MEASUREMENT OF INFRASTRUCTURE PERFORMANCE IN LARGE IRRIGATION SCHEME AS A TOOL FOR ASSESSMENT OF IRRIGATION MODERNIZATION IN INDONESIA

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ABSTRACT

Irrigation modernization is a series of efforts to realize a participatory irrigation management system that is oriented in compliance the irrigation service level effectively, efficiently, and sustainably, in order to support food and water security. Irrigation modernization begins with the asessment of readiness index of irrigation modernization (IKMI), which consists of the assessment of 5 irrigation pillars: water availability, irrigation infrastructure, irrigation management system, irrigation institution, and human resources. This study discuss about the measurement of irrigation infrastructure of two large irrigation scheme in Indonesia, there are Serayu Irrigation Scheme (20,795 Ha) and Kedung Putri Irrigation Scheme (4,341 Ha). The assessment of infrastructure performance includes of 5 parts: main building, main network channel, main network building, drainage channel, and tertiary network. The assessment used the scale of 1 – 100, which includes irrigation network functions and conditions. The results showed that Serayu Irrigation Schemes and Kedung Putri Irrigation Schemes had the value of IKMI as 88.16 and 68.05 respectively. It means Serayu I.S included in the adequate predicate. Thus, the irrigation infrastructure of Serayu I.S. are ready to support the implementation of irrigation modernization. Meanwhile, Kedung Putri I.S included in the sufficient predicate. Then it is needed to improve the system for the 1 – 2 years on the irrigation infrastructure pillar.

Keywords: irrigation modernization, readiness index, irrigation pillars, infrastructure

1. INTRODUCTION

At this time, ecological and also strategic environment has changed globally, which is very influence the implementation of irrigation management. Moreover, many less conditions of irrigation system were found due to some reasons, there are: the end of irrigation network lifetime, the degradation of function and performance condition of irrigation system, lack of irrigation management service, and the requirement of irrigation management that not effective and efficient. To handle these problems, the related government has encouraged the development programme in irrigation sector by Irrigation Modernization (PUPR, 2011).

Irrigation modernization is considered able to resolving these problems because basically the management of irrigation system is not adequate conducted by general rehabilitation due to the changing of environmental factor. Therefore, it is required an innovation action to conduct the irrigation management, whether related to managerial, institution, as well as technical aspects so it's needed the irrigation modernization. The modernization irrigation is identic by the development. The

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development is a phenomenon that is considered to have future direction. The meaning of modernization is identic by the process of transformation in the whole aspects in it, the development form traditional to modern (Schoorl, 1982). Meanwhile, according to Soekanto (2007), modernization is a form of directed and planned change to improve the quality of a society and accelerate the economic development.
The assessment of the readiness index of irrigation modernization, can be conducted by rapid appraisal procedure (RAP). The RAP was originally developed by the Irrigation Training and Research Centre of California Polytechnic University in 1996-97 as a diagnostic and evaluation tool for a research programme financed by the World Bank on the evaluation of impact on performance of irrigation systems of the introduction of modern control and management practices in irrigation (FAO, 1999).
Infrastructure is one of irrigation pillar that has the highest proportion compared to other pillars, in term of the assessment of the readiness index of irrigation modernization. Thus, the measurement of infrastructure performance is essential in term of preparation of irrigation modernization in Indonesia. Moreover, this paper want to find out the performance of an irrigation system physically. According to Subekti et al (2013), preparation & implementing irrigation modernization readiness index, priority selection at selected irrigation command area will be used as a field irrigation modernization sample. The two selected samples are Serayu and Kedung Putri Irrigation Schemes.

2. METHODS

2.1 Research Location

This study was conducted in Serayu Irrigation Scheme (I.S.) and Kedung Putri I.S, Central Java Province, Indonesia. The service area of Serayu I.S and Kedung Putri I.S are 20,795 Ha and 4,341 Ha respectively. Based on the regulation of Indonesian Ministry of Public Works and Housing (PUPR Indonesian ministry) 14/PRT/M/2015, the development and management of irrigation system in irrigation scheme with the service area above 3,000 Ha, is the authority and responsibility of central government. In this case, the authorized institution is Central River Region of SerayuOpak (BBWS SerayuOpak). Both Serayu I.S and Kedung Putri I.S are located in SerayuBogowonto River Basin. Serayu I.S gets the water supply from Serayu River, through the Serayu Barrage, which is located in the coordinate of 109°12’6.75” E dan 7°31’33.22” S.Serayu I.S consists of 5 main channels with the total length of 95,947 m, and 32 secondary channels with the total length of 11.582 m. While Kedung Putri I.S gets the water supply from Bogowonto River through Kedung Putri Weir, which is located in the coordinate of 110°02’12.86”Eand 7°41’12.1” S. Kedung Putri I.S consists of 1 main channel with the total length of 60,196 m. The location of Serayu I.S and Kedung Putri I.S showed in Figure 1.

2.2 Pillars of Irrigation

According to Murtiningrum (2017), irrigation system consists of components of irrigation infrastructure, water availability, management system, institution, and human resources. Those 5 components are generally known as pillars of irrigation. Interaction process of those 5 pillars aims to meet the water need in agriculture land, to support the farming productivity, therefore the food security and public prosperity, especially for farmers can be achieved in the future. In irrigation systems, the sustainability of 5 pillars can forming a cycle as shown in Figure 2 (Arif and Sulaeman, 2014).

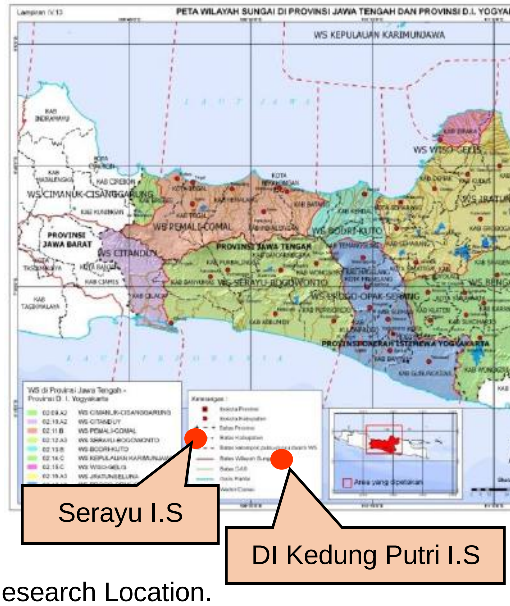

Figure 1. Research Location.
Source: Regulation of PUPR Indonesia Ministry 04/PRT/M/2015.

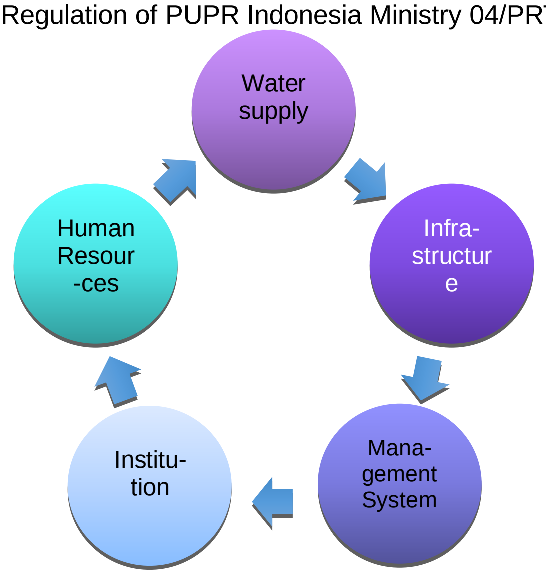

Figure 2. The Concept of Five Pillars in The Sustainability of Irrigation, Which is Cyclic.

Source: Arif and Sulaeman (2014).

Figure 2 shows that although the interaction is cyclic, each pillar can be the trigger of irrigation systems sustainability. Furthermore, the cyclic rotation can be reversed. If one of pillars has less role, thus can affect the performance of other pillars. In the irrigation management, all of the pillars have the same position. However, in the future, the problem of institution and human resources pillar will be more important than the problem of other pillars, because both of these two pillars have the strong effect on the other pillars (Arifand Sulaeman, 2014).

3. IRRIGATION MODERNIZATION

According to Food and Agriculture Organization (FAO) (2007), irrigation modernization is a process of improvement of technique and management (contradict with only rehabilitation) in irrigation scheme through the development of human resources (labor, water, economy, and environment) and water distribution service. Irrigation modernization in Indonesia interpreted as the effort to realize the participatory irrigation management system which oriented to the fulfillment of irrigation service level effectively, efficiently, and sustainably in order to support food and water security, through the enhancement of water supply, infrastructure, management system, institution, and human resources (PUPR, 2011).

Some irrigation in Indonesia are damaged, which their condition and function are inadequate to be applied in modernization, because the performance of irrigation system are too low. The implementation of modernization in those irrigation schemes need the high financing, and not efficient enough. For the irrigation scheme which has good performance, the modernization can be applied directly, while for those which have bad performance need to be enhanced first as the step of modernization preparation. Therefore,each irrigation scheme which will be implemented to modernization, has to selected first with the analysis of readiness index of irrigation modernization (IKMI). In the assessment of IKMI involves 5 irrigation pillars, there are water availability, irrigation infrastructure, irrigation management system, irrigation institution, and human resources. According to PUPR (2011), each pillar has the different proportion. Those proportion are 20%, 25%, 15%, 20%, and 20% for the pillar of water availability, infrastucture, management system, institution, and human resources respectively. This paper only discuss about the assessment of IKMI in term of infrastructure pillar, because this pillar have the highest proportion compared with other pillars. Moreover, this paper wantto find out the performance of an irrigation system physically.

3.1 Data Collection

The data collection was conducted with the tracking along irrigation network, to see irrigation infrastructure condition in field, inventory and measure the damages, accompanied with the photos for the documentation. This activity started from the weir until the tertiary network of irrigation scheme. This irrigation network tracking were done by surveyors and the technicians of the regional technical implementation unit (UPTD) from the Serayu I.S and Kedung Putri I.S. The equipment used were gage, stationary, the map of irrigation network scheme, assessment form, GPS, and camera. The measured data were (i) IKMI of main building (as shown in eq. 3), (ii) IKMI of main network channel (as shown in eq. 4), (iii) IKMI of main network building (as shown in eq. 7), (iv) IKMI of tertiary network (as shown in eq. 10), and (v) IKMI of drainage channel (as shown in eq. 11).

1. $Value\ of\ main\ building\ function = \frac{Number\ of\ main\ buildings\ that\ functioned\ well}{total\ number\ of\ main\ buildings} \times 100\%$
2. $Value\ of\ main\ building\ condition = \frac{Number\ of\ main\ buildings\ that\ conditioned\ well}{total\ number\ of\ main\ buildings} \times 100\%$
3. $IKMI\ of\ main\ building = \frac{eq.(1)+eq.(2)}{2}$
4. $IKMI\ of\ main\ network\ channel = \frac{Length\ of\ channel\ that\ conditioned\ well}{total\ length\ of\ channel} \times 100\%$
5. $Value\ of\ main\ network\ building\ function = \frac{Number\ of\ buildings\ that\ functioned\ well}{total\ number\ of\ main\ buildings} \times 100\%$
6. $Value\ of\ main\ network\ building\ condition = \frac{Number\ of\ buildings\ that\ conditioned\ well}{total\ number\ of\ main\ buildings} \times 100\%$

7. $IKMI\ of\ main\ network\ building = \frac{eq.(5)+eq.(6)}{2}$
8. $Value\ of\ tertiary\ network\ channel = \frac{Length\ of\ channel\ that\ conditioned\ well}{total\ length\ of\ channel} \times 100\%$
9. $Value\ of\ divider\ box\ of\ tertiary\ network = \frac{Number\ of\ divider\ boxes\ that\ conditioned\ well}{total\ number\ of\ divider\ boxes} \times 100\%$
10. $IKMI\ of\ tertiary\ network = \frac{eq.(7)+eq.(8)}{2}$
11. $IKMI\ of\ drainage\ channel = \frac{Length\ of\ channel\ that\ conditioned\ well}{total\ length\ of\ channel} \times 100\%$

Beside the irrigation network tracking, the interview of the technicians from UPTD was conducted to find out the cause of the damage that happened. Based on the assessment of condition of irrigation network infrastructure, a series of action plans were prepared which are divided into several criteria, there are (i) good condition, if the damaged level is under 10% from the initial condition of building/channel, thus it is needed a routine maintenance, (ii) lightly damaged condition, if the damaged level is between 10 – 20% from the initial condition, thus it is needed a periodic maintenance (treatment), (iii) medium damaged condition, if the damaged level is between 21 – 40% from the initial condition, thus it is needed an improvement maintenance (repair), and (iv) severe damage condition, if the damaged level is above 40% from the initial condition, thus it is needed a rehabilitation.

4. RESULTS AND DISCUSSION

4.1 The Assessment of Irrigation Infrastructure of Serayu I.S. In Term of Irrigation Modernization

The assessment of irrigation infrastructure in term of irrigation modernization was conducted by some index which is called by readiness index of irrigation modernization (IKMI). IKMI used 0 – 100 scale, which involved both of function performance and physical condition of the irrigation infrastructure. Based on PUPR (2011), IKMI can be classified into 4 categories, there are(i)IKMI> 80, adequate predicate, the modernization can be implemented directly; (ii)IKMI between 50 and 80, sufficient predicate, implementation of modernization should be delayed, irrigation system needs to be improved in 1 – 2 years; (iii)IKMI between 30 and 50, less predicate, modernization should be delayed, improvement is required in 2 – 4 years; and (iv)IKMI< 30, very less predicate, modernization is unnecessary and fundamental improvement is required.

As mentioned before, the assessment of IKMI of irrigation infrastructure can be divided into 5 parts, there are main building, main network channel,main network building drainage channel, and tertiary networks.

The main building consists of weir, intake, flushing gate, draining gate, sediment trap and discharge measurement structure. Based on the assessment, the whole of main building parts was in good condition and works fine. Therefore, the IKMIof the main structure in Serayu I.S. can be obtained as 100.

The main network channel of Serayu I.S. is divided into 5 systems, namely Cilacap, Binangun, Sumpiuh, Doplang and Maos. Generally, there were some problems in main network channel, there were the damage of side channel protection, the channel sedimentation and the illegal extraction by damaging the main/secondary channels. The damage of side channel protection can be caused by several factors, among others the age of construction, the maintenance is not optimum, and also the load from heavy equipment during channel normalization activity. This damage can increase the water loss along the channel, so that it affects the first irrigation pillar (water availability).

From those 5 systems, Maos Main Channel System has the lowest IKMI as 35.32. The length of channel with good condition in Maos Main Channel System was only 8,300 m from 23,500 m of the whole channel length. Therefore, it was suggested to conduct channel improvement of Maos Main Channel System (including 6 secondary channels) before the implementation of modernization.

Table1. IKMI of Main Channel System of Serayu I.S.

Main Channel System	Number of Secondary Channels	Total Length (m)	The Length of Good Condition (m)	IKMI
Cilacap	5	54,483	45,414	83.35
Binangun	10	50,610	39,900	78.84
Sumpiuh	7	36,229	32,868	90.72
Doplang	4	17,153	15,769	91.93
Maos	6	23,500	8,300	35.32

Table 2. IKMI of Main Network Channel, Main Network Building, and Tertiary Network of Serayu I.S.

No	Channel	Main Network Channel		Main Network Building			Tertiary Network			
		Total Length (m)	Length of Good Condition (m)	Total Number	Number of Good Condtion	Number of Good Function	Channel Length (m)		Number of Divider Box	
							Total	Good Condition	Total	Good Condition
1	MC Cilacap	37,500	30,969	108	93	98	882	699	24	24
2	SC Tinggar Jambe	1,668	1,500	3	3	3	110	100	1	1
3	SC Wujil	1,180	1,000	6	6	6	150	120	0	0
4	SC Kalisabuk	4,740	4,550	16	14	14	350	225	0	0
5	SC Kesugihan	6,645	5,645	25	24	25	266	266	5	5
6	SC Mertelu	2,750	1,750	13	12	13	268	268	2	2
7	MC Binangun	6,691	6,540	31	22	22	513	513	3	2
8	SC MCbalung	2,631	2,450	19	18	17	250	250	0	0
9	SC Nusawungu	5,722	4,870	20	13	12	408	408	1	0
10	SC KarangMangu	7,153	6,450	26	19	19	256	256	2	2
11	SC Tambak Sari/Merta Sari	142	80	0	0	0	0	0	0	0
12	SC Banjar Reja	11,155	9,850	43	37	37	929	929	4	3
13	SC GunungPantek	5,439	2,100	14	2	2	315	315	2	2
14	SC Jepara	6,924	4,200	23	20	17	350	350	0	0
15	SC Kepudang	657	210	6	1	1	250	250	0	0
16	SC Alangamba	1,266	850	6	3	2	100	85	1	1
17	SC WidaraPayung	2,830	2,300	19	17	15	203	203	2	2
18	MC Sumpiuh	19,232	17,061	76	65	74	349	329	23	22
19	SC MCbakung	4,053	4,003	14	13	13	53	3	2	2
20	SC Kebarongan	386	386	2	2	2	7	7	1	1
21	SC Grujugan	1,072	972	1	1	1	0	0	0	0
22	SC Nusamangir	1,994	1,894	4	4	4	87	87	1	1
23	SC Karangjati	1,970	1,645	12	12	12	450	360	0	0
24	SC Pabrasan	3,467	3,007	13	13	13	163	148	2	2
25	SC Buntu	4,055	3,900	12	12	12	300	235	0	0
26	MC Doplang	11,165	10,165	33	29	33	580	580	1	1
27	SC Nusajati	3,108	3,108	8	8	8	300	300	0	0
28	SC Paketingan	1,035	835	5	5	5	200	200	0	0
29	SC Ketanggungan	999	900	5	5	5	53	50	1	1
30	SC Mrenek	846	761	10	10	10	157	157	1	1

No	Channel	Main Network Channel		Main Network Building			Tertiary Network			
		Total Length (m)	Length of Good Condition (m)	Total Number	Number of Good Condtion	Number of Good Function	Channel Length (m)		Number of Divider Box	
							Total	Good Condition	Total	Good Condition
31	MC Maos	9,000	0	26	23	24	27,500	25,400	2	2
32	SC Kemojing	2,400	0	8	6	6	8,500	6,500	0	0
33	SC MaosKidul	800	0	2	0	0	2,000	2,000	0	0
34	SC Karangrena	1,100	1,100	1	0	0	1,500	1,500	0	0
35	SC Kalikudi	5,600	5,600	18	16	17	40,750	38,250	7	7
36	SC Adipala	1,900	900	6	6	6	8,350	7,450	0	0
37	SC Penggalang	2,700	700	359	302	313	10,000	5,000	0	0
Total		80,978	181,975	142,251	993	836	861	106,899	93,793	88
IKMI (%)		**74.20**		**78.17**		84.19	86.71		87.74	
				88.05			**85.45**			

Note. MC = Main Channel
SC = Secondary Channel

From Table 3, it can be seen that overall the IKMI value of Infrastructure pillar of Serayu I.S was 88.16. Based on PUPR (2011), it means Serayu I.S included in the adequate predicate. Thus, generally the infrastructure of Serayu I.S. has ready to support the implementation of irrigation modernization.

Table 3. IKMI of Irrigation Infrastructure of Serayu I.S

No.	The Part of Infrastructure	Proportion	Value (%)	Value × Proportion
1	Main Structure	15	100.00	15.00
2	Main Channel System	25	78.17	19.54
3	Installation in Main System	25	85.45	21.36
4	Drainage Channel	20	92.59	18.52
5	Tertiary Networks	15	91.60	13.74
IKMI ofIrrigation Infrastructure				88.16

4.2 The Assessment of Irrigation Infrastructure of Kedung Putri I.S. in Term of Irrigation Modernization

The Part of Channel and Building of Main Network. There are some problems in this part, such as the damage of side channel protection of the main/secondarys channel, the absence of inspection road in the main/secondary channels, the inclusion of urban drainage channels into the main/secondary channels, the illegal extraction by damaging the secondary channels, the damage of sluice gates, up to the stealing of sluice gate spare parts.

The damage of side channel protection related to the construction age, the way of utilization, and the less optimal of maintanance activity. In many section of main/secondary channel, inspection road were not available. It was caused by the violation of the use of irrigation border lines. That irrigation border lines were used as the permanent building place. The other problem was the inclusion of urban drainage channels into the main/secondary channels, which increased the sediment and waste volume into the main/secondary channels.

The Part of The Drainage Channel and The Tertiary Network. Generally the problems that happened in drainage channel were the damage of side channel protection and channel sedimentation. While the problem in the tertiary network was the channel sedimentation. This sedimentation in the tertiary network was caused by the lack of maintenance. The tertiary network management is the responbility of the farmers that is composed in Water Users Association (WUA). The WUA did not have sufficient funds to carried out the routine and priodic maintenance activities. Most of farmers did not pay contributions regulerly to the WUA. The sedimentation caused the rise of water level in the downstream, thus the water can not reach the tertiary

Figure 3. The Violation of The Use of Irrigation Border Line.

Table 5. IKMI of Main Network Channel, Main Network Building, and Tertiary Network ofKedung Putri I.S

No	Channel	Main Network Channel		Main Network Building			Tertiary Network			
							Channel length (m)		Numer ofDivider Box	
		Total length (m)	Length of Good Condition (m)	Total Num-ber	Number of good condition	Number of good function	Total	Good condition	Total	Good condition
1	MC Kedung Putri	7675	7155	49	45	45	200	70	2	1
2	SC BaledonoHewan	1500	1300	39	2	2	100	0	1	1
3	SC Pabrik Es	2000	1700	7	1	1	700	70	4	3
4	SCTegalKuning	3000	500	16	2	3	400	40	3	3
5	SCTegalLiser	2500	500	5	2	1	158	113	1	1
6	SCKentengGrantung	2375	875	7	5	3	168	104	7	7
7	SCKentengDewi	4451	1800	27	21	19	421	238	6	6
8	SCWongsoKrasan	5442	2000	35	29	29	533	326	3	2
9	SC Alas Korok Tengah	4500	1500	35	23	23	285	245	1	1
10	SCSeboroKrapyak	1475	700	8	4	4	13550	12450	14	2
11	SCKesambiPlenden	8376	0	53	27	49	5075	4875	2	0
12	SCSeboroBluduk	2470	1682	16	11	12	12600	12600	14	1
13	SCPangenMangunan	5685	2933	20	10	19	10250	10250	7	0
14	SCKembarKleben	4427	0	25	7	21	50	0	0	0
15	SCPlaosan	644	584	3	3	3	0	0	0	0
16	SCKauman	2987	2872	25	24	24	0	0	0	0
17	SCSindurjan	217	122	3	3	3	50	50	1	1
18	SCDoplang	500	379	7	7	7	50	50	2	2
19	SCTirem	3580	3157	26	25	26	100	50	2	2
20	SCPlered	2595	1036	8	5	5	50	0	1	1
21	SCKoplak	450	420	2	1	1	100	100	2	2
22	SCLegundi	1022	992	4	3	3	0	0	0	0
Total		67871	32207	420	260	303	44840	41631	73	36
IKMI (%)		**47.45**		61.90		72.14	92.84		49.32	
				67.02			**71.08**			

Note. MC = Main Channel
SC = Secondary Channel

Table 6. IKMI of Drainage Channel ofKedung Putri I.S

Drainage Channel	Channel Length (m)	
	Total	Good Condition
Penjalin	2872	2872
DrainaseBatok	8153	8153
Kledung	1994	500
Ngasem	2587	1000
Lorog	3590	1500
Condong	850	200
Triwarno	1239	430
Total	21285	14655
IKMI (%)	**68.85**	

According to Table 7, it can be seen that overall the IKMI value of Infrastructure pillar of Kedung Putri I.S was 68.05. Based on PUPR (2011), it means Kedung Putri I.S included in the sufficient predicate. Then it is needed to improve the system for the 1 – 2 years on the irrigation infrastructure pillar. That improvement consists of the parts which have IKMI value under 80, there are main network channel, main network building, drainage channel, and tertiary network.

Tabel 7. IKMI of Irrigation Infrastructure of Kedung Putri I.S

No.	The Part of Infrastructure	Proportion	Value (%)	Value × Proportion (%)
1	Main Building	15	100.00	15.00
2	Main Network Channel	25	47.45	11.86
3	Main Network Building	25	67.02	16.76
4	Drainage Channel	20	68.85	13.77
5	Tertiary Network	15	71.08	10.66
IKMI ofIrrigation Infrastructure				**68.05**

4.3 Recommendation of Infrastructure Performance Improvement in Related on Preparation of Irrigation Modernization

Regarding on the assessment as discussion above, Serayu I.S. had the IKMI value of 88.16 and based on the classification, generally Serayu I.S. had achieved adequate predicate. However, the IKMI of main network channel was still below 80.Therefore, it is suggested to conduct channel improvement especially on Maos Main Channel System. The channel improvement can be conducted in: Maos Main Channel 9,000 m; Kemajing Secondary Channel 2,400 m; MaosKidul Secondary Channel 800 m; Adipala Secondary Channel 1,000 m; and Penggalang Secondary Channel 2,000 m. The channel improvement is expected to increase the enhancement of the IKMI value of main network channel as 86.52 and the whole of infrastructure IKMI becomes 90.25.

Meanwhile, the infrastructure readiness index of Kedung Putri I.S. is 68.05. Based on the classification, the readiness index was categorized as sufficient predicates. This means that the implementation of modernization should be delayed and irrigation system needs to be improved in 1 – 2 years. The improvement of infrastructure consists of: rehabilitation of channel including river side protection and sediment dredging, gate reparation or replacement, etc.

5. CONCLUSIONS

Based on result and discussion as described above, it can be concluded that generally the value of IKMI for infrastructure pillar of Serayu I.S. was 88.16. It means Serayu I.S included in the adequate predicate.Thus, the irrigation infrastructure of Serayu I.S. are ready to support the implementation of irrigation modernization.

However, when noticed on the main channel system, especially on Maos Main Channel System, the value of IKMI was only 35.32. Therefore, before the implementation of modernization, it is suggested to conduct the improvement of infrastructure in Maos Main Channel System.

Meanwhile, for Kedung Putri I.S., it is obtained the value of IKMI as 68.05. It means Kedung Putri I.S included in the sufficient predicate. Then it is needed to improve the system for the 1 – 2 years on the irrigation infrastructure pillar.Therefore, before the implementation of modernization, the whole infrastructure of Kedung Putri I.S. is need to be improved.

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