ASSESSMENT OF IRRIGATION SYSTEM PERFORMANCE AND ITS ASSOCIATED IMPACTS ON POVERTY[1]

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ABSTRACT

It is indicated that the level of performance of an irrigation system affects the benefit received by farmers. Low level of performance leads on the low farmers' income, which furthermore affects farmers' welfare. On the opposite, farmers with low level of welfare have limited capability to manage their irrigation system so the level of performance of the system declines. This created a vicious circle of low performance and poverty. This paper aims to assess irrigation system peformance, relate the performance with poverty in the system, and examine possibilites of poverty alleviation through improvement of irrigation system performance.

Irrigation performance assessment comprises of characterization of irrigation system and performance assessment by using indicators. The study has been conducted in four irrigated systems in Java, namely Klambu Kiri, Glapan, Kalibawang, and Krogowanan. Lesson learnt were drawn from cases of the selected systems to find out factors affecting irrigation performance and how irrigation system performance affects farmers' welfare.

Possible efforts to improve irrigation system performance to alleviate poverty are crop diversification, Irrigation Management Transfer, empowerment of Water Users' Association (WUA), locally specific farming, and off-farm job opportunity. To implement those efforts there are some constraints to deal with, such as limited technical capability of farmers, diversity of social and culture, and limited available data and information.

Key Words : Irrigation system performance, poverty

INTRODUCTION

Among more than 200 million Indonesian populations, 45% of it depends on agriculture. In addition, contribution of agriculture to national GDP is 16.92% (BPS, 2000). Therefore the government pays much attention to agriculture. Many policies and programs have been dedicated to agriculture.

Irrigation has been one of the focuses in agricultural sector during the Indonesian development. At the beginning, irrigated agriculture development was focused on physical target to achieve the rice self-sufficiency by developing new rice fields and large irrigation systems. In macro level, irrigation has improved cropping intensity and yield.

The government of Indonesia has developed around 4.5 million hectares of technical irrigation in the country from early 1970s to 1990s. Water resources development and management has played an important role in agricultural and overall economic development, in terms of both production and public expenditures. By 1980, investment in irrigation accounted for more than half of the public expenditures, with publicly funded irrigation accounting for 85 percent of the irrigated area and 75 percent of the country's rice production (Pasandaran and Zuliasri, 2001).

Following the extensive development of irrigation systems, the fund for operation and maintenance are increasing. Because the government is unable to generate sufficient funds to pay for the cost of routine Operation and Maintenance (O&M), many irrigation systems fail to perform as they were expected.

It is indicated that the level of performance of an irrigation system affects the benefit received by farmers. Low level of performance leads on the low farmers' income, which furthermore affects farmers' welfare. On the opposite, farmers with low level of welfare have limited capability to manage their irrigation system so the level of performance of the system declines. This created a vicious circle of low performance and poverty.

In irrigation system with low level of performance, poor farmers may suffer more than non-poor farmers because poor farmers have less access to resources. Therefore, they getting poorer and poorer.

Considering the impact of irrigation system performance to farmers benefit, it is possible to alleviate poverty by improving irrigation system performance. This paper aims to assess irrigation system peformance, relate its performance with poverty in the system, and examine the possibility to reduce poverty through improvement of irrigation system performance.

METHODOLOGY

Assessment of irrigation system performance comprises of two methods:

1. Characterization of irrigation system

   The initial step in this study is to recognize the characteristics of irrigation system. This aims to understand the context and the present situation of the system, including their resource base. Irrigation characteristics are classified as physical characteristics, agricultural characteristics, social and economic characteristics, as well as institutional characteristics.

2. Performance assessment by using indicators

   In this study, performance of irrigation system is assessed in three levels so that the indicators reflect the three levels are employed. They are output, impact, and process indicators. The assessment is given into three criteria i.e. productivity, water supply, and environment. The criteria and detail indicators are given in Table 1.

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Table 1. Indicators of performance assessment of irrigation system

No.	Criteria/Indicators	Definition
A.	**Criteria: Productivity**	
1.	Irrigation intensity (II)	Ratio of net irrigated area and the command area.
2.	Cropping intensity (CI)	Ratio of gross cultivated area to command area
3.	Output of rice per unit area (OCA-rice)	Ratio of total sample of rice production and the respective sample area
4.	Output per unit of diverted water (ODW)	Ratio of total production to total diverted water.
5.	Output per unit consumed water (OCW)	Ratio of actual total production to the volume of water consumed by evapotranspiration (ET).
B.	**Criteria: Water Supply**	
6.	Relative water supply (RWS)	Ratio of total water supply and crop water requirement.
7.	Relative irrigation supply (RIS)	Ratio of total irrigation supply and irrigation requirement.
8.	Water delivery capacity (WDC)	Ratio of canal capacity to deliver water at system head and peak consumptive demand.
9.	Water delivery performance (WDP)	Ratio of actual to target volume of water delivered.
10.	Overall system efficiency (OPE)	Ratio of crop water requirement and total inflow into irrigation system.
11.	Head-tail equity in water supply (HTERW)	Ratio of WDP of 25% upper of the system to average WDP of 25% tail of the system
C.	**Criteria: Environment**	
12.	Percent of command area affected by water logging (AWL)	Ratio of area affected by water logging to command area
13.	Percent of command area affected by salinity (AS)	Ratio of area affected by salinity to command area
14.	Groundwater depth (GWD)	Groundwater depth from land surface
15.	Percent of command area affected by chemical pollution (ACP)	Ratio of area affected by chemical pollution to command area

RESULTS AND DISCUSSION

Characteristics of Selected Irrigation System

The study was conducted in four irrigation systems in Java, namely Kalibawang, Krogowanan Klambu Kiri, and Glapan as shown in Figure 1. Administratively, Kalibawang System is located in Yogyakarta Special Province while Krogowanan, Klambu Kiri and Glapan are situated in Central Java Province.

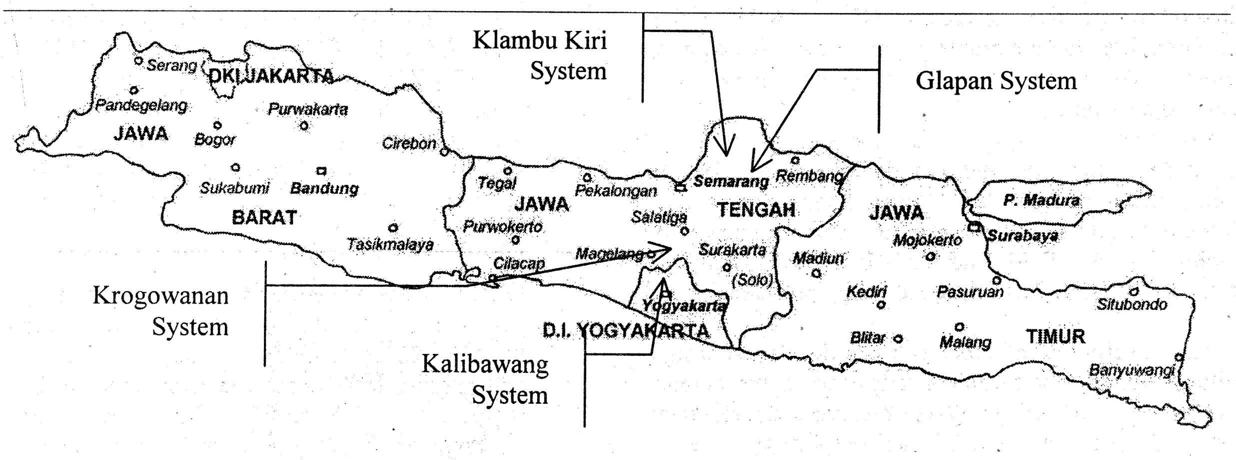

Figure 1. Location of selected irrigation systems

The sample of irrigation system were chosen to show variation on size of the system, water availability, experience of Irrigation Management Transfer (IMT), and the incidence of poverty. Table 2 shows the characteristics of the samples. Furthermore, the samples are characterized based on their hydrology, climate, discharge, institution, and poverty condition. Although the characteristics are considered to affect irrigation performance and its impacts on poverty, the relationship is expressed in descriptive way.

Table 2. Characteristics of sample irrigation system

	Klambu Kiri	Glapan	Kalibawang	Krogowanan
System size	21,475 ha (large)	18,284 (large)	6,454 ha (medium)	813 ha (small)
Water availability	Adequate	Shortage	Shortage	Surplus
IMT experience	No	No	Yes	Yes
Incidence of poverty	High	High	High	Low

Hydrology

Kalibawang System is the largest irrigation system in Kulonprogo District, which diverts water from Progo River on its right bank. Along the Kalibawang Primary Canal water is diverted into several tertiary blocks under Kalibawang Irrigation Scheme (1525 ha). At the end of Kalibawang Primary Canal, water is divided into two directions. To the left it supplies Donomulyo Secondary Canal as well as Papah River and to the right it supplies Serang River. Furthermore, Penjalin (652 ha) and Papah (983 ha) Irrigation Schemes divert water from Papah River while Pengasih (2075 ha) and Pekik Jamal (739 ha) divert water from Serang River.

Magelang district in Central Java lies among three mountains i.e. Mounts Merapi and Merbabu to the East and Mount Sindoro to the West. Progo River flows from North to South in the middle of the district. Among several Progo tributaries are Pabelan River, Kunjang River and Klesem River, which become the main water source of Krogowanan System. Krogowanan (832 ha) is an interconnected irrigation system diverts water from several weirs and springs.

Almost all irrigated areas in Demak District are located in Jratunseluna River Basin, which consists of five rivers namely Jragung, Tuntang, Serang, Lusi, and Juana. In the upper part of Serang River, Kedung Ombo Reservoir was developed in 1987. Klambu Weir is situated in Serang River, which is supplied from Kedung Ombo reservoir. Klambu has 48,715 ha command area divided into two irrigation schemes namely Klambu Kiri (Left Klambu; 21,457 ha) and Klambu Kanan (Right Klambu; 27,258 ha).

Glapan Weir diverts water from Tuntang River, which is originated from Rawa Pening Lake. The weir is located in Glapan Village, Grobogan District. The command area of Glapan Scheme is divided into Glapan Timur (East Glapan; 8,671 ha) and Glapan Barat (West Glapan; 10,113 ha).

Climate

General climatic condition in Central Java and Yogyakarta falls under category of tropical monsoon climate. It is influenced primarily by the seasonal monsoons, namely the Southeast (SE) and Northwest (NW) monsoons. The SE monsoon creates the dry season normally occurs from mid May to October and characterized by fewer amounts of rainfall, lower humidity, and less cloudiness. The NW monsoon creates the rainy season generally from November to April which have frequent and heavy rainfall, high relative humidity and more cloudiness. More than 80% of annual rainfall falls in this period.

Rainfall is distributed unevenly throughout the year. The mean annual rainfall recorded in Yogyakarta, Borobudur, and Semarang weather station is 2330 mm, 2147 mm, and 2234 mm, respectively. The average monthly rainfall pattern at the three selected rainfall station is shown in Figure 2. This figure shows that the rainfall in the three selected stations follows SE-NW monsoon pattern and has small differences.

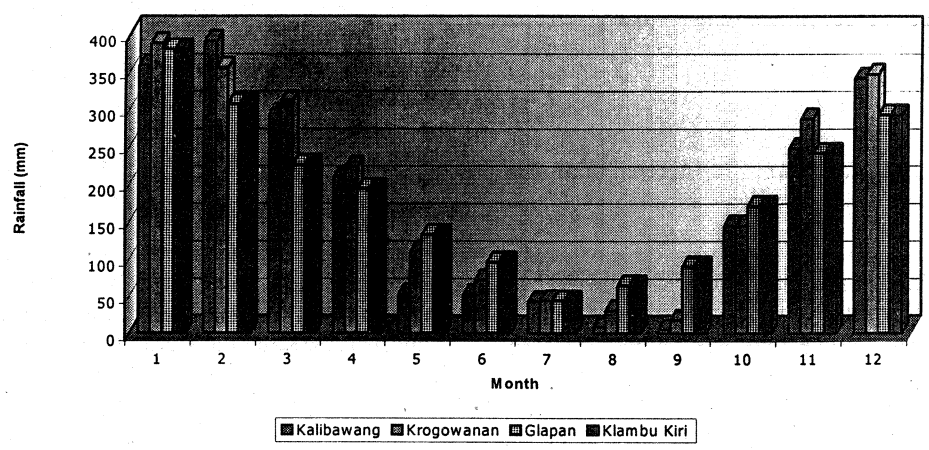

Figure 2. Average monthly rainfall in selected area

The climatic parameters recorded at the three weather stations vary insignificantly. The average maximum temperature varies from 29.9 °C to 33.2 °C while average minimum temperature varies from 14.6 °C to 24.6 °C. The mean monthly relative humidity varies from minimum 61% to maximum 87%. The mean monthly wind speed varies from 150 km/day to 286 km/day. The wind direction generally follows the monsoon wind direction. In addition, the sunshine duration ranges from 37% to 98%.

Discharge

Discharge measured in the main intake of the selected systems revealed in Figure 3. Large systems (Glapan and Klambu Kiri) show bigger discharge and larger fluctuation while smaller systems are vice versa. Generally main intake discharge follows the fluctuation of rainfall with some adjustment to the irrigation water requirement, for example high water demand for land preparation, low water demand on harvesting period of rice, and low water demand when upland crops become dominant.

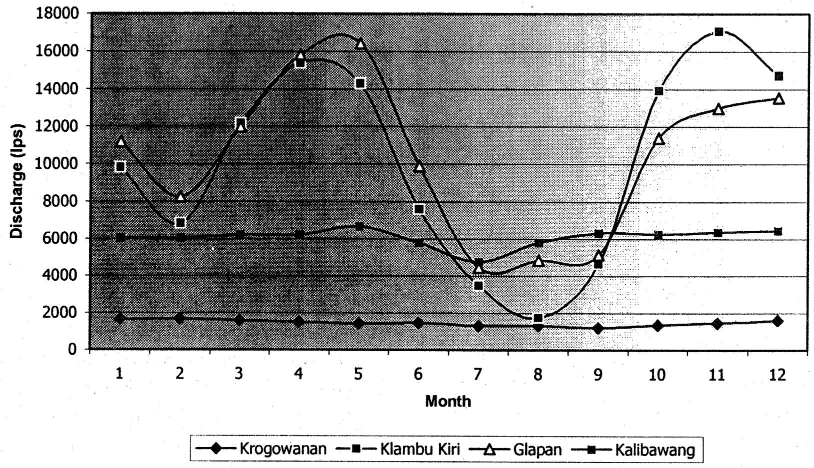

Figure 3. Average monthly discharge at main intake of selected system

Institutional characteristics

Generally there were two levels of irrigation management, i.e. the government that manage the main system of irrigated area while farmers manage the tertiary level. Since the mid of 80's the government established water user association (WUA) in tertiary level. Members of WUA consist of land owners and tenants in the respected tertiary area. Following to the Irrigation Policy Reform, farmers are encouraged to establish water user organization not only in tertiary level but also in secondary and primary levels. Based on the Government Regulation No 77/2001, the District Government facilitated farmers to develop Federation of Water User Associations (FWUA) both in Secondary and Primary Levels. Members of FWUA are WUA in respected secondary canal. Different from the previous development of WUA, the FWUA was developed in participatory way.

One policy under Irrigation Management Policy Reform is Irrigation Management Transfer (IMT) program. The IMT had been implemented in Kalibawang and Krogowanan. In Kalibawang System, the IMT program has been implemented in Papah and Pengasih Irrigation schemes in 1999 and followed by Kalibawang and Pekik Jamal in 2002. In Central Java, irrigation management has been transferred to WUA for the first phase in two schemes. One of them was Krogowanan Irrigation Schemes.

Poverty characteristics

Poverty in the selected irrigation systems is characterized based on BPS criterion (BPS, 1999) and Sayogyo's criterion (Sajogjo, 1994). Table 3 illustrates poverty of farm household in the sample area. Percentage of poor household calculated based on rupiah income as shown in BPS criterion is generally lower than that calculated based on rice-equivalent income in Sajogjo's criterion. Although the four systems shows similar poverty characteristics on BPS criterion, Krogowanan to some extent shows more prosperous farm household on Sajogjo's criterion. Further explanation on poverty in the study area and its method of analysis is presented in Hartono and Mawarni (2003).

Table 3. Percentage of poor farm household in sample irrigation system

	Klambu Kiri	Glapan	Kalibawang	Krogowanan
BPS Criterion				
• Poor	43.13	38.02	36.78	40.64
• Not poor	56.87	61.98	63.22	59.36
Sayogjo's Criterion				
• Very poor	0.00	0.00	0.00	0.00
• Poor	10.23	11.09	18.03	4.52
• Slightly poor	33.35	33.71	20.65	34.31
• Not poor	56.42	55.20	61.32	61.17

Source: Hartono and Mawarni, 2003

Performance of Selected Irrigation System

Water Supply Performance

Water supply indicators describe the performance of an irrigation system based on its direct output of the system that is water supply for agriculture. Irrigation system with a certain level of O&M interacts with its environment and produces a certain level of water supply. The indicators to describe water supply performance are water adequacy, efficiency, and equity. Table 4 shows the value of the indicators in selected irrigation systems.

Among several factors affect water availability in a surface irrigation system is the condition of catchment area. Biophysical condition of the catchment area of a river basin controls the discharge fluctuation of the river. Moreover it also controls sediment content in the river so this affects irrigation system. Because the deterioration of ecosystem in the catchment area, erosion occurs in upper part of Jratunseluna River Basin, which consist of five main rivers, namely Jragung, Tuntang, Serang, Lusi and Juana. Serang is the main water resource of Klambu Kiri System while Tuntang is the main water resource of Glapan System. The erosion results in the sedimentation within Klambu Kiri and Glapan Systems. As a consequence, canal capacity of the two systems reduces and adequacy of irrigation water reduces as well.

Infrastructure condition is also an affecting factor to the performance of an irrigation system. Poor infrastructure condition allows water losses, which in turn reduce efficiency. In spite of that, infrastructure condition depends on its maintenance. In case of transferred system, farmers manage their irrigation system according to their own culture. In Krogowanan and Kalibawang Systems, it is difficult to expect farmers to take care of their system daily due to different reasons. Krogowanan System is blessed with abundant water so farmers are not accustomed to strive for water. However they are willing to participate in rehabilitation and contribute large amount of money. Kalibawang System was developed through a government project without farmer participation, so farmers have limited knowledge about the system and on how to manage it. Empowerment efforts for the two cases should be different.

Table 4. Water supply indicator of selected schemes

Indicators	PS*	Klambu Kiri	Glapan		Kalibawang			Krogo-wanan
			West Glapan	East Glapan	Kali-bawang	Pengasih	Pekik Jamal	
RWS	1	0.98	1.26	0.75	1.53	1.78	1.80	1.91
	2	0.99	1.29	1.12	1.75	1.44	1.66	1.71
	3	0.18	0.52	0.59	2.23	1.94	2.01	1.55
RIS	1	0.75	0.43	0.52	1.30	0.94	1.30	1.23
	2	0.56	0.46	0.69	1.36	0.88	1.22	1.21
	3	0.11	0.12	0.40	1.85	1.40	1.58	1.36
WDC		0.14	0.07	0.18	0.72	0.44	0.18	0.80
WDP	1	2.84	1.65	1.83	6.05	2.21	4.17	3.50
	2	2.04	1.77	2.63	10.43	2.11	4.70	4.01
	3	0.60	0.66	1.46	12.55	3.43	3.88	8.86
OPE	1	1.15	1.94	1.60	0.64	0.89	0.64	0.68
	2	1.46	1.82	1.20	0.61	0.95	0.68	0.69
	3	1.96	3.52	2.06	0.45	0.59	0.53	0.61
HTERW	1	2.53	2.66		1.45			
	2	1.72	3.01		2.22			
	3	1.07	2.51		3.23			

Notes: PS = Planting season

The reform in Indonesia, which leads to local autonomy, allows the district level government to manage its own business. The boundary of this autonomy is the district administrative boundary, which sometimes does not coincide with hydrological boundary. In spite of its benefit, the local autonomy arise a problem in irrigation management, for example the declining of O&M management in Glapan System.

Irrigated area across two different districts becomes a problem in Glapan System in this political reform era. Glapan weir is situated in Grobogan District and its irrigated area is located in Grobogan and Demak Districts. In Grobogan District, the staff in charge of O&M of Glapan System now has no background in O&M of irrigation system because they were assigned based on employment hierarchy.

In Demak District, which is located in the tail, farmers receive less water recently. Indicator of water supply equity shows head-tail inequity in Glapan System. Farmers argue that management by BPSDA (water resources management body in river basin level), an autonomous body responsible to the national government, provides less satisfaction because of: (i.) reduction of irrigation water availability, (ii) disappointed management staff in district level because of reduction of their responsibility, and (iii) inequity in water allocation and distribution.

Productivity Indicators

An irrigation system produces water to supply an agriculture system, which produces output in term of agricultural product. Productivity indicators of selected irrigation system, as revealed in Table 5, consist of cropping intensity and irrigation intensity, land productivity, as well as water productivity. Productivity, actually, is a result of interaction among several production factors, including water.

Table 5. Productivity indicators of selected schemes

Indicators	PS*	Klambu Kiri	Glapan		Kalibawang			Krogo-wanan
			West Glapan	East Glapan	Kali-bawang	Pengasih	Pekik Jamal	
II		2.50	2.60	2.89	2.90	2.72	2.95	2.02
CI		2.52	2.75	2.89	2.96	2.93	3.00	2.64
OCA-rice	1	4.48	4.33		4.28	2.77	1.67	3.36
	2	3.46	2.00		3.41	2.50	1.07	2.86
ODW	1	0.40	1.23	1.45	0.21	0.81	0.24	0.45
	2	0.46	0.88	0.94	0.23	0.38	0.17	0.19
	3	0.09	0.089	0.21	0.01	0.01	0.02	0.18
OCW	1	0.36	0.62	0.89	0.52	0.90	0.37	0.64
	2	0.31	0.48	0.78	0.54	0.39	0.17	0.28
	3	0.01	0.01	0.10	0.33	0.02	0.44	0.09

Notes: PS = Planting season

Physical condition of systems influences farmer choice on crops. More water availability gives farmers more choice of crops. Krogowanan system is located in the slope of Mount Merapi with such characteristics as porous soil, sloppy area, and abundant water. Plentiful water availability is shown in the adequacy indicators. However, the abundant water leads to disobedient to the planting pattern. Farmers choose their crops and planting date as they wish although they registered different crops at the beginning of the first planting season.

When water is available, other factors become constraint to the crop selection. For example in Kalibawang Scheme water is also available but the soil condition is the best suit for rice. Therefore, farmers choose to grow rice.

To show land productivity, gross product is measured for a unit of land. Among various crops, only rice is the common commodity grown in all selected systems, accordingly only rice productivity can be used as comparison of productivity across system. The rice production varies from 1.5 ton/ha to 4.5 ton/ha. Generally, rice production is higher in the first planting season. The case does not always coincide with water availability. In Glapan System and Kalibawang Scheme water availability is higher in the second planting season while in Krogowanan System, Pengasih Scheme, and Pekik Jamal Scheme water availability is higher in the first planting season.

Water productivity in the system is shown as gross product per unit of diverted water and per unit of consumed water. Water productivity has a correlation with irrigation adequacy. In such system where water is inadequate as in Klambu Kiri and Glapan Systems, diverted water is less than consumed water to produce the output. On the contrary, in such system where water is adequate as in Krogowanan and Kalibawang Systems, additional water diverted, which is not consumed, cannot be used to increase productivity.

Water productivity differs from one system to another as a result of interaction among input in agriculture system as well as between system and its environment. Water productivity is the lowest in Kalibawang and Pekik Jamal Schemes while the highest water productivity has been reached in Glapan System. Therefore, it is difficult to compare water productivity across system. However it is possible to compare water productivity between the first and second planting seasons for the same commodity, that is rice, with assumption that within system input is used similarly between the two planting seasons.

In Kalibawang and Krogowanan Systems more available water can increase production per unit water. In the system where water is adequate, more water can stimulate the use of other input to produce more output. In Glapan System, less water in the first planting season produces more products per unit of water compare to the second planting season. In the system where water is inadequate, it is utilized more efficiently with other agriculture input.

Environmental indicators

Environmental indicators reveal how physical environment interacts with irrigation system so the system performs in a certain level. The physical environment strongly influences the irrigation system performance.

Generally selected irrigation systems perform good environment indicators. Problems of physical environment occur in a few parts of the systems. The environment indicators of selected irrigation systems are revealed in Table 6.

Krogowanan is the system without any natural environment problem. The condition of water, soil, and topography is very conducive for agriculture. Soil texture allows good drainage that let no place with water logging. Salinity also appears nowhere in Krogowanan System. The only environment problem in this system is chemical pollution in the tail area where a pulp factory located. Farmers informed that the pollution started approximately 10 years ago when the factory change their main activities from producing paper from rice straw to recycling waste paper.

Table 6. Environment indicators of selected schemes

Indicators	Sea-son	Klambu Kiri	Glapan	Kali-bawang	Pengasih	Pekik Jamal	Krogo-wanan
AWL	Dry	None	None	None	None	None	None
	Rainy	10-25%	10-25%	None	10-25%	25-50%	None
AS	Dry	None	None	None	None	None	None
	Rainy	None	None	None	<5%	<5%	None
GWD	Dry	1–3 m	1–3 m	2–6 m	2–4 m	2–4 m	0.5–4 m
	Rainy	0.5–3 m	0.5–3 m	1.5–5 m	2–4 m	1 m–4 m	0.5–4 m
ACP		None	None	None	None	None	10-25%

In Kalibawang System, the upper scheme, Kalibawang, has the most accommodating physical environment. It suffers from neither salinity nor water logging. The middle scheme, Pengasih, experiences water logging in a few parts of its command area in its tail end during the rainy season. Some parts experience salinity in the command area nearby coastline during the dry season. Likewise in Pekik Jamal, the tail scheme, some parts of command area suffer from salinity during the dry season and water logging during the rainy season. The area faces water-logging problem in Pekik Jamal is wider than that in Pengasih. To overcome water-logging problem, farmers use *surjan* system. In the field with *surjan*, a part of the land is higher than the other part. Rice, which is more resistant to water logging, is grown in the lower part while vegetable or upland crops are grown in the upper part.

In Klambu Kiri and Glapan, none of their command area experiences salinity problem. Water logging is found in a few parts of them. Some farmers also use *surjan* system, but the intensity is lower than that of Pekik Jamal and Pengasih Schemes.

Basically, groundwater in the selected systems comes from shallow aquifer or unconfined aquifer. The depth varies from place to place as shown in Table 6. From rainy season to dry season, the change of groundwater depth can be considered negligible. Groundwater is utilized for agriculture in Pekik Jamal as well as the tail of Pengasih and Glapan. In Kalibawang and Klambu Kiri no farmers use groundwater to irrigate their farms. In Krogowanan System no well needed to abstract groundwater because springs already provide abundant water besides the abundant availability of surface water in Pabelan River.

Impact of Irrigation System Performance on Poverty

Impact of irrigation system performance on poverty is indirect. Considering irrigation as nested system, irrigation provides water as an input to agriculture, which then produces output in the form of crop production. Then the product gives income to farmers' family to fulfill their need.

Water is an important factor in agricultural production but it is not the only factor. Agriculture is an open system influenced by many factors, both natural condition and artificial impact. Therefore, impact of irrigation performance on production depends on the interaction between water and other factors.

Discussion on productivity indicators proves that, in case of rice, higher water availability is not always followed by higher production in a particular system. Because of very varied planting pattern, it is difficult to compare productivity across system in term of their weight. To observe the impact of water availability to agricultural product, productions of all food crops are then conserved into their value of currency and summed up. Income from food crops in irrigated land becomes one of the incomes to farmers' family beside other source of income both from farm and non-farm. To observe the relationship among them, Table 7 provides the values of water availability in term of Relative Irrigation Supply (RIS) and Relative Water Supply (RWS), total food crop value, and income per capita for the selected systems. Although it is not shown mathematically, the relationship is shown well descriptively.

Table 7. Water availability, food crop production and income per capita

System/ scheme	RIS	RWS	Rice production (ton/ha)	Value of food crop production (Rp/ha/year)	Income per capita (Rp/capita/year)
Klambu Kiri	0.7163	0.4745	4.48	9,094,851	2,317,952
Glapan	0.9216	0.4375	4.33	6,570,589	2,201,842
Krogowanan	1.6250	1.2660	3.37	9,034,063	1,757,772
Kalibawang	1.8368	1.5023	4.28	7,705,552	2,353,463
Pengasih	1.7218	1.0717	2.77	11,897,397	4,632,132
Pekik Jamal	1.8230	1.3674	1.67	11,387,531	1,570,553

Water availability is one of the factors affecting agriculture production. Table 7 shows that Klambu Kiri and Glapan Systems have less water availability and produce less value of crop compare to other system.

However, it sometimes in the systems where water is adequate, other factors becomes the driving force. One of them is soil condition. Kalibawang Scheme and Krogowanan System have such similar visual condition as hilly topography and abundant water availability. Rice productivity of Kalibawang Scheme is higher than that of Krogowanan System. However, the values of food crop production in the two systems are vice versa. Soil condition in the two systems is considered as the influencing factors. The soil of Krogowanan System was formed from young volcanic materials, which is porous and rich of mineral needed by crops. On the contrary, Kalibawang Scheme soil was formed from old volcanic materials, which is less porous and has poor mineral content. As a result, Kalibawang Scheme is more suitable for rice because the less porosity can conserve more water in the pounding system of irrigation in the rice field. In Krogowanan System, the mineral content and good internal drainage make its soil suitable for vegetables and upland crops so the cropping pattern is more diverse. This, in turn, produces more value of food crop. In addition, better market condition gives more support to agricultural production in Krogowanan System.

In a system where soil and water condition are similar, other factors may determine the value of food crop production. Within Kalibawang System with similar water availability among schemes, crop diversification becomes the influencing factors. Kalibawang Scheme produces less value of food crops while Pengasih and Pekik Jamal Schemes have more diverse cropping pattern and grow such high value crops as chili. Although Pekik Jamal Scheme has the lowest rice productivity, it produces more value of food crop during a year. To overcome problems of flood as the scheme located at the tail-end of Kalibawang System as well as to conserve water, farmers in Pekik Jamal Scheme and some parts of Pengasih Scheme apply *surjan system*, where a part of the land is higher called *tabukan* and the other part is lower called *ledokan*. In *ledokan*, rice is grown during rainy season while in *tabukan* various upland crops and vegetables are grown in strip cropping and transplanted in different planting date. This will guarantee income continuity of farmers and reduce the risk due to the failure of one crop. Entirely, the whole income from crops becomes higher.

Food crop production is one of the sources of family income. However, Table 7 shows that relationship between value of food crop and income per capita is not always clear. In Kalibawang System, values of food crop in Pengasih and Pekik Jamal Schemes are higher than that of Kalibawang Scheme. Despite of that, Pekik Jamal Scheme has the lowest income per capita while Pengasih Scheme has the highest. Although Klambu Kiri System food crop gives more income to farmers than that oh Glapan System, income per capita in the two systems are similar.

These may happen because farmers' income is influenced by income from other branches of agriculture as well as non-farm income. One example is the influence of non-farm job opportunity. In Pekik Jamal Scheme where food crop value is high, farmers have to spend their time more to take care of their high value crops so they have less time to conduct non-farm job. On the contrary, in Kalibawang Scheme farmers grow more rice, which need less attention. Therefore, they have more opportunity to go for non-farm job. Besides non-farm job opportunity, there are such factors to consider as income from livestock and animal husbandry, market system, which influences the price of agricultural products, and other source of income.

CONCLUSION: OPPORTUNITY AND CONSTRAINTS TO ALLEVIATE POVERTY BY IMPROVING IRRIGATION SYSTEM PERFORMANCE

The discussion on the relationship between water and income of farmers in irrigated agriculture shows that there may be some opportunities to improve farmers' income by improving irrigation system performance. The possible actions of improving irrigation system performance, which in turn may reduce poverty, are:

1. Crop diversification
   Although rice is the most suitable crop in tropical monsoon climate condition, its price is relatively low. Therefore, farmers are encouraged to grow other crops, especially the high-value ones, particularly in the second and third planting season. Diversification also provides the opportunity of soil to recycle its nutrient. For farmers, it also reduces the risk of failure because of pest and disease.
2. Irrigation Management Transfer (IMT)
   The IMT lets farmers decide the most suitable O&M practice to condition of the respective irrigation system. The management decided by farmers may differ from one system to another. Therefore, the irrigation system performance can be enhanced.
3. WUA empowerment
   WUA is the organization in charge of irrigation system management. Improvement of WUA capability to manage their system includes the technical O&M, farming practice, management, and finance. WUA empowerment ensures good management of irrigation system, which in turn improves irrigation system performance.
4. Locally specific farming
   Characteristics of irrigation systems in Indonesia differ widely in term of physics, social, economy, culture, and environment. Those components interact to each other to produce locally specific performances. The role of irrigation water to produce agriculture products as well as to contribute to farmers' income differs from one system to another. Consequently, treatment of irrigation system should also be locally specific. This includes, for example, choice of commodity, farm input, extension service, and so on.
5. Off-farm job opportunity
   In current condition, farming gives a very few income to farmers' family. Off-farm job availability gives farmers income between harvesting periods. The off-farm jobs provided should be related to the farming activity in the area. Post harvest activity that provides additional value to local agriculture product will be better.

To implement the efforts to enhance irrigation system performance, there are some constrains probably occurs. They are:

1. Limited technical capability of farmers
   Under the previous policy, farmers were treated as passive beneficiaries who receive water in their tertiary offtakes. They managed irrigation water only within their tertiary block. For that reason, they may have limited understanding about the management of irrigation system as a whole. To reduce this problem, WUA empowerment is essential.
2. Diversity of social and culture
   The diversity of social and culture in each region has not been fully recognized. This may cause ineffective and inefficient implementation of uniform programs as happen in the past.
3. Limited available data and information
   Nowadays, appropriate basis data and information related to water resources is unavailable. Additionally condition of measuring devices is poor besides data collection and analysis are not standardized. This makes efforts to improve irrigation system performance based on local condition become more difficult.

In this study, the relationship between irrigation system performance and its impact on poverty was analyzed descriptively. Therefore, it is potential to conduct further research to develop mathematical model of the relationship.

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