Study of Intermittent-Irrigation Technique to Cropping Patterns and Water Availability at Pemali Kanan Irrigation Area in Brebes Regency

B B Kusumo1,2*, Pranoto S A2, and I Sriyana2
1 Office of Water Resources Management and Spatial Planning of Brebes Regency, Brebes Regency, Central Java, Indonesia
2 Master of Civil Engineering, Diponegoro University, Semarang 50275, Central Java, Indonesia

*email : bayu.bbk@gmail.com

Abstract. Paddy farming is closely related to irrigation water supply since it is a kind of plant that has a high water requirement. Therefore, in major areas in Indonesia, paddy is not recommended to be grown in dry season. In Brebes Regency, many farmers still pick paddy for all three planting seasons that they suffer from insufficient of irrigation water supply. The objectives of this study is to find out how water availability compared with water requirement at Pemali Kanan Irrigation Area in both periods (present time and 20 years to come) and is intermittent irrigation technique required to solve this water supply problem. This research is conducted by calculating water availability using FJ Mock Method, generating water availability for the upcoming 2 decades using Thomas-Fiering Method and analysing water requirements for all 13 cropping patterns. Output of the analysis shows that water availability of Pemali River in both periods are statistically identical. Meanwhile, the average water requirements are mostly negative. It means that water requirements for all 13 cropping patterns could be fulfilled by rainfall. The conclusion is that in most 2-weekly periods, rainfall could provide adequate water supply for all areas. Intermittent irrigation technique will only be required in a certain period that is the 3rd planting season which lasts from Juni to October.

1. Introduction
Water requirement in paddy farming is an essential element farmers should consider in order to succeed in their business. Water availability must be in adequate amount as well so that it can supply all the areas. Most of Indonesian areas have high rainfalls, 2,800 mm/year in average. Unfortunately, they are accumulated only in short periods, approximately 4 to 9 months a year. As the result, there are quite long dry-periods every year[1]. This condition shows that there is imbalance between water availability and water requirement [2].

One method in paddy farming commonly implemented to manage water requirements and water availability is cropping pattern. This effort requires farmers to arrange what kind of plant to grow and when to start planting so that the pattern still corresponds with water availability. Farmers should be aware of months in which water supply are lower than water requirements. They should not grow plants with high water requirements, such as paddy, within these low-water months. This way, farmers will not suffer from lack of irrigation water.
In northern part of Brebes Regency, in the dry season which last from April to October, not less than 25,180 hectare land is threatened by drought[1]. Therefore, The Government of Brebes Regency through its agencies always urges farmers especially the ones whose lands are located in the northern part of Brebes Regency to obey and implement the cropping patterns that have been set by regent decree. This cropping pattern issue has become much more sensitive since many farmers still choose paddy as the commodity to grow in the dry season. Therefore, most of them complain about insufficient water supply. Their lands were not properly watered so that the plants didn’t grow well and the productions were lower than they used to be.

In terms of paddy farming, there are many kinds of advanced farming methods which had been introduced these recent years[3]. Besides providing scientific breakthroughs in farming, those methods also offer techniques to gain efficiency in water irrigation. One of the most popular farming methods which was once widely used in Indonesia is System of Rice Intensification (SRI). The principles of System of Rice Intensification (SRI) method are to do more eco-friendly farming, to minimize external input (e.g. irrigation water), to apply local wisdom, and to reduce chemicals consumption (e.g. fertilizer and pesticide)[4]. SRI methods would also offer greater paddy yields along with lower production costs due to lower consumption of seeds, chemical fertilizers and pesticides. These factors would generate higher profits to farmers[5]. SRI method contains a specific technique to deal with water requirements called Intermittent Irrigation[4, 5, 6]. Unlike conventional farming method, the intermittent irrigation applies periodical watering instead of continuous watering technique.

Regarding with this water availability issue, a study is required to figure out which cropping pattern has the least water requirement. The result of this study would help The Government of Brebes Regency to develop and to implement more suitable cropping patterns which correspond with water availability in Pemali Kanan Irrigation Area, and throughout Brebes Regency. How much the urgency of intermittent-irrigation technique implementation to save irrigation water in Pemali Kanan Irrigation Area will also be observed.

1.1. Problem Formulation
Based on that background, the major issues in this study are as follows:
1. How is water availability compared with water requirements in Pemali Kanan Irrigation Area at present time and in the next 20 years?
2. How much is water requirement for various cropping patterns in Pemali Kanan Irrigation Area?
3. What are farmers’ opinion regarding advanced farming method like SRI Method?

1.2. Purposes and objectives
The main objective of this study is to figure out which cropping pattern has the least water requirement so that it can be suited with the water irrigation availability in Pemali Kanan Irrigation Area. Therefore, this study is aimed to:
1. Analyze water availability in Pemali Kanan Irrigation Area either at present or in 20 years to come.
2. Analyze which cropping pattern and planting-season-commencement combination that require the least irrigation water whether it is applying conventional method or intermittent irrigation technique.

2. Methods
2.1. Materials
This research is conducted in Pemali Kanan Irrigation Area. Its area is 7,788 hectare and lies on 9 sub-districts in northern part of Brebes Regency. Pemali Kanan Irrigation Area is a part of Pemali Hilir Irrigation Area, a large irrigation area in the downstream of Pemali River whose area is 25,180 hectare[7].

Regarding the local farmers, by means of questionnaires, this study would also gain information from farmers who have an experience in applying System of Rice Intensification (SRI) Method, to find out what they consider about this advanced farming method. The respondents are chosen among farmers
who have implemented System of Rice Intensification (SRI) method themselves or they have been given such training regarding System of Rice Intensification (SRI).

Based on location, respondents live in the southern area of Brebes Regency which are Banjarharjo, Bantarkawung, Bumiayu, Tonjong and Sirampog sub-districts. All of them were chosen as demplot (a kind of farm land for new-methods trial) when System of Rice Intensification (SRI) was introduced to and implemented in Brebes Regency for the first time in 2005.

2.2. Research Framework

Once all data are collected, a sequences of analysis is carried out. The first step to be taken is analyzing the existing water availability of Pemali River using FJ Mock method. This stage will also need a series of analysis to figure out what is the potential evaporation in Pemali River based on weather and climatology data.

Next step is to use the existing water availability data as an input to generate numbers of water availability of Pemali Kanan in the upcoming 20 years. Thomas Fiering Method[8] will be utilized in this step..

In order to find out how the condition of water requirements in Pemali Kanan Irrigation Area is, a number of cropping pattern simulations are carried out. These simulations involve not less than 13 cropping patterns which are formed by 4 kind of crops: paddy, corn, soybean and red onion. Technically, these simulations are conducted by switching the commencement of planting seasons for every single cropping pattern based on a 2-weekly period. It means, every cropping pattern would have 24 alternatives for a one-year period. That way, various water requirements will be obtained. After that, each of these numbers are compared to figure out which cropping pattern (along with the planting-seasons-commencement combination) that needs the least irrigation water. This step is based on the facts that incompatibility of water requirements to water availability is caused by cropping pattern violation which surely will cause loss of productivity.

In the end, questionnaires are used to get information about how farmers’ opinion about certain farming methods, namely as System of Rice Intensification (SRI) method, which contains this intermittent irrigation technique. This information would be useful to discover why such a developed farming method could not last long in terms of their implementation.

3. Results and Discussions

3.1. Water Availability

The analysis output shows that for present time, water availability in Pemali River is quite high. The highest debit could reach 250.31 m³/sec (took place in Februay II, 2009), while the average debit is 49.75 m³/sec. For certain periods, during dry seasons which last from June to October, Pemali River’s water availability is recorded low that it sometimes is incapable of supplying the entire area.

This condition is similar with the ones in the upcoming 20 years. The output of Thomas-Fiering Method, Pemali River’s maximum water availability is recorded high as 246.54 m³/sec (took place in February II, 2030) and the average debit is 48.05 m³/sec. Furthermore, statistically those two data has an identical pattern. This similarity also proven by paired T-Test. The paired T-Test result shows that, the historical and the generated data come from the same population. Figure 1 and Figure 2 show how historical and generated debit are compared in terms of Average Debit and Standard Deviation.

3.2. Water Requirements

Based on the simulation, it shows that for all 13 cropping patterns, the average water requirements are relatively low compared to Pemali River’s water availability. However, in certain months (from June to October) and in certain occasions such as Land Preparation phases, water requirements are recorded to be a little bit higher.
Table 1 shows the recap of all of the alternatives which has the least water requirements for each cropping patterns. This recap shows the water requirements of DI Pemali Kanan whose area is 7,788 hectare when conventional irrigation is applied. Figure 3 and Figure 4 show the comparison of water requirements (when conventional irrigation is applied) to both dependable existing debit and generated debit. For generated debit, year 2035 is taken as the example since it is the year in which the generated debit has the least average among others.

Table 1. Recap of Conventional Irrigation Water Requirements

| No. | CULTIVATION | JAN | FEB | MAR | APR | MAY | JUN | JUL | AGT | NOV | DEC |
|-----|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1   | PADDY (PD)  | 0.00| 0.00| 0.00| 0.00| 0.00| 0.00| 0.00| 0.00| 0.00| 0.00|
| 2   | CORN (CR)   | 0.00| 0.00| 0.00| 0.00| 0.00| 0.00| 0.00| 0.00| 0.00| 0.00|
| 3   | SOY BEAN (SB)| 0.00| 0.00| 0.00| 0.00| 0.00| 0.00| 0.00| 0.00| 0.00| 0.00|
| 4   | LAND PREPARATION (LP) | 0.00| 0.00| 0.00| 0.00| 0.00| 0.00| 0.00| 0.00| 0.00| 0.00|

KETERANGAN:
- PADDY (PD)
- CORN (CR)
- SOY BEAN (SB)
- LAND PREPARATION (LP)
- FALLOW

Figure 3. Comparison of Water Requirement (Conventional) to Existing Debit

Figure 4. Comparison of Water Requirement (Conventional) to Generated Debit

Meanwhile, the further calculation done regarding to intermittent irrigation shows that the proper implementation of intermittent-irrigation technique could save irrigation water to a remarkable number.
During land preparation period, intermittent irrigation could save up to 25.81% irrigation water. In cultivating period, this irrigation technique could help farmers to save irrigation water up to 37.54%. The recap of intermittent-irrigation water requirements is shown in **Table 2**.

**Table 2. Recap of Intermittent-Irrigation Water Requirements**

| No. | CULTIVATION | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|-----|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1   | DI Pemali Kanan | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 |
| 2   | DI Pemali Kanan | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 |
| 3   | DI Pemali Kanan | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 |
| 4   | DI Pemali Kanan | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 |
| 5   | DI Pemali Kanan | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 |

**Figure 5** and **Figure 6** show that water requirement in which intermittent-irrigation technique is applied tends to be lower than the ones with conventional irrigation. Those figures show that 2035-debit, which has the lowest average, sometimes is incapable of supplying the entire DI Pemali Kanan area. As shown in **Figure 4** and **Figure 6**, even when intermittent-irrigation is applied, there are still spots (representing certain 2-weekly periods) where the Pemali Kanan’s debit are lower than its water requirements. From these facts, there are two conclusions. The first is that even though water requirements of DI Pemali Kanan is too low compared to Pemali river’s debit, in certain 2-weekly periods, Pemali river’s debit is somehow lower and inadequate to supply the entire DI Pemali Kanan. That would need a special treatments related to both cropping patterns and water supplies. Even when intermittent-irrigation technique is applied and water requirement is lower than it used to be, in certain period, this low-debit circumstances has successfully triggered complaint from farmers regarding to water supplies in their farm land.

**Figure 5.** Comparison Water Requirement (Intermittent) to Existing Debit

**Figure 6.** Comparison of Water Requirement (Intermittent) to Generated Debit (2035)

The second thing to consider is that in Pemali Kanan Irrigation Area due to its low water availability, it is not recommended to grow paddy within dry seasons which lasts from Juni to October or what so called 3rd-planting-season. Farmers is highly recommended to grow other kind of plants whose water requirement is lower than paddy (e.g corn or soy bean).
3.3. Farmers Opinion

Based on the questionnaires, as shown in Figure 7, it can be discovered that 24 out of 35 respondents (equal to 68.57%) prefer the System of Rice Intensification (SRI) method than the conventional farming method. Most of respondents are familiar with this System of Rice Intensification (SRI) so that they could give an objective preference regarding this option. They prefer to choose System of Rice Intensification (SRI) as they think that this advanced farming method has some visible advantages, such as: better quality and higher yields, more efficient in terms of irrigation-water consumption and less seeds needed. All of those advantages are considered to have positive impact to their productivity and surely would also give more benefits (especially in terms of financial aspects) to farmers.

![Figure 7. Farmers' Farming Method Preference](image)

As shown in Figure 8, beside of its greater productivity and better quality, efficiency in water consumption has successfully attracted farmers to choose SRI as their method to grow paddy. Not less than 83% of respondents thought that it becomes more difficult to obtain a stable and adequate amount of irrigation water. Therefore, in addition to gain more financial benefit, farmers also consider more efficient ways in order to cut their expenses.

However, although farmers have recognized that System of Rice Intensification (SRI) method is more suitable, more efficient, more profitable and more environmentally friendly, they decide to return to conventional farming method as there are many factors that made System of Rice Intensification (SRI) seems to be difficult to implement.

![Figure 8. Farmers' Opinion on SRI Method](image)

![Figure 9. Farmers’ opinion on SRI Method's Disadvantages](image)
As shown in Figure 9, among 7 factors that could possibly be the most anticipated by farmers, lack of skilled agricultural-labourers is the factor that could be the one which cause that farmers to switch from System of Rice Intensification (SRI) method to conventional farming method which they have applied over the last decades. By this point, the question of why farmers No. longer implementing the System of Rice Intensification (SRI) method has found the answer. Shortage of skilled agricultural labourers has become more reasonable since in the System of Rice Intensification (SRI) method, there are techniques that require special skills and personal ability.

4. Conclusion
In the end, the result of this study shows that water availability of Pemali River should be more than adequate to fulfill water requirement of crops at Pemali Kanan Irrigation Area, either at present or in the next 20 years. Only in certain months, which are June to October, and in certain years, the water availability is lower than water requirement of Pemali Kanan Irrigation Area. This situation will cause some of the farm lands will not get water supply in such an adequate amount.

Water requirements of all 13 cropping patterns are varied, with a maximum number of 28,31 m³/sec which took place in October II in Land Preparation phase. The average water requirement of all 13 cropping pattern is 6,41 m³/sec. Among all 13 cropping patterns along with their 24 commencement alternatives, formation of paddy – onions – soy bean is considered as the best cropping pattern in terms of water consumption since it has the least average of water requirement (5,60 m³/sec).

Related to the huge amount of water availability of Pemali River, The Government of Brebes Regency should consider the best way to utilize that potentials so that surplus of water could be useful during dry season (which lasts from June to October) when water availability of Pemali Kanan river is not capable to supply the entire field, especially the northern area of Brebes Regency.

Regarding the farming method, SRI method, specifically the intermittent irrigation technique, is proven to be suitable to be implemented in dry seasons. The farmers have realized that SRI Method offers many advantages compared to conventional farming method. Those farmers also had experienced in applying SRI Method in the past. However, nowadays due to many obstacles in SRI Method (e.g. lack of skilled agricultural-labourers and expensive organic fertilizer), they decide to go back to conventional farming method. The government agencies should consider ways to build farmers’ awareness to start implementing farming methods which are more environmentally-friendly such as SRI method. Furthermore, supports from the Government of Brebes Regency in various ways could provide confidence to farmers to implement such a new farming methods.

References
[1] Sumarno, Wargiono J, Kartasasmita U G, Hasanudin A, Soejitno, Ismail I G 2008 Anomali Iklim 2006/2007 dan Saran Kebijakan Teknis Pencapaian Target Produksi Padi Jurnal Iptek Tanaman Pangan, 3(1), 69-97
[2] Nurrochmad F 2007 Kajian Pola-Hemat Pemberian Air Irigasi Forum Teknik Sipil 12(2) 517-529
[3] Suara Merdeka News 2018 25.180 Ha Lahan Pertanian di Brebes Rawan Kekeringan able to access at https://www.suaramerdeka.com/news/baca/104507/25180-ha-lahan-pertanian-di-brebes-rawan-kekerengan.
[4] Bupati Brebes 2017 Peraturan Bupati Brebes nomor 080 tahun 2017 tentang Pedoman Pengaturan Pola Tanam dan Tata Tanam di Kabupaten Brebes 2017-2018 (Brebes, Central Java)
[5] Sato S, Hasan M 2007 Water Saving for Paddy Cultivation Under The System of Rice Intensification (SRI) in Eastern Indonesia Jurnal Tanah dan Lingkungan, 9(2), 57-62
[6] Sato S, Yamaji E, Kuroda T 2011 Strategies and engineering adaptations to disseminate SRI methods in large-scale irrigation systems in Eastern Indonesia Paddy Water Environ, 9, 79-88
[7] Syam M 2006 Kontroversi System of Rice Intensification (SRI) di Indonesia Jurnal Iptek Tanaman Pangan, 1, 30-40
[8] Balitbang Pertanian 2015, Panduan Teknologi Budidaya Padi System of Rice Intensification
Regazzoni O, Sugito Y, Suryanto A 2013 Irigasi Berselang (Intermittent Irrigation) pada Budidaya Padi (Oryza Sativa L.) Varietas Inpari-13 dalam Pola SRI (System of Rice Intensification) *Jurnal Produksi Pertanian*, 1(2), 42-51

Puteriana S A, Haruseno D, Prayogo T B 2016 Kajian Sistem Pemberian Air Irrigasi Metode Konvensional dan Metode SRI (System of Rice Intensification) pada Daerah Irigasi Pakis Kecamatan Pakis Kabupaten Malang *Jurnal Teknik Pengairan*, 7(2), 236-247

PT. Yodya Karya 2010 *Laporan Detail Desain Rehabilitasi DI Pemali Kanan (7.909 ha)* (Semarang).

Pratiwi, B S, Sachro S S, Suharyanto 2017 Pembangkitan Data Debit dan Skenario Pola Tanam Daerah Irigasi Embung Suruhan *Media Komunikasi Teknik Sipil*, 23 (1), 29-37

Chahayati C, Sutrisno 2014 Pengaruh Debit Air terhadap Pola Tanam pada Baku Sawah di Daerah Irigasi Kebonagung Kabupaten Sumenep Jurnal MITSU *Media Informasi Teknik Sipil UNIJA*, 2(2), 30-39