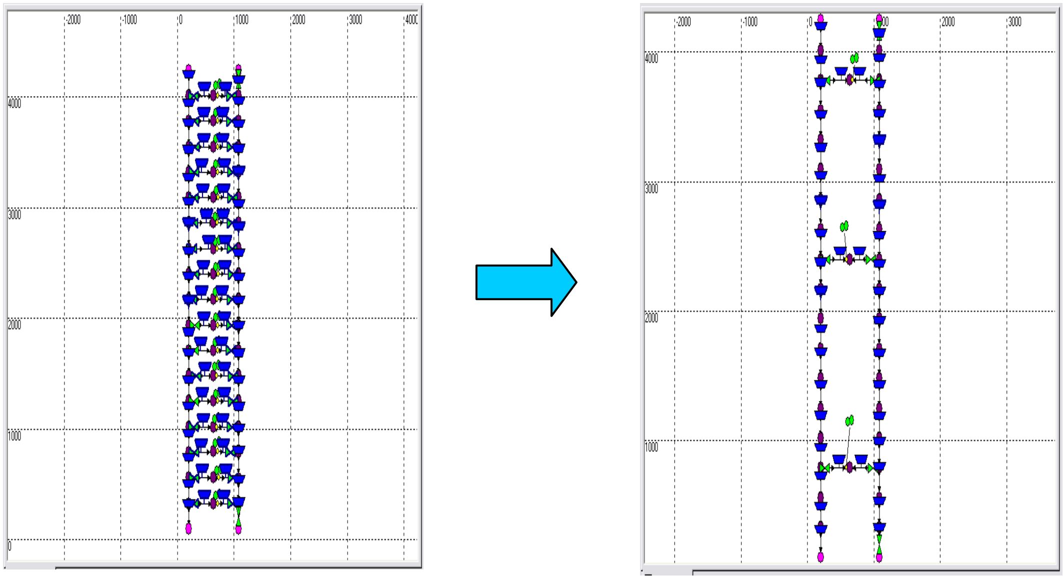
Figure 3. Example of movable flap gate in a tertiary canal and a flap gate in a secondary canal

Table 3. Adapted value of roughness in tertiary canals

O&M scenario	Resistance (Chezy) value		
	Secondary canal	Tertiary canal (TC)*)	
		Head and tail canal (5 TC become 1 TC)	Middle canal (7 TC become 1 TC)
100%	40	27	26
75%	25	17	16
50%	20	14	13

*) adapted values due to clustering in the mathematical schematisation

Figure 4 presents the original and the modified schematization of the secondary blocks. For the simulation of the different scenarios the modified schematisation has been applied. For the DUFLOW simulation, a rainfall of 200 mm on the first day was chosen. All the gates were in drainage position. The mean tidal fluctuation of 1.65 m was used as the boundary at Primary Canal 5 and Primary Canal 6. The secondary block was simulated with two secondary canals: SDU and SPD, and three big tertiary canals. The results of different scenarios of the DUFLOW simulation will be discussed underneath.



Original schematization of the secondary block

Modified schematization of the secondary block

Figure 4. Original and modified schematization of the secondary block

Scenario I: Secondary block with complete structures (flap gates in the secondary canal (SPD) and tertiary canals)

Scenario I concerns a secondary block with complete structures (flap gates in the secondary canal (SPD) and tertiary canals) as is the case in P6-3N. The secondary canal (SDU) at the other end of the tertiary canals is in open connection with the primary canal. Figures 5 and 6 show the mean water level in the tertiary canals on day 1, 2 and 3 after the rain. As shown in Figures 5 and 6, the higher the level of O&M, the lower the water level, or in other words, the lower the resistance value (roughness), the lower the water level. This shows that the functioning of the drainage system depends on the level of O&M. Figures 5 and 6 show that the water level in the tertiary canal near the SPD is lower than the water level near the SDU. The difference is caused by the flap gate in the SPD and the open connection of the SDU with the primary canal. Due to this the water level in the SDU cannot be controlled and follows the tidal fluctuation. With the flap gate in the SPD in drainage position a lower water level could be maintained.

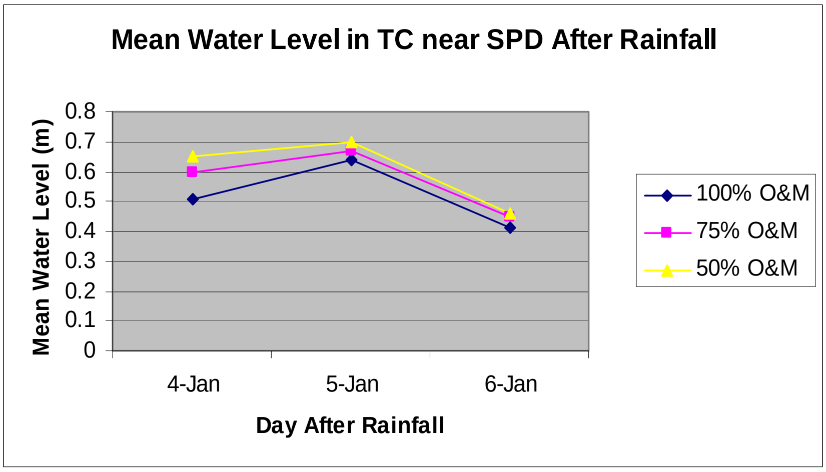


Figure 5. Mean water level in tertiary canals near SPD after Rainfall

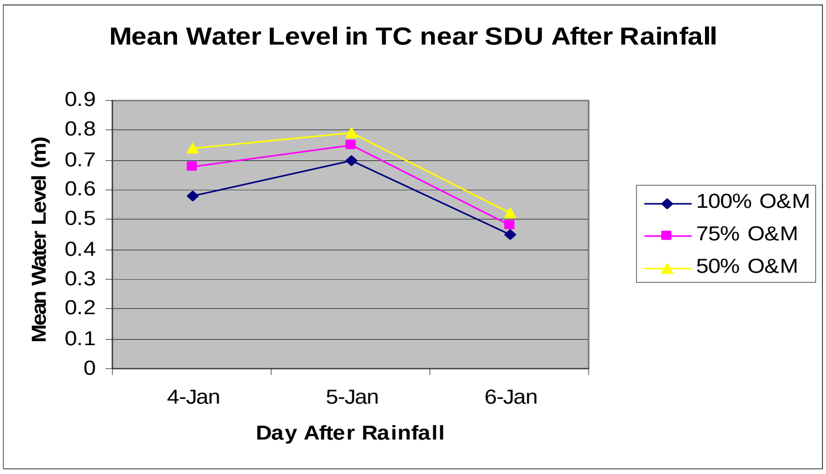


Figure 6. Mean water level in the tertiary canals near the SDU after rainfall

Scenario II: Secondary block with half structures

Scenario II concerns a secondary block with half structures. In Scenario II.a there is only a flap gate in the SPD. This situation doesn't occur in one of the four areas. It occurs, however, in other areas in Telang I. In Scenario II.b there are only flap gates in the tertiary canals as is the case in P8-12S and P8-9S. However, the simulations are based on the conditions of P8-12S, while here the spacing between the tertiary canals is 200 m. In both cases the secondary canal (SDU) at the other outlet of the tertiary canals has an open connection with the primary canal.

Scenario II.a. Only a flap gate in the SPD

Figures 7 and 8 show the mean water level in the tertiary canals on day 1, 2 and 3 after the rain. The mean water level in Scenario II.a is higher than in Scenario I. This means that the drainage system in Scenario II.a is not as good as in Scenario I. This is due to the open connection between the tertiary canals and the SPD. It shows that the tertiary gates optimize the drainage function of the canal system. Furthermore, in Scenario I, the mean water levels on day 3 after the rain don't show a significant difference between the levels of O&M, while in Scenario II.a there is a significant difference in mean water level for different levels of O&M, particularly for 100% O&M compared to 75% and 50% O&M. In day 3 after the rain, the mean water level for 75% and 50% level of O&M is about the same, but the are about 0.25 m higher than the mean water level of 100% O&M. For this reason in a canal system provided with half structures the level of O&M would have to be given higher priority than for a canal with complete structures.

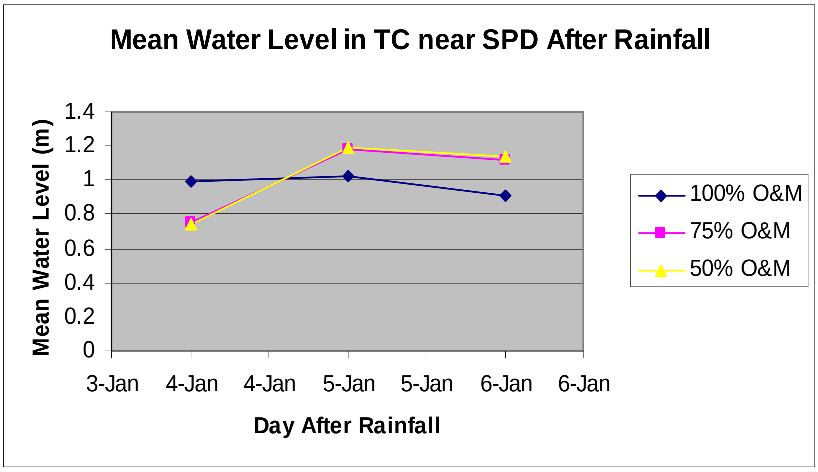


Figure 7. Mean water level in the tertiary canal near the SPD after rainfall

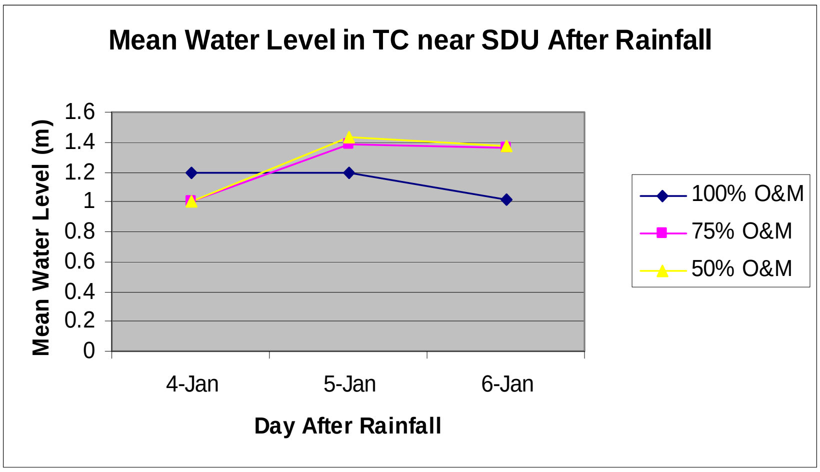


Figure 8. Mean water level in the tertiary canal near the SDU after rainfall

Scenario II.b. Only flap gates in the tertiary canals

Figures 9 and 10 show the mean water level in the tertiary canals on day 1, 2 and 3 after the rain. The mean water level in Scenario II.b is lower than in Scenario II.a, which means that having only flap gates only in the tertiary canals is better for the drainage function than only flap gates in the SPDs. In addition the overall results show that in this Scenario there are significant differences in mean water levels among 100%, 75% and 50%, respectively. Therefore, as with Scenario II.a, in this scenario the level of O&M would have to be prioritized above canals with complete structures.

Scenario III. Secondary block without structures (no flap gates provided)

In scenario III there are no structures as is the case in P6-3S. Although in this area the spacing between the tertiary canals is 400 m the simulations have been based on a spacing of 200 m to make the results comparable with the results for the other areas. Figures 11 and 12 show the mean water level in the tertiary canals on day 1, 2 and 3 after the rain. The mean water level in this scenario is high since the day of rain and only lowers about 20 mm in day 3 after rain. It shows that the drainage function of this canal system is almost zero. As in Scenario II in this scenario the level of O&M would have be high to optimize the drainage function.

The results of DUFLOW simulations for the scenarios I, IIa, IIb and III show that:

- the optimum drainage function can be achieved when the canal systems are provided with complete structures;
- various levels of O&M will give different levels of the drainage function. The higher the level, the better the drainage function;
- particularly in case of only half structures or no structures, the level of O&M would have to be high.

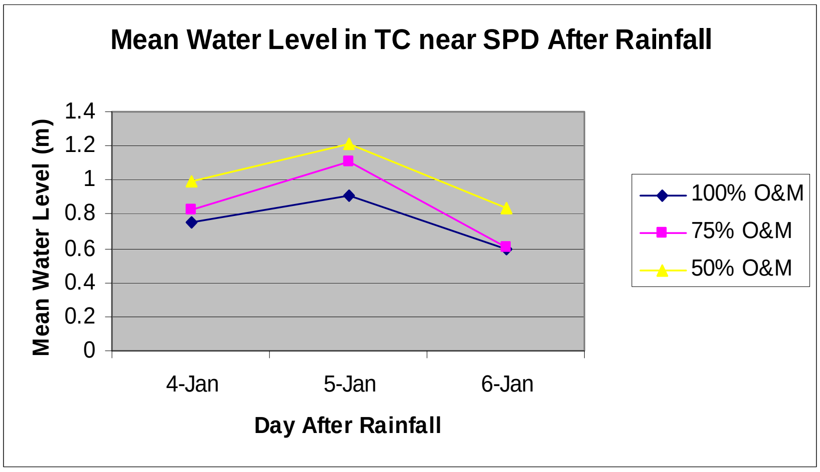


Figure 9. Mean water level in the tertiary canal near the SPD after rainfall

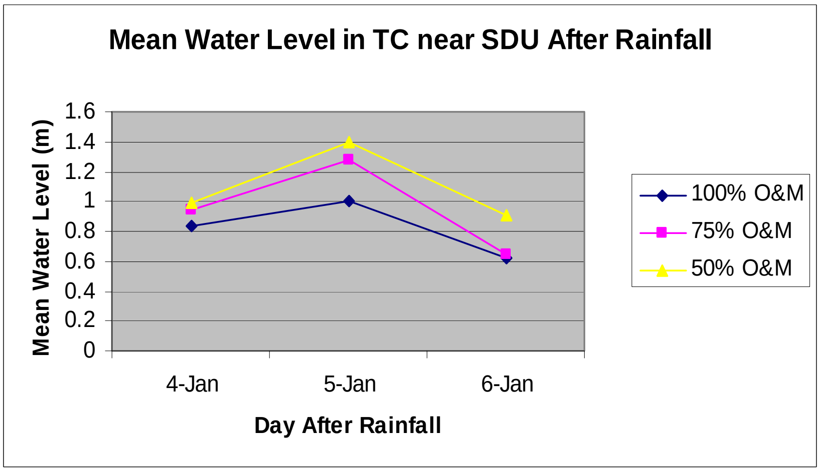


Figure 10. Mean water level in the tertiary canal near the SDU after rainfall

Required O&M activities and budget for the canal systems in Telang I

The required operation and maintenance activities for the canals are based on the considerations as presented in the Technical Guidelines on Tidal Lowland Development (Joint Working Group, 2006a and 2006b).

At the moment, although the available budget is called operation and maintenance budget, it is actually only for funding the maintenance cost. Furthermore, no field staff is available for the Telang I scheme. Nevertheless, the estimated operation costs for the Telang I scheme have been calculated for analysis purposes only. The calculations were based on the Technical Guidelines on Tidal Lowland Development. Volume III: Operation and Maintenance as shown in Table 4 (Joint Working Group, 2006b).

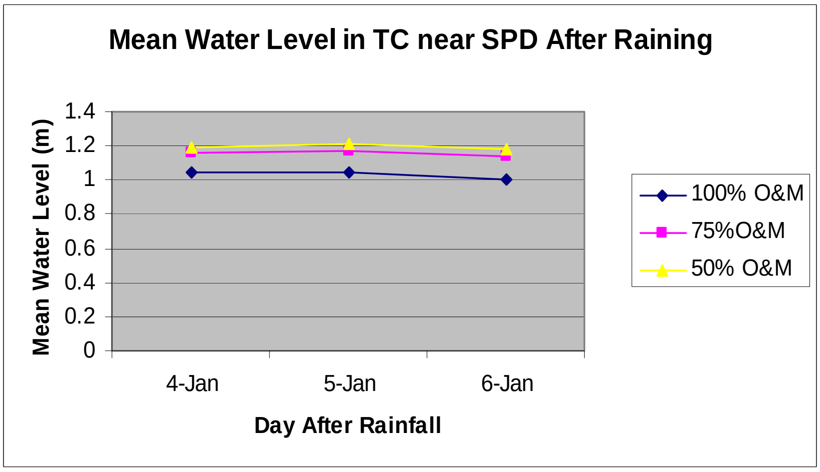


Figure 11. Mean water level in the tertiary canals near the SPD after rain

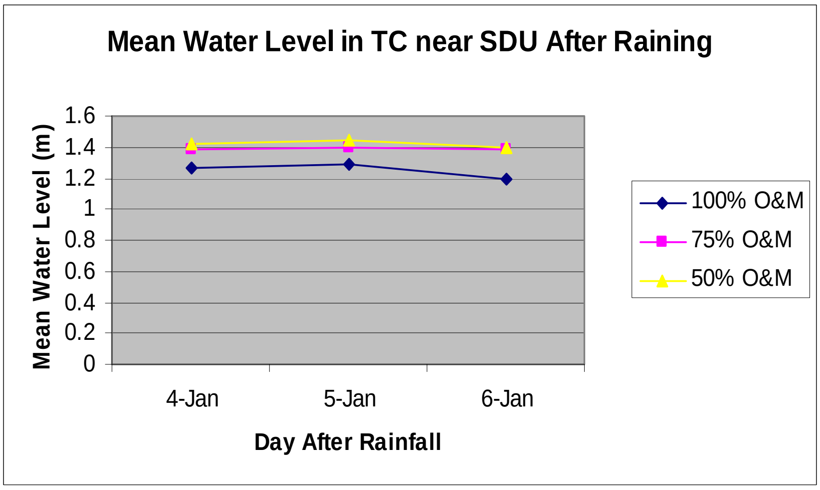


Figure 12. Mean water level in the tertiary canals near the SDU after rain

Table 4. Number of field staff and service area (Joint Working Group, 2006b)

Number of field staff	Service area
1 scheme manager Supported by 3 staff	3,000 – 25,000 ha
1 secondary block staff	1,000 – 2,000 ha
1 gate operator	3 – 5 gates in secondary canals
Water Users Association (WUA)	tertiary block

Required maintenance activities ideally consist of routine, periodic and emergency maintenance. However, in the cost analysis, not all activities are included, due to priority of the maintenance activities and also the existing conditions of the canal systems. As the reference the Standard Unit Prices 2007 from Local Government - in this case Banyuasin District - has been used. Labour output criteria that were used for the calculations were also taken also from the Technical Guidelines on Tidal Lowland Development as shown in Table 5. Table 6 summarizes the total O&M cost per ha per year for Government and farmers share.

Government budget for O&M and farmers capability in contributing to O&M cost

O&M budget per ha per year for Telang I follows the general O&M budget for irrigation as much as Rp 200,000 (when the study was under process). If it is compared to the total cost which would have to be shouldered to the government, that amount of money is still not sufficient to cover the total cost even when the level of maintenance is only 50%. In fact, from the previous analysis, the fewer the structures in the canal system, the higher the maintenance needs will be. Therefore, with this insufficient financial condition, optimal operation and maintenance of the canal systems can not be achieved. In addition, referring to previous analyses, the yield rate is hard to be maximal. Farmers' capability is viewed from income. Table 7 shows the average net income per ha.

Table 5. Labour output criteria (Joint Working Group, 2006b)

Activity	Location	Production per man day	Remarks
Grass cutting	Embankment	225 m^2	Dense vegetation
Grass cutting	Embankment	450 m^2	Normal vegetation
Minor repair	Embankment	500 m^2	Embankment surface
Canal cleaning	Canal	165 m^2	Aquatic weeds
Soil compaction*)	Structure	5 m^2	Normal condition

*) based on interview

Table 6. Required operation and maintenance budget

Category	Secondary block	Total operation and maintenance cost /ha/year (Rp 1,000)					
		Government share			Farmers share		
		100% M	75% M	50% M	100% M	75% M	50% M
I	P6 - 3N	323	266	263	658	616	615
II	P8 - 12S	297	240	236	623	580	579
III	P8 - 9S	287	233	229	284	268	268
IV	P6 - 3S	284	230	227	259	243	243

M = level of maintenance

Table 7. Net Income per ha for one planting season

Category	Secondary block	Average yield (kg/ha)	Dry husked rice price (Rp/kg)	Gross income per ha (Rp 1,000)	Total production cost per ha (Rp 1,000)	Net income per ha (Rp 1,000)
I	P6 – 3N	7,000	2,700	18,900	6,150	12,800
II	P8 – 12S	5,500	2,700	14,900	5,280	9,570
III	P8 – 9S	4,500	2,700	12,200	4,720	7,440
IV	P6 – 3S	3,000	2,700	8,100	4,310	3,790

1 US$ = Rp 9,150 (Indonesian National Budget, 2008)

Expected damage (yield reduction)

The relationship between damage and O&M cost was analyzed in order to find the optimum level of O&M. From Figure 13, showing the relationship between Relative Yield Decrease (1 - Ya/Ym) and number of days of submergence with clear and muddy water for Rice (Doorenbos and Kassam, 1986), and the results of the DUFLOW simulations, the analysis as shown in Table 8 has been undertaken.

Optimal O&M scenario

It is considered as the optimal O&M cost, when the total cost of average annual damage and O&M is the lowest.

For scenario I (similar to secondary block P6-3N) Table 9 and Figure 14 show that by focusing on the drainage function of the canal systems the optimal level of O&M is at 50%.

Different from the result of scenario I Table 9 and Figure 15 show that for scenario II.a, the optimal level of O&M is 75%, since 75% and 100% level of maintenance give no significant difference.

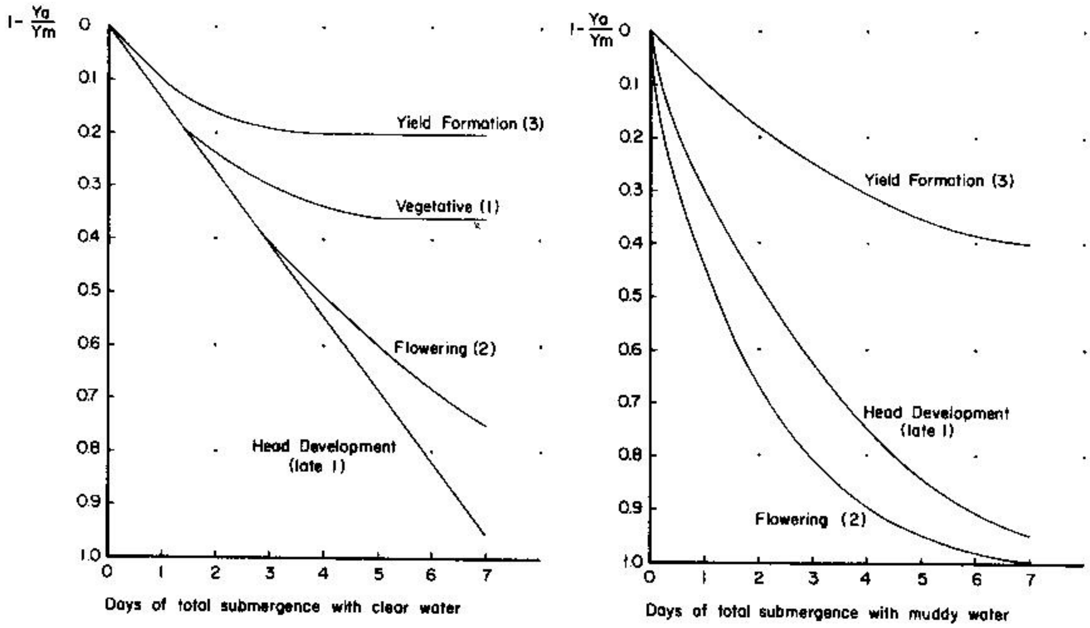


Figure 13. Relationship between Relative Yield Decrease (1 – Ya/Ym) and number of days of submergence with clear and muddy water for Rice (Doorenbos and Kassam, 1986)

Table 8. Yield reduction in the studied secondary blocks

Category	Secondary block	Yield reduction (damage)		
		100% level of maintenance	75% level of maintenance	50% level of maintenance
I	P6-3N	0%	0%	0%
II	P8-12S	0%	0%	14%
III	P8-9S	0%	0%	14%
IV	P6-3S	0%	27%	27%

Table 9. O&M cost and damage (yield reduction) relation in P6-3N, P8-12S, P8-9S and P6-3S

O&M cost (RP 1,000)			Damage (yield reduction)								
100% M	75% M	50% M	100% M			75% M			50% M		
			%	Tot (kg)	Tot (Rp 1,000)	%	Tot (kg)	Tot (Rp 1,000)	%	Tot (kg)	Tot (Rp 1,000)
P6-3N											
323	266	263	0	0	0	0	0	0	0	0	0
P8-12S											
297	240	236	0	0	0	0	0	0	14	770	2,079
P8-9S											
287	233	229	0	0	0	0	0	0	14	630	1,701
P6-3S											
284	230	227	0	0	0	27	810	2,187	27	810	2,187

For scenario II.b (similar to secondary blocks P8-12S and P8-9S) it is shown in Table 9 and in the Figures 15 and that the optimal level of O&M is also at 75%.

Finally for scenario III (similar to secondary block P6-3S) from Table 9 and Figure 17 it is shown that the optimal level of O&M is at 75%.

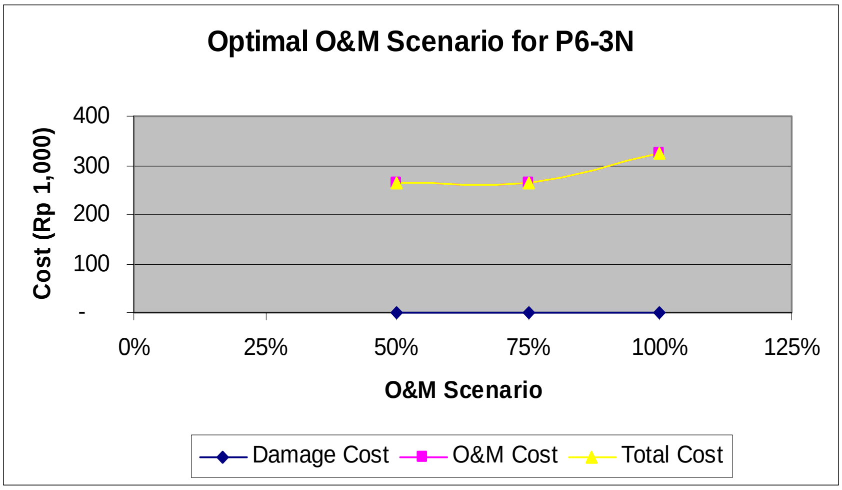


Figure 14. Optimal O&M Scenario for P6-3N

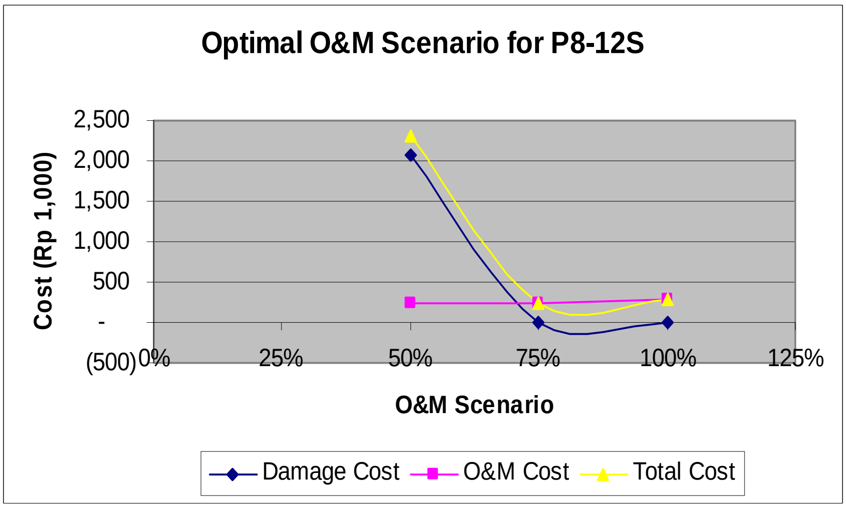


Figure 15. Optimal O&M Scenario for P8-12S

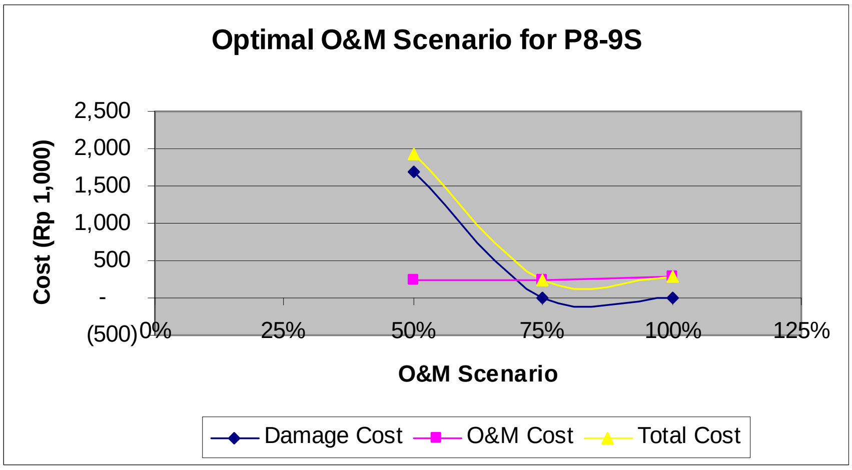


Figure 16. Optimal O&M Scenario for P8-9S

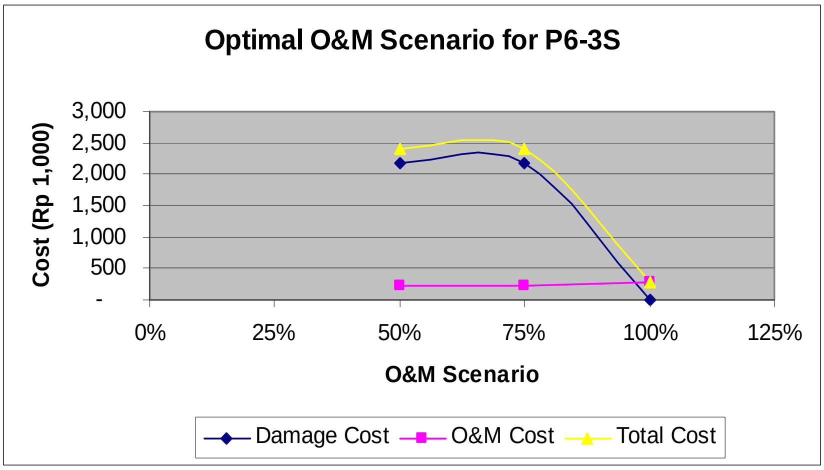


Figure 17. O&M cost and damage (yield reduction) relationship in P6-3S

Water Management Service Fee (WMSF)

Table 10 shows the amount of water management service fee (WMSF) compared to the optimal O&M costs (farmers' share) for four particular secondary blocks as by the previous analysis. WMSF is charged with the same flat percentage, 5%, for all secondary blocks from gross revenue. 5% is taken due to the general accepted percentage for irrigation service fee with respect to the willingness to pay of farmers. This 5% of gross income is also used due to the fairness in dealing with the O&M costs of each secondary block, which will affect the yield.

Table 10. Water Management Service Fee for the sampling secondary blocks

Category	Secondary block	Optimal O&M	Gross income (per ha)	Tertiary O&M cost (per ha)		WMSF *) (per ha)	Net income (per ha)	WMSF of NI
			(Rp 1,000)	(Rp 1,000)	% of GI	(Rp 1,000)	(Rp 1,000)	%
I	P6-3N	50%	18,900	615	3%	945	12,754	7%
II	P8-12S	75%	14,850	580	4%	743	9,568	8%
II	P8-9S	75%	12,150	268	2%	608	7,435	8%
IV	P6-3S	100%	8,100	259	3%	405	3,790	11%

*) 5% x Gross Income

In this case WMSF charged to the four particular secondary blocks in one planting season is adequate to cover the O&M cost for optimal O&M scenario in one year. Furthermore, if the planting season in one year is more than one time, WMSF becomes more affordable. Besides, the farmers can also combine WMSF with labour work as alternative.

WMSF needs to be collected and managed by the Water Users Association (WUA). In case of surplus or extra money from WMSF this can be used modernisation of canals and structures. For this reason, the existence of active WUAs is vital.

CONCLUSIONS

Based on the above analysis the following conclusions can be drawn:

- the required activities and budget for optimal O&M of the canal systems in Telang I was analyzed referred to Technical Guidelines on Tidal Lowland Development of 2005. Based on existing conditions, the drainage function of Telang I system is optimum when the secondary and tertiary canals are equipped with complete structures. The higher the level of maintenance, the better the drainage performance. The level of maintenance in canal systems that are not provided with structures needs to be high. The combination of hydro-topography, completeness of the structures in canal systems and level of maintenance will determine the yield;

- each secondary block in Telang I has its own optimum level of maintenance. In general, the more complete the structures, the lower the required level of maintenance. Therefore, the required budget for optimal O&M for each secondary block is different. However, the present government budget for O&M of the canal systems does not fully cover the required budget;
- the farmers in Telang I are actually capable to cover the required budget for O&M of their share (tertiary canals). However, farmers whose lands are provided canal systems with complete structures show more willingness to pay than others. Furthermore, the farmers who belong to active WUAs show more willingness to pay than those who don't;
- charging 5% WMSF of gross income from one planting season is sufficient to cover the cost for an optimum maintenance level. Hence, if there are more than one planting seasons in one year, WMSF in is even more affordable. Contribution of labour work from the farmers is also an option.

RECOMMENDATIONS

Some recommendations to achieve optimal operation and maintenance of canal systems in Telang I tidal lowland agriculture schemes by charging the farmers WMSF are listed hereunder:

- the Indonesian government would have to consider to allocate sufficient budget to fulfil its operation and maintenance tasks for primary and secondary canals and related hydraulic control structures;
- upgrading and improvement of the canal systems are required to improve the water management and encourage the farmers' willingness to pay in order to achieve sustainability;
- empowerment and strengthening of WUAs is vital to encourage the farmers to participate actively in O&M activities, by labour and or financial contribution.

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