

Spatial Dimensions of Irrigation System Performance Status in The Semi Arid Region of Timor Island, East Nusa Tenggara, Indonesia



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ABSTRACT: One aspect that plays an important role in the performance of irrigation systems is the institutional division of irrigation areas' authority covering the authority of district/municipality, provincial and the central government. This study aimed to assess how the institutional division of irrigation areas' authority affect the performance of irrigation systems, to reclassifies the standard of performance index of irrigation systems, to analyze the status of irrigation system performance in 6 districts/municipalities in the semi arid region of Timor Island, East Nusa Tenggara based on their authority and mapping of spatial diversity. This study used descriptive statistical method through the performance index of irrigation systems in 6 districts/municipalities. This study concluded that the status of the irrigation system performance of 6 districts/municipalities in the semi arid region of Timor Island increased along with the level of irrigation systems' authority. The best Status of the performance of irrigation systems in 6 districts/municipalities was Malaka District Irrigation System, the performance tended to be better in the irrigation system under the authority of central government that administratively placed in one district/municipality (non cross-district irrigation system). Based on the analysis of the status of irrigation system performance in 6 districts/municipalities in Timor Island, a specific step for each district/municipality to adjust the location characteristics with policies can be taken to overcome irrigation systems' problems in the semi arid regions of Timor Island.

KEYWORDS: institutional authority, irrigation system performance, spatial dimension, semi arid region.

1. INTRODUCTION

Irrigation systems play an important role in achieving continuous food production targets. One important aspect of the irrigation system is the institutional division of the irrigation areas' authority. Based on Law No. 22 of 1999 of the Republic of Indonesia concerning Regional Government, irrigation system institutions in Indonesia related to the authority distribution for the development and management of irrigation systems are based on the existence of irrigation canals on administrative areas and the total area strata. The administrative areas are stated in Ministerial Regulation for Public Works and Housing (PUPR) of the Republic of Indonesia Number 14/PRT/M/2015 concerning Criteria and Determination of Irrigation Area Status. Based on the institutional authority, Timor Island of East Nusa Tenggara (NTT) has 10 irrigation areas under the authority of the central government with total area of 40,956 hectares, 14 irrigation areas under the authority of the provincial government of 18,177 hectares, and 321 irrigation areas under district/municipality authority with total area of 43,347 hectares (Ministry of Public Works and Housing, 2015). However, these irrigation areas show a relatively low index of irrigation system performance with various indicators such as regularity, accuracy, and distribution of irrigation water (Abernethy 1986; Molden and Gates 1990; Bos et al. 1994; Molden et al. 1998; Kloezen and Garcés-Resrepo 1998), availability/ water discharge and adequacy of irrigation water (Molden and Gates 1990; Tang 1992; Murray-Rust and Snellen 1993; Benjamin et al. 1994; Plusquellec et al. 2002; Gorantiwar and Smout 2005).

The problems on the performance of the irrigation system not only occur in Timor Island but also in some parts of the world. The study of Amede's (2015) in Ethiopia and Balderama et al. (2014) in the Philippines reported low irrigation performance and efficiency; Mangrio et al. (2014) reported that 70 percent of the performance ratio of water distribution in the secondary canal of Mirpurkhas Jamrao subdivision was under the bad performance category. Furthermore, Bolaños et al. (2011) in Senegal rated 22 small irrigation schemes along the banks of the Mauritania River run by small and medium-sized communities categorized with low performance and worsened by bad maintenance. Likewise, a study by Garcés-Restrepo et al. (2007); Wang et al. (2000, 2005)

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in Chai and Schoon (2016) also stated that most district irrigation systems continue to experience bad performance with deterioration in facilities, lack of water supply and uneven water distribution. Then, Nurrochmad (2007) argued that the performance of irrigation canals can be sustainable with support by 3 factors, namely physical and non-physical aspects and consistency in the application of laws and regulations.

Apart from the performance of irrigation systems with bad categories, some results of research on medium and large-scale irrigation areas show the performance of a good irrigation system. The results of the study by Kusuma et al. (2012) in the Bodor irrigation area (1,886 hectares) of Nganjuk District showed good performance. Mulyadi (2014) rated good category to the Barugbug irrigation sub-area of the Jatiluhur irrigation system using 6 parameters; physical infrastructure, crop productivity, supporting facilities, personnel institutions, documentation and participation of water-user' associations (WUA). Moreover, the results of the study of Amriyadi et al. (2016) in the Wawotobi irrigation area (16,572.26 hectares) in Konawe District Southeast Sulawesi and Kuscu et al. (2015) on the Bursa-Karacabey irrigation (16,683 hectares) in Turkey during the period 2002-2007 reported the performance rate of irrigation systems above the national's average rate with positive financial performance.

Timor Island of NTT Province includes 6 districts/municipalities with characteristics of semi arid regions, low and fluctuating water availability, and rainfall ranging from 3-4 months in a year with high intensity. These conditions impacted the performance of irrigation systems. On the other hand, based on the criteria of Ministerial Regulation for Public Works and Housing Number 12/PRT/M/2015, most irrigation areas are classified as irrigation system with low/bad performance index category. This category applies generally to all regions, both areas with abundant water and insufficient water, however, it seems to be less detailed and impacted policy-making steps are less sensitive, especially for areas with insufficient water. On the other hand, the performance index of individual irrigation systems in each irrigation area with the same assessment will complicate the policy-making steps for irrigation system in the district/municipality scale, yet irrigation areas under the authority of the provincial and central governments are also in the district/municipality areas. Thus, it is expected to show "the status of the performance of irrigation systems at the district/municipality level" related to the institutional authority of the irrigation area and the performance of the irrigation system. This study aimed to assess the criteria for performance index of the irrigation system, to find out the status of irrigation system performance in 6 districts/municipalities based on the irrigation system under the authority of district/municipality, provincial, and central government in Timor Island, and to analyze the spatial mapping of the performance status of irrigation systems.

II. MATERIALS AND METHODS

The study was conducted in Timor Island, East Nusa Tenggara Province, covering 6 districts/municipalities, namely Kupang municipality, Kupang District, Timor Tengah Selatan (TTS) District, Timor Tengah Utara (TTU) District, Belu District, and Malaka District. The study sites are a semi arid region of the irrigation system under the authority of district/municipality, provincial, and central governments with a performance index of relatively low and needs attention.

The data used are secondary data on irrigation system performance index from 345 irrigation areas in 6 districts/municipalities. Data source are from provincial /districts/municipalities Public Works Agency, Ministry of Public Works and Housing in the form of e_monitoring/online data, and basic maps from Geospatial Information Agency (GIA).

The method for reclassifying the criteria of irrigation system performance index is based on ministerial regulation for public works and housing Number 12/PRT/M/2015 which consists of 4 (four) scales, namely: 1) scale 80-100 (very good performance); 2) scale 70-79 (good performance); 3) scale 55-69 (less good and needs attention) and scale <55 (bad and needs attention). Each scale is divided into 2 (two) based on the middle value, then 8 scales are obtained. Furthermore, based on the performance index of individual irrigation systems for each irrigation area, the status of the irrigation system performance in each district/municipality is analyzed based on its authority by using a concentrated single median data and juxtaposed with 8 scales, as follows

$$Me = \chi_{(n+1)/2} \text{ for } n = \text{add numbers}$$

$$Me = \frac{1}{2} \{ \chi_{(n/2)} + \chi_{(n/2+1)} \}, \text{ for } n = \text{even numbers}$$

Where:

Me : Median for status of district/municipality irrigation systems performance based on its institutional authority, which consists of:

SM_{ik} : Median for status of i -th district/municipality irrigation systems performance based on its institutional authority

SM_{ipt} : Median for status of i -th district/municipality irrigation systems performance under the authority of provincial government for non-cross district/municipality irrigation areas

SM_{ipl} : Median for status of i -th district/municipality irrigation systems performance under the authority of provincial government for cross district/municipality irrigation areas

SM_{int} : Median for status of i -th district/municipality irrigation systems performance under the authority of central government for non-cross district/municipality irrigation areas

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SM_{ink} : Median for status of i -th district/municipality irrigation systems performance under the authority of central government for cross district/municipality irrigation areas

SM_{inc} : Median for status of i -th district/municipality irrigation systems performance under the authority of central government for cross countries irrigation areas

n : number of data

χ : value of data (performance index of individual irrigation systems in irrigation areas)

Mapping on the status of irrigation system performance was carried out at the district/municipality level to show the status of the irrigation systems performance of each district/municipality using ArcGIS 10.3 software.

III. RESULTS AND DISCUSSION

3.1. Status of District/Municipality Irrigation System Performance Based on Its Authority

The evaluation on the criteria of irrigation system performance index and the performance status of irrigation systems in each district/municipality were based on the performance index scores of individual irrigation systems in the irrigation area. The status of the irrigation system for 6 districts/municipalities in Timor Island NTT based on their authority (Table 1 and Figure 1) is in the range of "extremely bad to bad". This condition illustrated those 321 irrigation areas (43,347 hectares) under the authority of districts/municipalities with small areas (<1,000 hectares) are scattered locations and difficult to reach, impacted on difficult supervision, guidance, and maintenance process by the government responsible for the headworks and canals.

Table 1. The results of the scale classification based on ministerial regulation of public work and housing Number 12/PRT/M/2015; into 8 (eight) scales

No	PUPR scale	Category	Number	Development scale by researcher	Category
1	80 - 100	Very good	1	90 - 100	Excellent
			2	80 - 89	Very good
2	70 - 79	Good	3	75 - 79	Good
			4	70 - 74	Quite good
3	55 - 69	Fair	5	62 - 69	Fair
			6	55 - 61	Bad
4	< 55	Poor	7	28 - 54	Very bad
			8	< 28	Extremely bad

Source: Analysis of this study, 2020

The results of this study are similar to the results of Amede's study in Ethiopia (2015), 52 small irrigations show bad performance and weak local institutions. However, despite these constraints, small irrigation areas were useful for reducing poverty (Bacha et al. 2009), might increase crop yields, improved crop diversification (Kidane 2016), reduced the risk of crop failure, and developed rural community's economies. In addition, according to Bagson and Kuuder (2013), Deribie (2015), Gebrehiwot et al. (2015), the existence of small irrigation greatly supports the improvement of food security of farmer families, especially during the dry season. In parallel, a study of Zamaniyan et al. (2014) in Iran with 10 micro-irrigation systems, Balderama et al. (2014) on small irrigation in the Philippines also suggested low irrigation performance. Moreover, Bolaños et al. (2011) in Senegal reported low irrigation performance was also exacerbated by bad maintenance. Garcés-Restrepo et al. (2007); Wang et al. (2000, 2005) in Chai and Schoon (2016) also support this argument; most district irrigation systems continue to experience bad performance with the deterioration of facilities, lack of water supply, and uneven water distribution.

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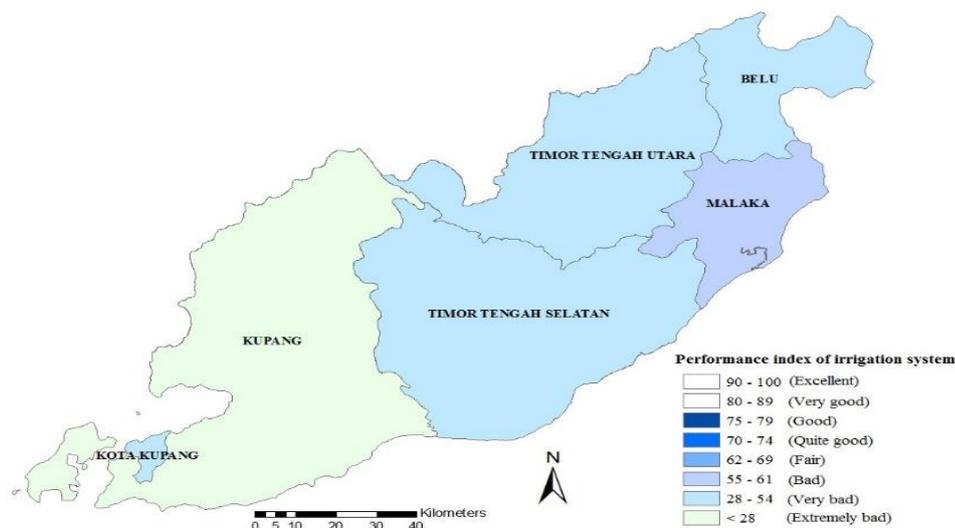


Figure 1. Median for status of *i*-th district/municipality irrigation systems performance based on its institutional authority (SM_{ik})

Of the 6 districts/municipalities, Kupang District (129 irrigation regions covering 14,528 hectares) showed the lowest status of irrigation system performance (extremely bad). The district had the most numerous semi arid region in villages and sub-districts instead many problems such as small area, large total area numbers, the scattered location, difficult to access, and canal buildings' material are from the soil. Meanwhile, Kupang municipality (9 irrigation regions), TTS District (70 irrigation regions), TTU District (52 irrigation regions) and Belu District (37 irrigation regions) showed very bad status, and only Malaka District (24 irrigation regions) showing better status than other districts with bad status.

The status of irrigation system performance in each district/municipality is not only to maintain irrigation infrastructure but also how irrigation institutions' performance, such as regulation, maintenance, farmers participation, thus impacting the sustainability of irrigation systems. Ward (2010) stated policy instrument in maintaining irrigation infrastructure that considers an institutional aspect approach (district/municipality governments) is needed. This policy instruments might play a constructive role in effecting irrigation performance by establishing/implementing regulations, standards or requirements that may improve the irrigation system's performance.

Small irrigation areas in the semi arid region with limited rainfall can only survive with support by the government as the responsible person who has the task of rehabilitating, expanding, repairing and building new systems. On the one hand, this will have a very high dependency. Decentralized irrigation management is needed in addition to the limited resources owned by the district/municipality government as well as to increase the efficiency of government funds. However, the limited resources of the district/municipality caused many irrigation areas to require urgent rehabilitation or improvement. Damage to irrigation infrastructure is caused by bad maintenance, not anticipation of changes in climate conditions, low maintenance costs and not needs-based, and low participation of WUA in O & M for primary and secondary canals. These factors affect the performance of district/municipality irrigation systems which tend to be very low.

The total area of surface water irrigation under the authority of districts/municipalities in Timor Island in 2015 was 43,347 hectares (23.88 percent of NTT). Most of the area was heavily damaged with low financing capacity from district/municipality governments; rehabilitation and/or improvement activities has done through the Special Allocation Fund (DAK-a transfer fund from the government to the regional government) of the irrigation sector. However, even though the central government has allocated DAK with supporting fund of O&M by local governments, not all local governments are willing to comply with these regulations. On the other hand, public investment in the irrigation sector has largely focused on infrastructure development and only a little attention has been paid to the problems of operation and maintenance. This argument is in line with Brown's study (2011); Tilahun et al. 201; and Yami 2013, they reported that public investment was focused on infrastructure development and little attention to operations and maintenance. Moreover, Saleth and Dinar (2004) suggested a negative trend of financial decline, low water costs and low maintenance cost endangering maintenance and the potential future investment in water infrastructure development.

Irrigation areas under the authority of the district/municipality have a high possibility in improving the performance of their irrigation system through a decentralization process. However, in reality, the implementation is not easy and does not always bring positive results. This is because attention is only focused on finding solutions to constraints during implementation and less emphasis on understanding the context, processes, and consequences of institutional change. In fact, continuous linkages, involvement, integrity, and integration between various components such as human resources, control for the system, physical

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aspects of irrigation infrastructure, funding and budget allocation, institutions (rules and sanctions), are expected to solve the problem of low irrigation system performance under the district/municipality authority. In the case of the characteristics of Timor Island, it was concluded that semi arid regions were also one of the triggers for irrigation infrastructure damage which had an impact on the low performance of irrigation systems.

3.2. Status of District/Municipality Irrigation System Performance under Provincial Institution Authority

There are 14 irrigation areas under the authority of the provincial government (18,177 hectares) which spread in 6 districts/municipalities in Timor Island of NTT including 10 non-cross irrigation areas and 4 cross-district/municipality irrigation areas. The status of irrigation system performance in 6 districts/municipalities under provincial institution authority shows "one level upward" (better performance) compared to those irrigation systems under district/municipality authority (Table 1, Figure 2 / SM_{ipt} and 3 / SM_{ip}). Irrigation systems under the authority of a provincial institution with a medium area (1,000-3,000 hectares) were supported by better irrigation infrastructure, as it has the potential to irrigate wider land with the headworks in the form of dams or reservoir and equipped by technical irrigation canals, and good human resources responsibility for the irrigation area.

The status of irrigation system performance under the authority of the provincial institution with non-cross irrigation areas in 6 districts/municipalities (Figure 2/ SM_{ipt}), in Kupang District and TTS District, showed the lowest irrigation system performance status with category of very bad, while TTU District and Belu District indicated bad status, only Malaka District had a fair status or better status than the other 5 districts. Kupang District and TTS District are the driest districts in Timor Island, and even drought and food insecurity often occur. Although the physical aspects of irrigation infrastructure under provincial authority are better than those under the authority of districts/municipalities, the performance of the irrigation systems in several places showed different results, depending on geographical, hydrogeological, climate, and ecological factors of each irrigation area, intensity of intervention on irrigation infrastructure, and management control intensity to keep the irrigation system running well.

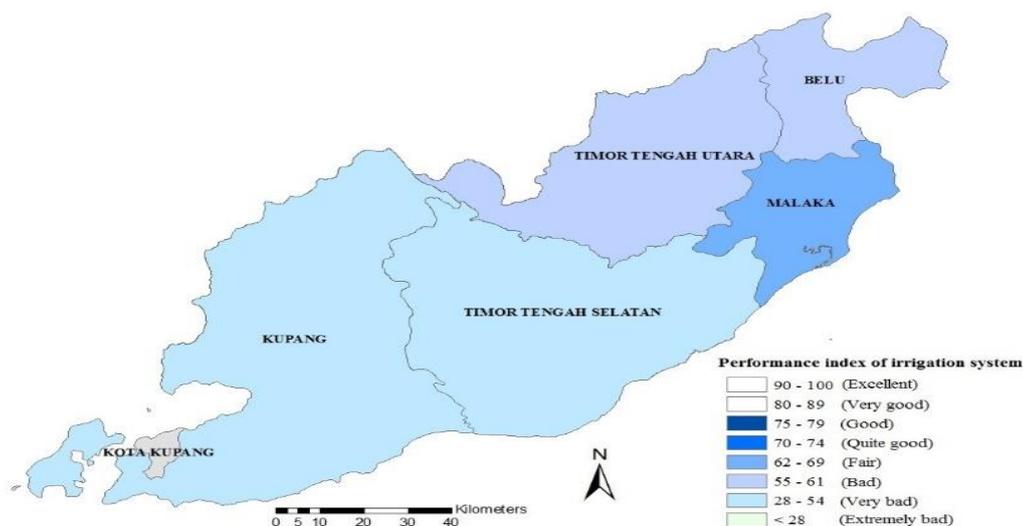
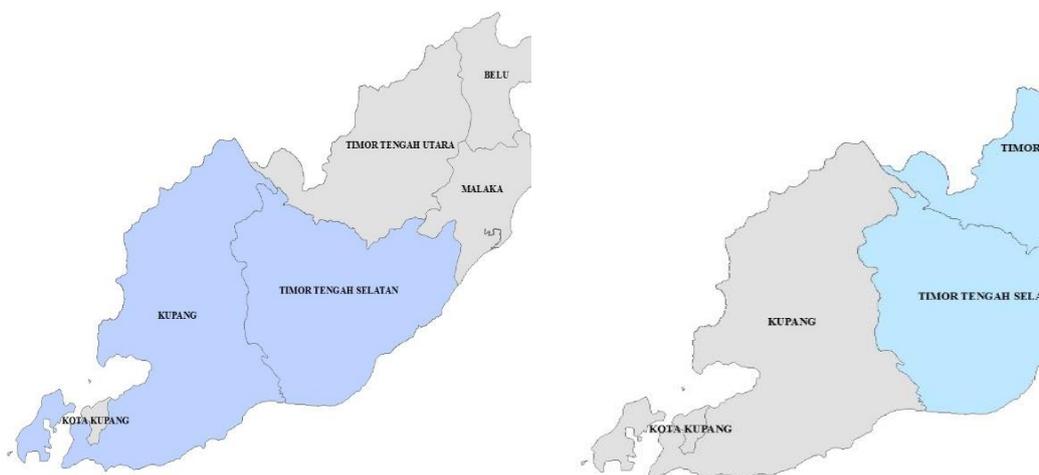


Figure 2. Median for status of i -th district/municipality irrigation systems performance under the authority of provincial government for non-cross district/municipality irrigation areas (SM_{ipt})



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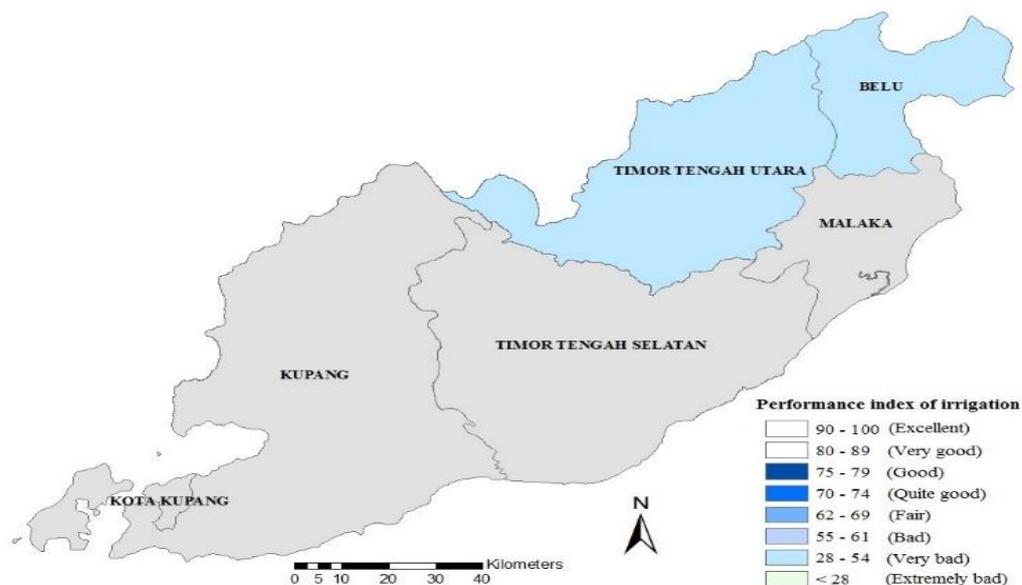


Figure 3. Median for status of i -th district/municipality irrigation systems performance under the authority of provincial government for cross-district/municipality irrigation areas (SM_{ipi})

The results of this study are also in line with a study by Awulachew and Ayana (2011) in 64 moderate irrigation areas (1,000-3,000 hectares) in Ethiopia, indicated that bad performance caused by planning failure, lack of maintenance intensity, soil erosion, sedimentation, low responsibility of management institutions and low financial capacity for O&M. Likewise, Rizalihadi et al. (2014) in Pandrah irrigation area of Aceh (1,007 hectares) showed a decrease performance rate of the irrigation system, and Fauzi et al. (2017) in the irrigation area of Uwai Pangoan (1,029 hectares) in Kampar District Riau Province showed poor performance and needed attention. However, the results by Kusuma et al. (2012) in the Bodor irrigation area (1,886 hectares) in Nganjuk District showed good performance of the irrigation system.

Based on the irrigation institutional authority of the province with irrigation system across districts/municipalities (Figure 3/ SM_{ipi}), the status of irrigation system performance in 4 districts/municipalities was categorized to very bad to bad. The Irrigation system covered Kupang District-TTS District with status 'bad', TTS District-TTU District and TTU District-Belu District with status 'very bad'. Based on the total Performance status, both cross and non-cross irrigation areas, Malaka District was better than other districts/municipalities, this is mainly supported by very abundant water resources, cultural communities as hereditary wetland farmers, good awareness of interaction and cooperation between stakeholders in the region.

In general, irrigation areas within the same district or municipality showed better status compared to irrigation areas with cross districts/municipalities. The division of institutions for provincial irrigation systems with administrative locations across districts/municipalities provided a challenge in coordination, as the government administration area with irrigation coverage is not symmetrical, whereas the hydrological characteristics do not follow the administrative map of the government, thus lead the emergence of various problems affecting low performance of irrigation institutions and thereby impacted on the performance of the irrigation system. Upstream-downstream coordination, between stakeholders, cross-sectoral coordination, and the division of tasks and functions in the context of the sustainability of the irrigation system are contained in the respective regulations. Development and management responsibilities in the main canals (primary and secondary canals) and headwork under the authority of the Provincial Public Works Office as mentioned in Ministerial Regulation for Public Works and Housing Number 12/PRT/M/2015 and 14/PRT/M/2015, while tertiary networks are carried out by water user's association (WUA) in accordance with Ministerial Regulation for Agriculture Number 79/OT.140/ 12/2012 concerning Guidelines for assistent and Empowerment of WUA.

In order to maintain and improve irrigation conditions and functions, districts/municipalities/ provinces also need to establish an Irrigation Commission in accordance with Ministerial Regulation for Public Work and Housing Number 17/PRT/M/2015. The irrigation commission in question is an independent institution with functions to provide considerations and policy proposals to the regional government in the management of irrigation canals, irrigation water management, and conversion policies for irrigation areas. District/municipality/provincial irrigation commissions are formed by regents/mayors/ governors consisting of representatives from district/municipality/provincial governments and non-government institutions including WUA representatives and/or representatives of irrigation canals' user groups with the principle of proportional membership and representation. This commission was formed based on consideration to realize integrated irrigation system management in each province and

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district/municipality. Thus, the most important aspect is increasing interaction, communication, and coordination between parties. This is in line with the study by Tan-Kim-Yong (1987) in Thailand about the importance of increasing interaction, communication, and coordination between irrigation labor and farmers to overcome coordination problems. However, district /municipality/provincial governments may also fail to maintain and improve irrigation conditions and functions and could impact the decline performance of irrigation systems.

3.3. Status of District/Municipality Irrigation System Performance under Central Government Institution Authority

The performance of the irrigation system in the irrigation area under the authority of central government, covered 6 districts/municipalities, showed "one level upward" or better performance compared to those irrigation areas under provincial authority with the range "bad to good" (Table 1, Figure 4/ SM_{int} , $5/SM_{inlk}$, and $6/SM_{inlc}$). Ten irrigation areas under the authority of the central government (40,956 hectares), spread across 6 districts/municipalities in Timor Island; 3 non-cross irrigation areas, 4 cross-district/municipality irrigation areas and 3 cross-country irrigation areas (Indonesia-Democratic Republic of Timor-Leste/DRTL).

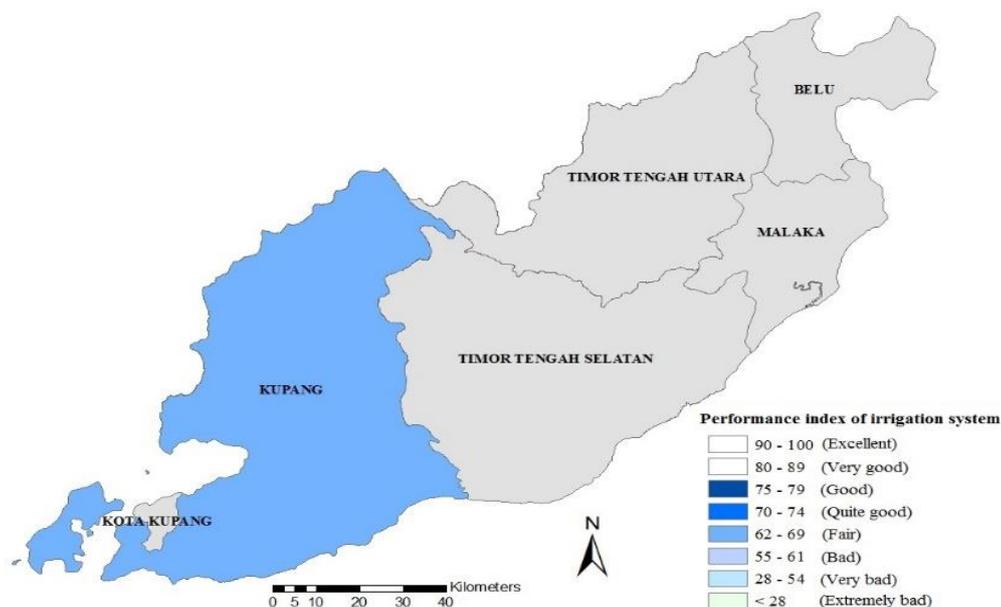
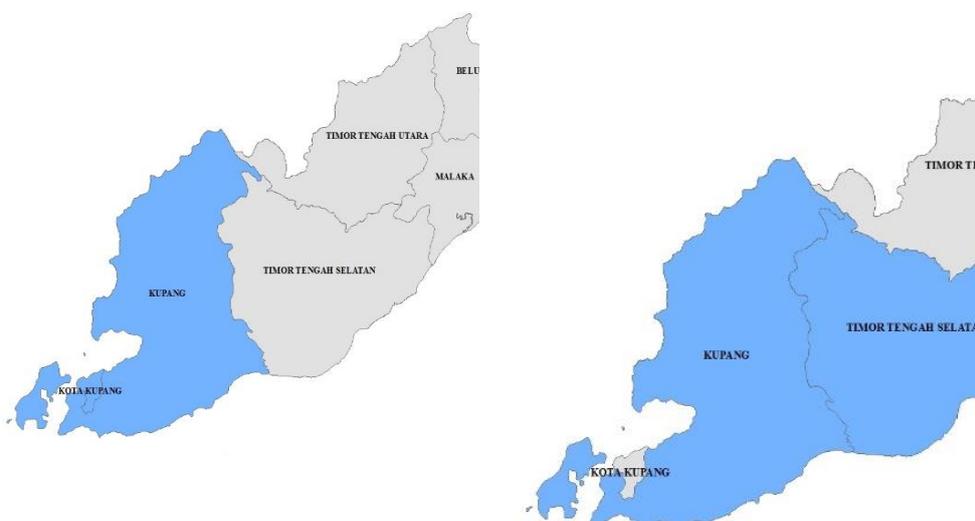


Figure 4. Median for status of *i*-th district/municipality irrigation systems performance under the authority of central government for non-cross district/municipality irrigation areas (SM_{int})



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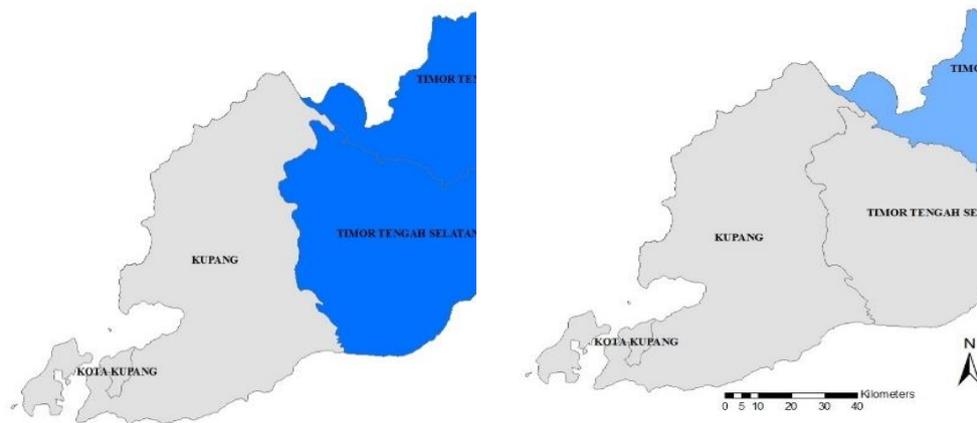


Figure 5. Median for status of *i-th* district/municipality irrigation systems performance under the authority of central government for cross district/municipality irrigation areas (SM_{ink})

Irrigation system under the authority of central government with an area of more than 3,000 hectares often called large-scale irrigation system. This irrigation system is supported by better human resources, good O&M, complete personnel institutions/there are formal irrigation organizations. In addition, the irrigation infrastructure such as headworks was in the form of reservoirs and dams, and technical irrigation canals capable of irrigating large areas. The implementation of O&M of irrigation system under the authority of central government using the principle of deconcentration (delegation of authority) and co-administration (assignment) as stated in the Ministerial Regulation for Public Work and Housing Number 11/PRT/M/2017. Thus, the operations are carried out by the provincial government, as not all governmental authority could be done by the principle of decentralization (transfer of authority).

The status of irrigation system performance under the authority of the (central) government in 6 districts/municipalities based on non-crossing irrigation areas (Figure 4/ SM_{int}), only in Kupang District (3 irrigation region) shows the status of "fair" irrigation systems. Meanwhile, the cross districts/municipalities (4 irrigation areas) (Figure 5/ SM_{ink}) are better than those non-crossed areas, which are in the range of "fair to quite good", covering the irrigation areas of Kupang municipality-TTS District, Kupang District-TTS District, and TTU District/ Belu District, with fair status, whereas irrigation areas of TTS District-TTU District showed "quite good" status. Despite the differences in the status of the irrigation system performance, the irrigation area under the authority of central government is better than those under the authority of districts/municipalities and the provincial governments. This is might be caused by design of the irrigation infrastructures which are technically better, as the anticipation for the potential of large water sources for irrigating large areas to serve more water users. Therefore, the operation and maintenance of the irrigation area must be supported by the human resource capacity of the provincial government to assist the central government's duties. In addition, considering that the investment incurred for the irrigation system is quite large, adequate farmer participation in dealing with the complexities of large-scale irrigation problems is also needed. Study by Turrall et al. 2010 and de Fraiture et al. 2010, showed the performance of large-scale irrigation systems in developing countries faces considerable policy challenges in global irrigation governance; this challenge is in the form of the need to improve irrigation performance and the effectiveness of water utilization, improve management through better institutions, and requirement for adaptation and capability for better application of technology.

Several studies on the performance of irrigation systems under the authority of the central government generally categorize the irrigation system performance with good performance. For example, Mulyadi (2014) rated good for the irrigation system of Barugbug Sub-district in the Jatiluhur irrigation area, based on using 6 parameters; physical infrastructure, crop productivity, supporting facilities, personnel of irrigation institutions, documentation, and participation of water-user associations (WUA). This is in line with the results by Amriyadi et al. (2016) in the Wawotobi irrigation area (16,572.26 hectares) of Konawe District Southeast Sulawesi. Moreover, Kuscu et al. (2015) in Bursa-Karacabey irrigation system (16,683 hectares) in Turkey, during the period 2002-2007, suggested physical performance indicators provided a better irrigation performance and positive financial performance above the national average; positive financial performance in the form of cost-effectiveness, financial independence, high funds for O&M. However, in China, Jiamakou irrigation area covering 10,517 hectares in Shanxi Province, with physical indicators only (efficiency, dependence, and equality), showed relatively bad performance of irrigation canals (Fan et al. 2018).

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To ensure a large-scale irrigation system is in good performance, the institutional aspects are one of the keys to provide a good status of irrigation system performance through regulations/laws, besides executives as users of the rules must have accountability, good participation, transparency, cooperation, and clear functions and responsibilities. According to Lankford et al. (2016), a single definition for large-scale irrigation is not easily obtained or applies globally. In the case of command areas, large-scale generally include irrigation systems with an area of more than 3,000 hectares. However, in some parts of Asia, irrigation systems are considered large-scale for areas larger than 10,000 hectares. More accurately, large-scale is defined as a system in which formal irrigation organizations are formed which are responsible for providing water distribution services to farmers or WUA with government support through O&M funds at least at the level of the distribution system and at least nominal funds support. Thus, these aspects are increasingly clear of its roles and responsibilities.

Status of irrigation system performance for the irrigation under central government across districts/municipalities of Kupang District-TTS District (Bena irrigation area, 3,500 hectares) was categorized as fair status. In 2018, this irrigation area won the first place for national level competition on O&M of irrigation areas and got the title of "exemplary irrigation area in 2018". This award reflects the potential of good capacity and coordination between the provincial government as the assistance task, TTS District-Kupang District governments as the location's authority of the irrigation area, and the participation of farmers (WUA) in running the irrigation system properly.

According to Qtaishat (2013), large-scale irrigation systems carried out by (central) governments are very effective, so that allocation of public water resources can support food security. However, large-scale irrigation systems cannot guarantee an equitable water distribution and sustainable O&M without irrigation institutions with a good capability. This opinion is also supported by Ross and Martinez-Santos (2010); Meinzen-Dick (2014) which suggested that larger and more complex irrigation systems are better to be handled by the central government. This might be caused by the greater irrigation scale need more coordination and experts; in addition, most appropriate institutions depend on certain local conditions.

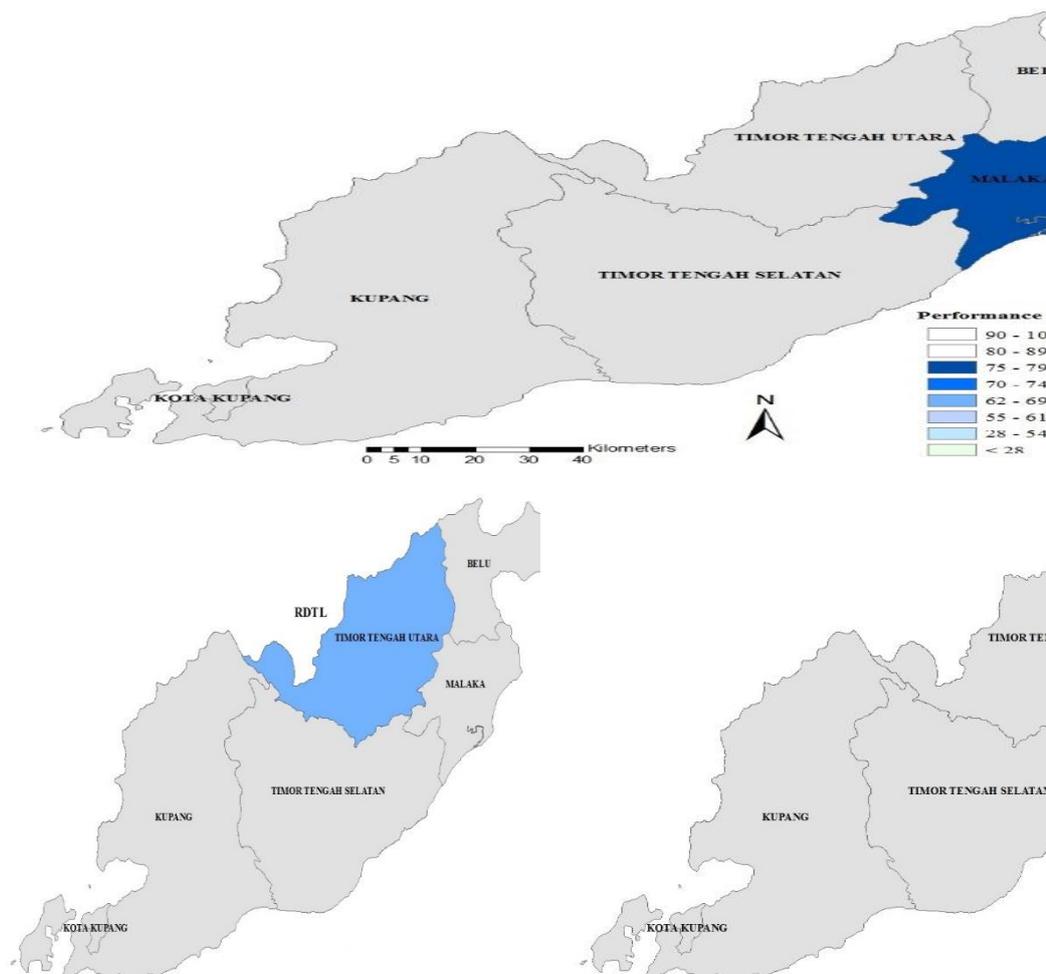


Figure 6. Median for status of *i-th* district/municipality irrigation systems performance under the authority of central government for cross countries irrigation areas (SM_{inc})

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There are many advantages in large-scale irrigation systems, for example, to increase crop yields such as rice and secondary crops that affect the economy, food supply and reduce local poverty (Hussain and Hanjra 2004; Hanjra et al. 2009; Faures and Mukherji, 2009; in Lankford et al. 2016). In addition, large-scale irrigation systems change the hydrological cycle and river water quality through diversion, consumption and water return flow (Wisser et al. 2010 in Lankford et al. 2016). Furthermore, if managed effectively by gravity distribution of water (mapping), the large-scale irrigation system will use less energy, thus contributing to the sustainable development to end poverty through food security.

The status of the performance of the district/municipality irrigation system under the authority of the central government in a cross-country pattern (Figure 6/*SM_{inc}*) was only found in 3 districts/municipalities, namely TTU District-DRTL (Democratic Republic of Timor Leste) showing fair status, Belu District-DRTL showing status bad, and only Malaka District-DRTL with good status. Irrigation areas across the Malaka District-DRTL are Malaka irrigation areas which potential to irrigate 15,000 hectares areas. In 2016, this irrigation area won the first place on the national level competition for the category of Irrigation area with best O&M. In fact, although it is a cross-country irrigation area, the upstream of Benanain River that irrigated the Malaka irrigation area is in the territory of the Republic of Indonesia.

Ministerial Regulation for Public Work and Housing Number 11/PRT/M/2017 is a guideline in carrying out the task of assisting the operation and maintenance of irrigation areas under the authority of the central government or irrigation area with an area of over 3,000 hectares assigned to the provincial government to headworks, primary and secondary canals, in operation by a unit "task force" under the authorization of the provincial public works agency, called regional Technical Implementation Unit (TIU). The TIU management structure is in accordance with Ministerial Regulation for Public Work and Housing Number 12 PRT/M/2015 concerning Exploitation and Maintenance of Irrigation Networks. These regulations are expected to be able to eliminate scattering in carrying out the task of refining irrigation areas under the authority of the central government, considering the location and characteristics of the irrigation area are better understood by the local government. Therefore, the term government here is an analytical approach that is used to describe and assess reality, while "reality in irrigation" itself is about how to maintain facilities and regulate the distribution of irrigation water for fair and sustainable use. Thus, the division of irrigation systems' authority is expected to reflect performance specialization so that the quality of institutional performance can be assessed/seen from the authority of the work.

In carrying out operations and maintenance in accordance with the division of authority, farmers as users of irrigation water are also involved in participatory in the maintenance of irrigation infrastructure. This reflects that in carrying out the operation of the irrigation system it is not fully carried out by the state/government alone. Frey et al. (2016) report benefits with joint management between government and farmers: 1) greater sensitivity to local conditions, produce sustainable harvests, increase compliance through better monitoring and utilize local knowledge (Gutiérrez et al. 2011), 2) higher legitimacy, creating incentives to comply with rules without external sanctions (Cinner et al. 2012), 3) equity and efficiency of decisions can be increased, 4) increasing local capacity in the long-term planning (Plummer and Armitage, 2007) and 5) clear ownership and ownership rights encourage productive participation and involvement in decision making (Gutiérrez et al. 2011).

Of the three institutional forms of irrigation systems in carrying out the development and management of irrigation systems, the performance status of the district/municipality irrigation system based on the irrigation area's authority showed a gradual increase in line with the level of the irrigation area authority (Figure 7). On the other hand, the potential of water resources, the area supported by irrigation infrastructure, and human resources are the "basic capital" of the irrigation system performance based on the level of authority. The best status of irrigation system performance in the 6 districts/municipalities is found in large-scale irrigation areas under the authority of the central government and tend to be found at the irrigation areas that are more "localized", this may be affected by the coordination factor, as coordination is needed in controlling irrigation infrastructure and irrigation water distribution. However, some factors affected irrigation systems performance should be studied such as the level of maintenance and monitoring (Frey and Rusch 2013 in Frey et al. 2016), nonetheless, it remains not detailed in this study.

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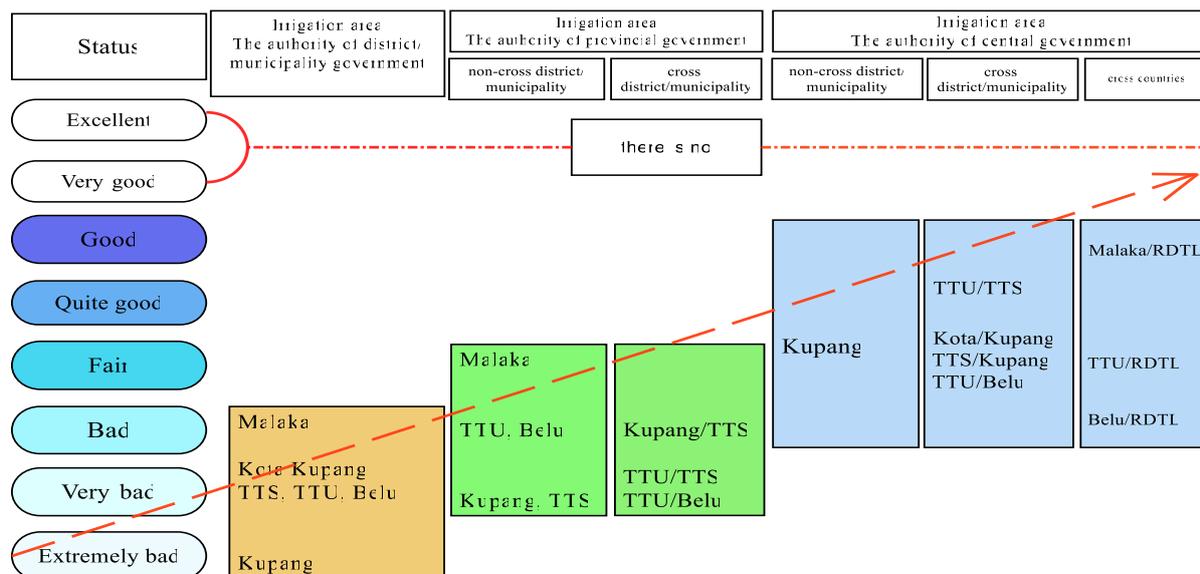


Figure 7. Performance scheme of district/municipality irrigation system performance status based on its institutional authority

Source: data analysis of this study, 2020

The results of the analysis of the status of irrigation system performance in 6 districts/municipalities can be a reference in formulating policy steps that need to be taken, such as consideration of semi arid region conditions and the performance index criteria of irrigation systems for the insufficient water region. The policy taken is expected to overcome the problem of irrigation in the semi arid regions of Timor Island, NTT Province with low and fluctuating water availability. Although it was realized that the government might not be able to solve all irrigation problems, this step showed that the government had implemented the decentralization mandate of the irrigation system to continue to adapt for better changes, including the development of the division of institutional authority.

IV. CONCLUSIONS

1. Status of irrigation system performance in 6 districts/municipalities in Timor Island increased along with the increased level of authority.
2. The best Status of the performance of irrigation systems in 6 districts/municipalities was Malaka District Irrigation system, the performance tended to be better in the irrigation system under the authority of central government that administratively placed in one district/municipality.
3. Analysis of the status of irrigation system performance in 6 districts/municipalities in Timor Island can be a specific step for each district/municipality to adjust the location characteristics with policies that will be taken in overcoming irrigation problems in the semi arid regions of Timor Island which have low and fluctuating water availability.
4. Improving the status performance of the district/municipality authority irrigation system, needs to strengthen the institutional authority of the district/municipality. Rearrange the standard of district/municipality authority irrigation area. Rearrange the irrigation system performance index criteria by considering local conditions in the region (dry and wet regions).

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