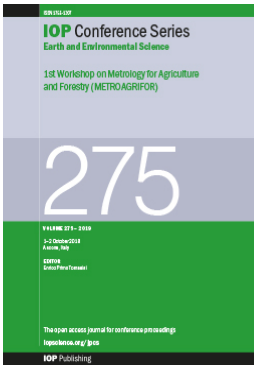

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IOP Conference Series: Earth and Environmental Science
doi: 10.1088/issn.1755-1315
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Functional design of smart evaporative irrigation for *mina-padi* system in Indonesia

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Citation C Arif *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **622** 012052

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https://doi.org/10.1088/1755-1315/622/1/012052

Abstract

The smart evaporative irrigation is offered as an appropriate option in regulating irrigation water more effective. Smart means the system of irrigation is automatically controlled by a floating ball valve based on evaporation and evapotranspiration rate without electrical power. The objective was to evaluate the functional design of the evaporative irrigation on water demand aspect particularly for Mina-padi (paddy–fish farming). The system was evaluated based on the experimental field in the lab-scale since 10 July 2020. There were three irrigation regimes, i.e., continuous flooded (CR), wet (WR), and dry (LR) regimes. During the vegetative growth stage, the smart evaporative irrigation worked well. The irrigation was supplied by a floating ball valve automatically according to the evapotranspiration rate. The actual water levels were well kept and fitted to the setpoint as indicated by low mean absolute error (MAE). The CR regime needs more irrigation water and evaporated more water through the evapotranspiration process. Its rate was highest ranged between 5.81 – 6.6 mm/day. On the other hand, the LR regime has the lowest evapotranspiration rate in between 1.65 – 4.09 mm/day. The irrigation control system became crucial for control the evapotranspiration rate in which less irrigation water evaporate less water.

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PUBLISHER

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PUBLICATION TYPE

Conferences and Proceedings

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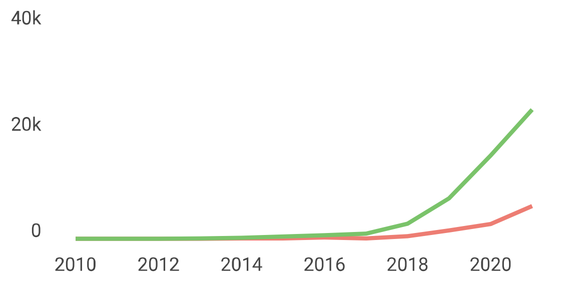

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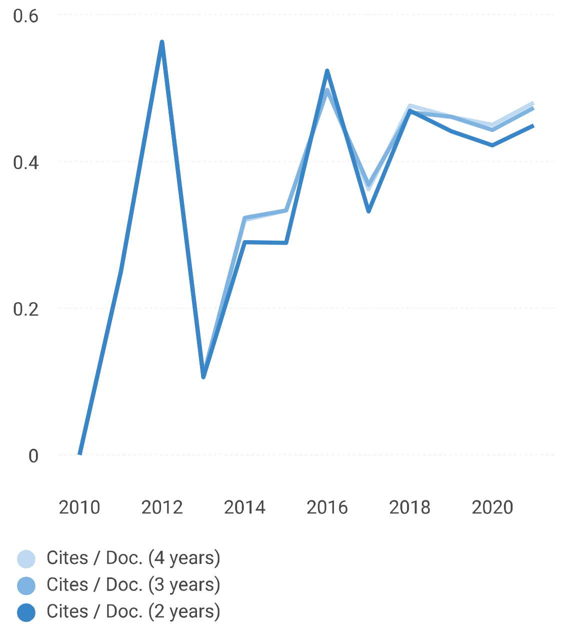

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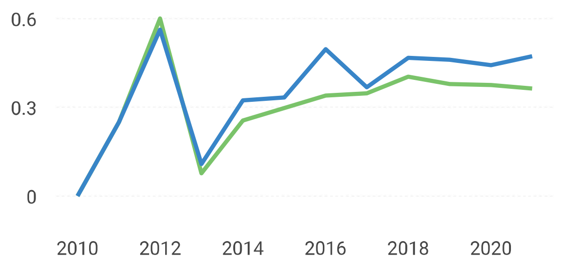

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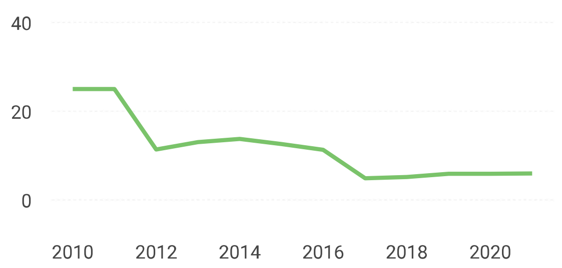

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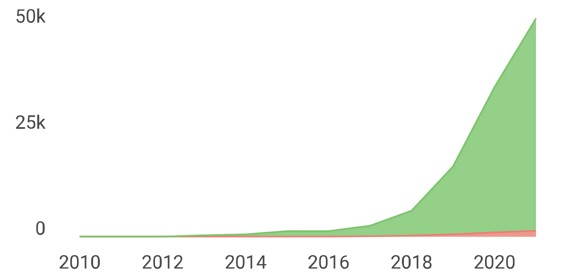

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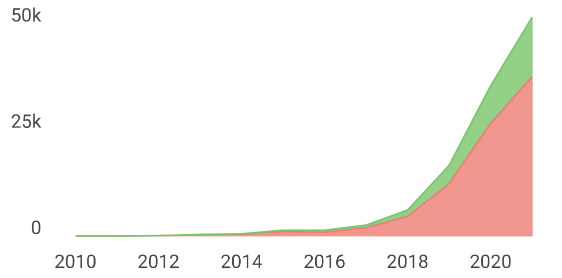

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Functional design of smart evaporative irrigation for *mina-padi* system in Indonesia

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Functional design of smart evaporative irrigation for *mina-padi* system in Indonesia

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Abstract. The smart evaporative irrigation is offered as an appropriate option in regulating irrigation water more effective. Smart means the system of irrigation is automatically controlled by a floating ball valve based on evaporation and evapotranspiration rate without electrical power. The objective was to evaluate the functional design of the evaporative irrigation on water demand aspect particularly for Mina-padi (paddy–fish farming). The system was evaluated based on the experimental field in the lab-scale since 10 July 2020. There were three irrigation regimes, i.e., continuous flooded (CR), wet (WR), and dry (LR) regimes. During the vegetative growth stage, the smart evaporative irrigation worked well. The irrigation was supplied by a floating ball valve automatically according to the evapotranspiration rate. The actual water levels were well kept and fitted to the setpoint as indicated by low mean absolute error (MAE). The CR regime needs more irrigation water and evaporated more water through the evapotranspiration process. Its rate was highest ranged between 5.81 – 6.6 mm/day. On the other hand, the LR regime has the lowest evapotranspiration rate in between 1.65 – 4.09 mm/day. The irrigation control system became crucial for control the evapotranspiration rate in which less irrigation water evaporate less water.

1. Introduction

As the main crop in Indonesia, rice is cultivated in the largest area of agriculture. The extent of paddy fields is recorded at 7.4 million ha in 2019. Paddy field is known as the highest agricultural water consumption because flooding irrigation is commonly used by the farmers. However, this method does not always have a linear correlation to the increasing in rice yield [1]. Previous studies in Indonesia showed flooding irrigation reduced 28% of yield compared to water-saving irrigation with the *System of Rice Intensification* [2]. Also, percolation, seepage, and runoff increased and caused losses of water [3, 4, 5].

To apply effective water used, some farmers combine rice cultivation to fish farming. This method is known as *mina-padi* (paddy-fish farming). Actually, this farming has been known a long time ago and provides carbohydrates and protein simultaneously. Also, this farming also provides many socio-economic benefits [6, 7]. A specific study in Yogyakarta province showed this farming increased farmers' income significantly; thus, it became the main factor to be adopted [8]. However, the system is known as wasteful in water used since more water is supplied in the system. Due to climate change and increasing of industrialization in Indonesia, water resources for agricultural use have become scarcer and limited, particularly in the dry season. Extreme drought occurred, so crop failure threat some paddy areas in Indonesia. Therefore, saving more irrigation water became urgent and are needed for sustainable rice farming in Indonesia.

In 2019, an evaporative irrigation idea was introduced as one alternative to water-saving irrigation [9]. This idea controls water supply by irrigation floating ball valve based on evaporation and evapotranspiration rate. This system doesn't need electrical power to regulate the valve because it works automatically at a particular water level. So, it is called a "smart" system. However, there is no study reported evaluating this system yet. The objective of the study was to evaluate the functional design of the evaporative irrigation for paddy-fish farming with a closed system, particularly in the water demand aspect. The scope of evaluation aspects consisted of comparison actual water level and setpoint, the evapotranspiration rate of different irrigation schemes by performing water balance analysis.

2. Methodology

2.1. Field Design and Experiments

The evaporative irrigation was designed by adopting a closed system (recirculate water irrigation) as shown in Figure 1. Irrigated water was stored in a water tank and then supplied automatically to the field experiments by a floating ball valve. Water drainage from the field was drained to the fish pond. Three water regimes were set in this experiment; they are continuous flooded (CR), wet regime (WR), and dry regime (LR). The CR was set as a control treatment in which standing water (2 cm) was expecting during all days experiment. This regime is commonly applied by the farmers in Indonesia and known as conventional practice. WR was set as a moderate regime in which the water level was kept at the soil surface (0 cm) during the experiment. Meanwhile, LR was known as water-saving irrigation in which water level was kept 0 cm (at the soil surface) during 0-20 days after transplanting, and then water level was maintained at -5 cm (at 5 cm under the soil surface).

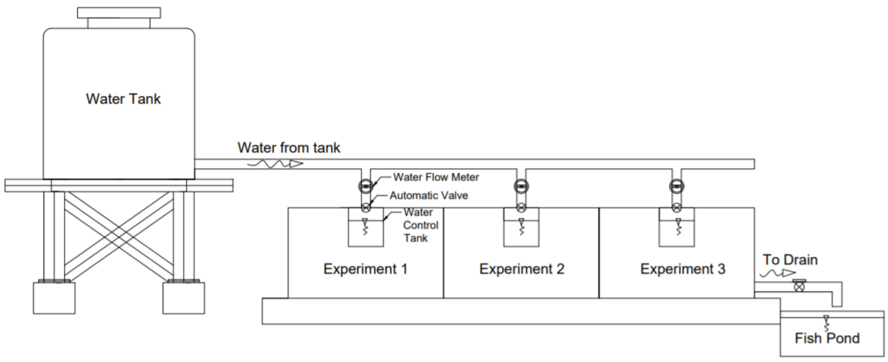


Figure 1. Design of the evaporative irrigation for paddy-fish farming by adopting a closed system.

The experiment was started on 10 July 2020 at the Kinjiro Farm located in Bogor, West Java, Indonesia. For rice farming, we adopted *the System of Rice Intensification* (SRI) elements, such as young seedling (14 days sowing), wider spacing (30 x 30 cm^2), and single transplanting in each hill [10]. In addition, we used some sensors and data loggers to collect the field data. They are consisted of weather sensors to collect rain and reference evapotranspiration (ETo), water level, and soil moisture sensors. Each sensor was set in 15 minutes interval, and all data were stored in the data loggers. Weather sensors consisted of air temperature and humidity sensor, rain gauge, solar radiation sensor, wind speed, and direction sensor. Reference crop evapotranspiration was determined by the Penman-Monteith model as FAO's standard model [11]. In addition, irrigation and drainage were measured by the water meter.

2.2. Water Balance Analysis

The water balance was performed in each regime on a daily basis by the following equation:

$$h(t + \Delta t) = h(t) + \Delta h \quad (1)$$

$$\frac{\Delta h}{\Delta t} = (R - RO - ET) \pm Q \pm S \quad (2)$$

Where, h is water level (in mm), Δh is the change of water level (in mm), R is rainfall (in mm), RO is runoff (in mm), ET is actual evapotranspiration (in mm), Q is irrigation/drainage (in mm), S is seepage (in mm), t is time (day).

This analysis was performed to determine ET in each water regime, and then compare the results among the regimes. Also, total water balance components were compared among the regimes. The evapotranspiration rate was determined according to the accumulative evapotranspiration. This accumulative was plotted to the graph and then fitted with the third-order polynomial equation by the following:

$$Y = ax^3 + bx^2 + cx + d \quad (3)$$

Y is accumulative evapotranspiration, x is time (day), and a, b, c and d are constant. The evapotranspiration rate was then calculated based on the first derivative of Equation 3.

2.3. Evaluation of evaporative irrigation

The effectiveness of the evaporative irrigation was determined by mean absolute error (MAE) by the following equation:

$$MAE = \frac{1}{N}\sum_{i=1}^{N} |WL_o - WL_{set}| \quad (4)$$

Where WL_o is observed water level (in cm), WL_{set} is the expected water level (setpoint) (in cm), N is the number of data. MAE is known as dimensioned evaluations showing the average error of the observed and expected data. It is appropriately used in climate and natural science applications and has an advantage, more realistic average error measure, and unambiguous like root mean square error (RMSE) [12].

2.4. Limitation of study

The current study only presented the hydrological aspect of the evaporative irrigation, including its performance. The analysis was limited in the vegetative plant growth phase (0-50 days after transplanting). Plant and fish growth performances, including yield in each irrigation regime, were planned for the next phase of the study.

3. Results and Discussion

3.1. Actual Field Condition

The actual and expected (setpoint) water levels were presented in Figure 2. In some days, the actual water level was fitted to the setpoint for all regimes. In the early vegetative stage (10 days), the CR regime's water level was easier maintained than two other regimes. The average actual water level was 2.05 cm above the soil surface. On the other hand, the water level in both the WR and LR regimes fluctuated, and the averages were 1.04 cm and 0.47 cm, respectively. The system worked well as indicated closer values between actual and setpoint in all regimes on the late vegetative stage (35-45 days after transplanting). The average WL values were 1.8 cm, 0.54 cm, and -5.59 cm for the CR, WR, and LR regimes, respectively. It was indicated the system worked well when no rain event occurred.

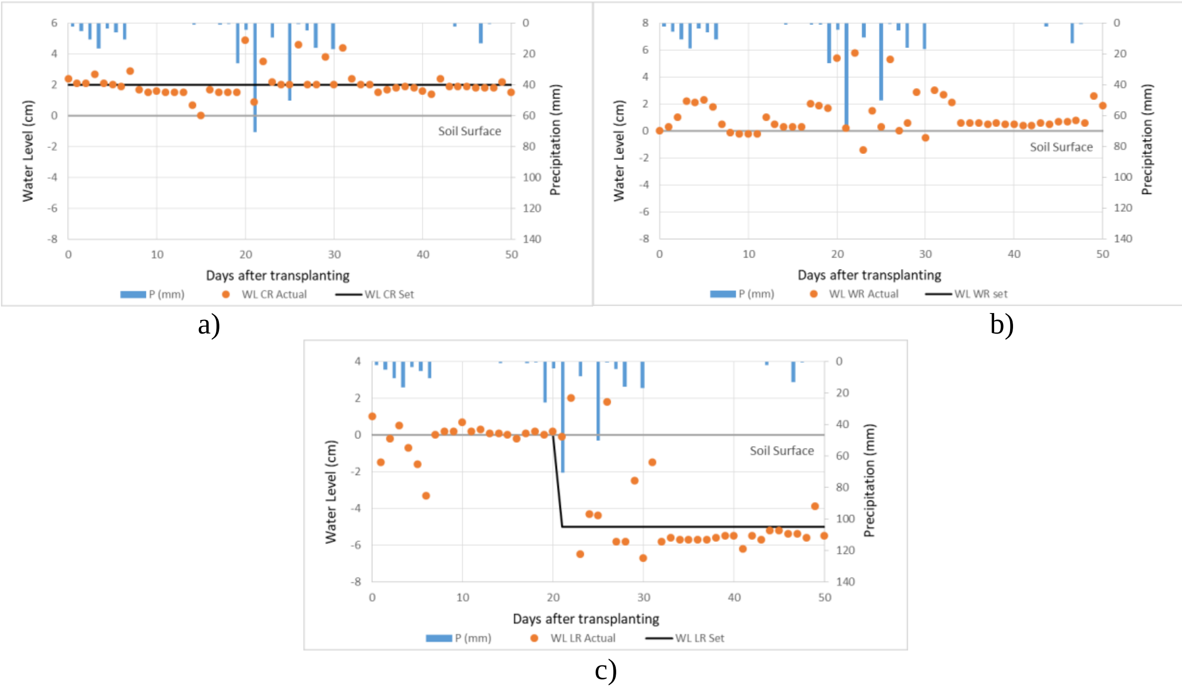


Figure 2. Actual field condition during the vegetative growth phase: a) CR regime, b) WR regime, c) LR regime

Table 1. Performance of the water control system by the evaporative irrigation

	MAE (cm)		
Event	CR	WR	LR
Rainfall Event	0.543	1.514	1.219
No Rainfall	0.537	1.097	0.883
All days	0.539	1.269	1.022

However, the evaporative irrigation was seemingly not working well on the rainy days for all regimes. The water level increased dramatically when heavy rain occurred. During rainy days, MAE values were higher than those during sunny days for all irrigation treatments (Table 1). Similar results were also found by a previous study that error was significantly increased during rainy days [13]. Although using a fuzzy control system, the water level increased incredibly as well as the error during rainy days. It showed the control system automatically by both the controller machine and the evaporative system was less effective in the rainy days. It is recommended to control the drainage rate, such as applying a subsurface drainage system [14]; thus, the water level can be well maintained in the rainy days. Overall, the evaporative irrigation was satisfactorily applied indicated low MAE (< 1.3 cm) for all regimes.

3.2. Water Balance Components

Table 2 showed water balance components in all irrigation regimes. It was clear that the CR regime needs more water irrigation, among others. It was about 1.01% and 24.62% higher than those of the WR and LR regimes, respectively. The difference in water irrigation between the CR and WR regimes indicated the WR was less effective in water use due to more water drained in this regime. The same case also occurred in the LR regime. . It was recorded the regimes drained 26.4% and 25.2% higher than that of the CR regime. In addition, the LR regime contributed more water losses by seepage and drainage. The seepage happened because there was a leak in this experimental plot as well as uncounted water.

Table 2. Water balance component of each irrigation regime.

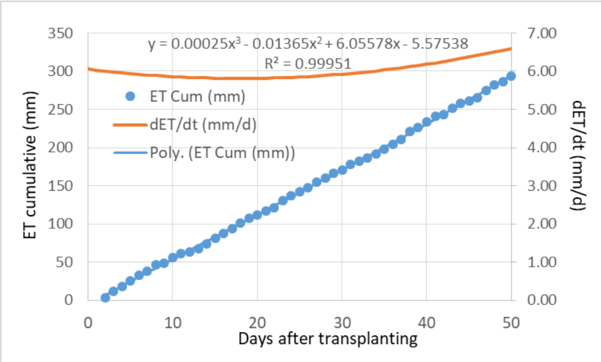
	Water regime		
Components	CR	WR	LR
Rainfall (mm)	269.4	269.4	269.4
Irrigation (mm)	325.4	322.1	245.3
Drainage (mm)	284.0	386.0	379.8
Evapotranspiration (mm)	314.8	212.5	126.9
Seepage (mm)	0.0	0.0	48.0
Uncounted water (mm)	4.0	7.0	40.0

According to Table 2, water losses through drainage and seepage contributed 47.75%, 65.26%, and 83.12% of inflow for the CR, WR, and LR regimes, respectively. As previously mention that the water irrigation was supplied according to the evapotranspiration rate operated by the floating ball valve; thus, most of the water losses from the rainfall. The total evapotranspiration in the CR regime was highest than in other regimes. The regime evaporated water through evaporation and transpiration of 32.50% and 59.69% higher. The total evapotranspiration in this regime was 314.8 mm, while other regimes were 212.5 mm and 126.9 mm for the WR and LR regimes, respectively. It was pointed out that standing water contributed more water loss by evaporation and evapotranspiration. Similar results also showed a previous study [15] that reported continuous flooding increased significant evaporation, particularly in the dry season.

3.3. Evapotranspiration rate

The cumulative evapotranspiration was fitted by the third-order polynomial equation, as showed in Figure 3. The coefficient determination (R^2) in all regimes were high (> 0.9), and the model can be accepted. According to the Equation, the evapotranspiration rate was well determined. It was clear that the evapotranspiration rate in the CR regime was highest. The evapotranspiration rate was ranged between 5.81 – 6.6 mm/day. On the other hand, the LR regime evaporated water at the lowest rate. The interval was 1.65 – 4.09 mm/day. Meanwhile, the WR regime's evapotranspiration rate reached a moderate level ranged in between of 3.49 – 5.01 mm/day.

The trend of the evapotranspiration rate among the regimes was quite different. The CR regime showed a raised rate, particularly after 20 days. For the WR and LR regimes, the maximum rate occurred in the early vegetative stage. The WR regime’s trend showed a decreasing rate until the end of the stage, while the LR regime showed a rising movement after 30 days (Figure 3). Under the same climate, available water became the main factor that affected the evaporation rate from the field. The current study showed that less irrigation water decreased the evapotranspiration rate. Therefore, the irrigation control system became key to control evapotranspiration [16].



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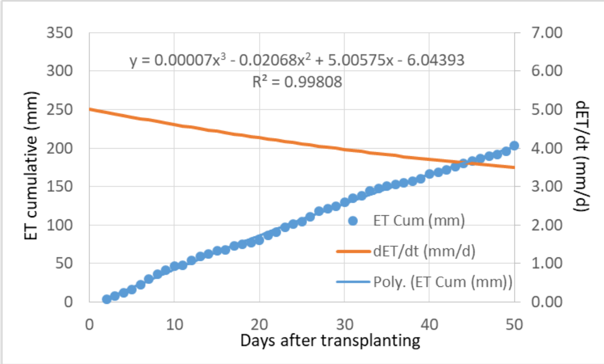

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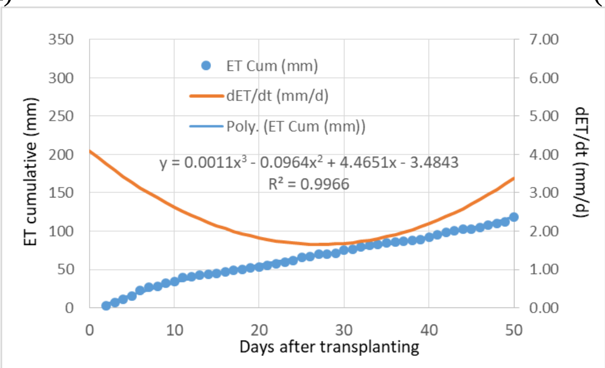

(c)

Figure 3. Cumulative evapotranspiration and evapotranspiration rate among the regimes: a) CR regime, b) WR regime, c) LR regime

4. Conclusion

The developed smart evaporative irrigation worked properly for *Mina-padi* farming in Indonesia. The indicator was by low mean absolute error (MAE) on three water irrigation regimes, namely: continuous flooded (CR), wet (WR), and dry (LR) regimes. Based on water balance analysis, the LR regime needs less water compared to those CR and WR regime. Also, the LR regime has the lowest evapotranspiration rate in between 1.65 – 4.09 mm/day. It is essential for further study to observe plant and fish growth under different water irrigation regimes and evapotranspiration rates.

Acknowledgments

The current study was fully funded by the Ministry of Research and Technology/National Research and Innovation Agency under research project with the title “Developing Smart Evaporative Irrigation for Precision Farming with more Environmental Friendly by using Artificial Intelligence” according to contract number of 2521/IT3.L.1/PN/2020.

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Functional design of smart evaporative irrigation for mina-padi system in Indonesia

by Ardiansyah Ardiansyah

IOP Conference Series: Earth and Environmental Science

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To cite this article: C Arif *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **622** 012052

IOP Conf. Series: Earth and Environmental Science **622** (2021) 012052 doi:10.1088/1755-1315/622/1/012052

Functional design of smart evaporative irrigation for *mina-padi* system in Indonesia

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Abstract. The smart evaporative irrigation is offered as an appropriate option in regulating irrigation water more effective. Smart means the system of irrigation is automatically controlled by a floating ball valve based on evaporation and evapotranspiration rate without electrical power. The objective was to evaluate the functional design of the evaporative irrigation on water demand aspect particularly for Mina-padi (paddy–fish farming). The system was evaluated based on the experimental field in the lab-scale since 10 July 2020. There were three irrigation regimes, i.e., continuous flooded (CR), wet (WR), and dry (LR) regimes. During the vegetative growth stage, the smart evaporative irrigation worked well. The irrigation was supplied by a floating ball valve automatically according to the evapotranspiration rate. The actual water levels were well kept and fitted to the setpoint as indicated by low mean absolute error (MAE). The CR regime needs more irrigation water and evaporated more water through the evapotranspiration process. Its rate was highest ranged between 5.81 – 6.6 mm/day. On the other hand, the LR regime has the lowest evapotranspiration rate in between 1.65 – 4.09 mm/day. The irrigation control system became crucial for control the evapotranspiration rate in which less irrigation water evaporate less water.

1. Introduction

As the main crop in Indonesia, rice is cultivated in the largest area of agriculture. The extent of paddy fields is recorded at 7.4 million ha in 2019. Paddy field is known as the highest agricultural water consumption because flooding irrigation is commonly used by the farmers. However, this method does not always have a linear correlation to the increasing in rice yield [1]. Previous studies in Indonesia showed flooding irrigation reduced 28% of yield compared to water-saving irrigation with the *System of Rice Intensification* [2]. Also, percolation, seepage, and runoff increased and caused losses of water [3, 4, 5].

To apply effective water used, some farmers combine rice cultivation to fish farming. This method is known as *mina-padi* (paddy-fish farming). Actually, this farming has been known a long time ago and provides carbohydrates and protein simultaneously. Also, this farming also provides many socio-economic benefits [6, 7]. A specific study in Yogyakarta province showed this farming increased farmers' income significantly; thus, it became the main factor to be adopted [8]. However, the system is known as wasteful in water used since more water is supplied in the system. Due to climate change and increasing of industrialization in Indonesia, water resources for agricultural use have become scarcer

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and limited, particularly in the dry season. Extreme drought occurred, so crop failure threat some paddy areas in Indonesia. Therefore, saving more irrigation water became urgent and are needed for sustainable rice farming in Indonesia.

In 2019, an evaporative irrigation idea was introduced as one alternative to water-saving irrigation [9]. This idea controls water supply by irrigation floating ball valve based on evaporation and evapotranspiration rate. This system doesn't need electrical power to regulate the valve because it works automatically at a particular water level. So, it is called a "smart" system. However, there is no study reported evaluating this system yet. The objective of the study was to evaluate the functional design of the evaporative irrigation for paddy-fish farming with a closed system, particularly in the water demand aspect. The scope of evaluation aspects consisted of comparison actual water level and setpoint, the evapotranspiration rate of different irrigation schemes by performing water balance analysis.

2. Methodology

2.1. Field Design and Experiments

The evaporative irrigation was designed by adopting a closed system (recirculate water irrigation) as shown in Figure 1. Irrigated water was stored in a water tank and then supplied automatically to the field experiments by a floating ball valve. Water drainage from the field was drained to the fish pond. Three water regimes were set in this experiment; they are continuous flooded (CR), wet regime (WR), and dry regime (LR). The CR was set as a control treatment in which standing water (2 cm) was expecting during all days experiment. This regime is commonly applied by the farmers in Indonesia and known as conventional practice. WR was set as a moderate regime in which the water level was kept at the soil surface (0 cm) during the experiment. Meanwhile, LR was known as water-saving irrigation in which water level was kept 0 cm (at the soil surface) during 0-20 days after transplanting, and then water level was maintained at -5 cm (at 5 cm under the soil surface).

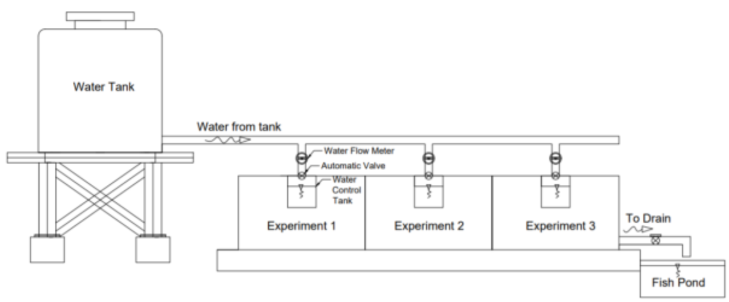


Figure 1. Design of the evaporative irrigation for paddy-fish farming by adopting a closed system.

The experiment was started on 10 July 2020 at the Kinjiro Farm located in Bogor, West Java, Indonesia. For rice farming, we adopted *the System of Rice Intensification* (SRI) elements, such as young seedling (14 days sowing), wider spacing (30 x 30 cm^2), and single transplanting in each hill [10]. In addition, we used some sensors and data loggers to collect the field data. They are consisted of weather sensors to collect rain and reference evapotranspiration (ETo), water level, and soil moisture sensors. Each sensor was set in 15 minutes interval, and all data were stored in the data loggers. Weather sensors consisted of air temperature and humidity sensor, rain gauge, solar radiation sensor, wind speed, and direction sensor. Reference crop evapotranspiration was determined by the Penman-Monteith model as FAO's standard model [11]. In addition, irrigation and drainage were measured by the water meter.

2.2. Water Balance Analysis
The water balance was performed in each regime on a daily basis by the following equation:

$$h(t + \Delta t) = h(t) + \Delta h \quad (1)$$
$$\frac{\Delta h}{\Delta t} = (R - RO - ET) \pm Q \pm S \quad (2)$$

Where, h is water level (in mm), Δh is the change of water level (in mm), R is rainfall (in mm), RO is runoff (in mm), ET is actual evapotranspiration (in mm), Q is irrigation/drainage (in mm), S is seepage (in mm), t is time (day).

This analysis was performed to determine ET in each water regime, and then compare the results among the regimes. Also, total water balance components were compared among the regimes. The evapotranspiration rate was determined according to the accumulative evapotranspiration. This accumulative was plotted to the graph and then fitted with the third-order polynomial equation by the following:

$$Y = ax^3 + bx^2 + cx + d \quad (3)$$

Y is accumulative evapotranspiration, x is time (day), and a, b, c and d are constant. The evapotranspiration rate was then calculated based on the first derivative of Equation 3.

2.3. Evaluation of evaporative irrigation
The effectiveness of the evaporative irrigation was determined by mean absolute error (MAE) by the following equation:

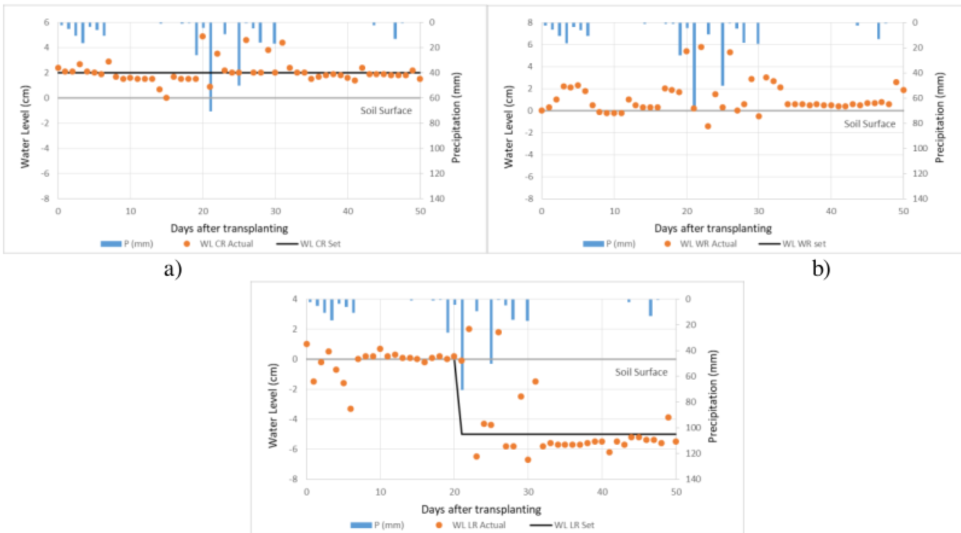
$$MAE = \frac{1}{N}\sum_{i=1}^{N} |WL_o - WL_{set}| \quad (4)$$

Where WL_o is observed water level (in cm), WL_{set} is the expected water level (setpoint) (in cm), N is the number of data. MAE is known as dimensioned evaluations showing the average error of the observed and expected data. It is appropriately used in climate and natural science applications and has an advantage, more realistic average error measure, and unambiguous like root mean square error (RMSE) [12].

2.4. Limitation of study
The current study only presented the hydrological aspect of the evaporative irrigation, including its performance. The analysis was limited in the vegetative plant growth phase (0-50 days after transplanting). Plant and fish growth performances, including yield in each irrigation regime, were planned for the next phase of the study.

3. Results and Discussion

3.1. Actual Field Condition
The actual and expected (setpoint) water levels were presented in Figure 2. In some days, the actual water level was fitted to the setpoint for all regimes. In the early vegetative stage (10 days), the CR regime's water level was easier maintained than two other regimes. The average actual water level was 2.05 cm above the soil surface. On the other hand, the water level in both the WR and LR regimes fluctuated, and the averages were 1.04 cm and 0.47 cm, respectively. The system worked well as indicated closer values between actual and setpoint in all regimes on the late vegetative stage (35-45 days after transplanting). The average WL values were 1.8 cm, 0.54 cm, and -5.59 cm for the CR, WR, and LR regimes, respectively. It was indicated the system worked well when no rain event occurred.



a) b)

c)

Figure 2. Actual field condition during the vegetative growth phase: a) CR regime, b) WR regime, c) LR regime

Table 1. Performance of the water control system by the evaporative irrigation

Event	MAE (cm)		
	CR	WR	LR
Rainfall Event	0.543	1.514	1.219
No Rainfall	0.537	1.097	0.883
All days	0.539	1.269	1.022

However, the evaporative irrigation was seemingly not working well on the rainy days for all regimes. The water level increased dramatically when heavy rain occurred. During rainy days, MAE values were higher than those during sunny days for all irrigation treatments (Table 1). Similar results were also found by a previous study that error was significantly increased during rainy days [13]. Although using a fuzzy control system, the water level increased incredibly as well as the error during rainy days. It showed the control system automatically by both the controller machine and the evaporative system was less effective in the rainy days. It is recommended to control the drainage rate, such as applying a subsurface drainage system [14]; thus, the water level can be well maintained in the rainy days. Overall, the evaporative irrigation was satisfactorily applied indicated low MAE (< 1.3 cm) for all regimes.

3.2. Water Balance Components

Table 2 showed water balance components in all irrigation regimes. It was clear that the CR regime needs more water irrigation, among others. It was about 1.01% and 24.62% higher than those of the WR and LR regimes, respectively. The difference in water irrigation between the CR and WR regimes indicated the WR was less effective in water use due to more water drained in this regime. The same case also occurred in the LR regime. . It was recorded the regimes drained 26.4% and 25.2% higher than that of the CR regime. In addition, the LR regime contributed more water losses by seepage and

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drainage. The seepage happened because there was a leak in this experimental plot as well as uncounted water.

Table 2. Water balance component of each irrigation regime.

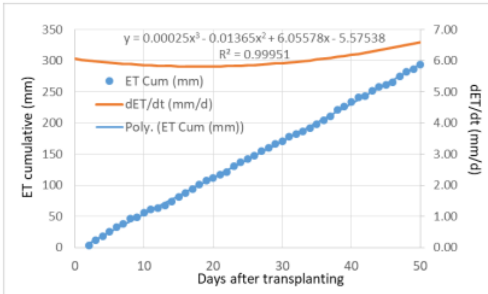
Components	Water regime		
	CR	WR	LR
Rainfall (mm)	269.4	269.4	269.4
Irrigation (mm)	325.4	322.1	245.3
Drainage (mm)	284.0	386.0	379.8
Evapotranspiration (mm)	314.8	212.5	126.9
Seepage (mm)	0.0	0.0	48.0
Uncounted water (mm)	4.0	7.0	40.0

According to Table 2, water losses through drainage and seepage contributed 47.75%, 65.26%, and 83.12% of inflow for the CR, WR, and LR regimes, respectively. As previously mention that the water irrigation was supplied according to the evapotranspiration rate operated by the floating ball valve; thus, most of the water losses from the rainfall. The total evapotranspiration in the CR regime was highest than in other regimes. The regime evaporated water through evaporation and transpiration of 32.50% and 59.69% higher. The total evapotranspiration in this regime was 314.8 mm, while other regimes were 212.5 mm and 126.9 mm for the WR and LR regimes, respectively. It was pointed out that standing water contributed more water loss by evaporation and evapotranspiration. Similar results also showed a previous study [15] that reported continuous flooding increased significant evaporation, particularly in the dry season.

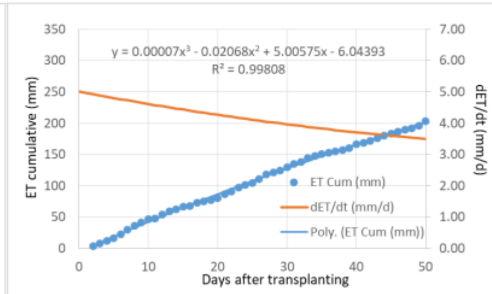
3.3. Evapotranspiration rate

The cumulative evapotranspiration was fitted by the third-order polynomial equation, as showed in Figure 3. The coefficient determination (R^2) in all regimes were high (> 0.9), and the model can be accepted. According to the Equation, the evapotranspiration rate was well determined. It was clear that the evapotranspiration rate 4 the CR regime was highest. The evapotranspiration rate was ranged between 5.81 – 6.6 mm/day. On the other hand, the LR regime evaporated water at the lowest rate. The interval was 1.65 – 4.09 mm/day. Meanwhile, the WR regime's evapotranspiration rate reached a moderate level ranged in between of 3.49 – 5.01 mm/day.

The trend of the evapotranspiration rate among the regimes was quite different. The CR regime showed a raised rate, particularly after 20 days. For the WR and LR regimes, the maximum rate occurred in the early vegetative stage. The WR regime's trend showed a decreasing rate until the end of the stage, while the LR regime showed a rising movement after 30 days (Figure 3). Under the same climate, available water became the main factor that affected the evaporation rate from the field. The current study showed that less irrigation water decreased the evapotranspiration rate. Therefore, the irrigation control system became key to control evapotranspiration [16].



(a)



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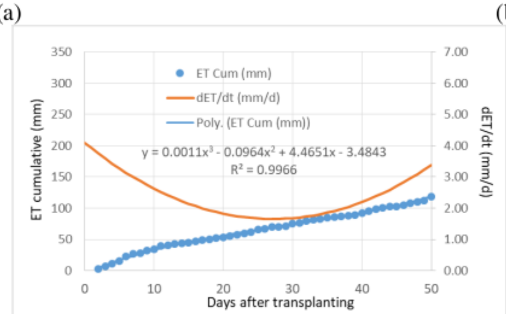

(c)

Figure 3. Cumulative evapotranspiration and evapotranspiration rate among the regimes: a) CR regime, b) WR regime, c) LR regime

4. Conclusion

The developed smart evaporative irrigation worked properly for *Mina-padi* farming in Indonesia. The indicator was by low mean absolute error (MAE) on three water irrigation regimes, namely: continuous flooded (CR), wet (WR), and dry (LR) regimes. Based on water balance analysis, the LR regime needs less water compared to those CR and WR regime. Also, the LR regime has the lowest evapotranspiration rate in between 1.65 – 4.09 mm/day. It is essential for further study to observe plant and fish growth under different water irrigation regimes and evapotranspiration rates.

Acknowledgments

The current study was fully funded by the Ministry of Research and Technology/National Research and Innovation Agency under research project with the title "Developing Smart Evaporative Irrigation for Precision Farming with more Environmental Friendly by using Artificial Intelligence" according to contract number of 2521/IT3.L.1/PN/2020.

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First day – Monday, November 2nd, 2020	
Time	**Activity**
08.00 – 09.00	Enter to Zoom Meeting and Preparation Opening and Greeting, MC: Ms. **Afu Vianti Driantika & Regina Apprilia Zulfikar**
09.00 – 09.05	Virtual National Anthem: **Indonesia Raya**
09.05 – 09.15	• Report from Chairperson of Steering Committee: **Dr. Ir. Nora H. Pandjaitan, DEA** • Welcoming Speech from Head of Department of Civil and Environmental Engineering: **Dr. Ir. Erizal, M. Agr., IPM** • Welcoming Speech from Dean of Faculty of Agricultural Engineering and Technology: **Prof. Kudang Boro Seminar**
09.15 – 09.30	Welcoming Speech and Official Opening by Rector of IPB University: **Prof. Arif Satria**
09.30 – 10.30	Keynote Speech: Innovation in Disaster Mitigation of Indonesia and Its Challenge (Head of BNPB: Letjend. **Doni Monardo**)
10.30 – 12.15	Invited Speech Panel session, Moderator: **Dr. Ir. Erizal, M.Agr., IPM** 1. Soil Improvement Technique for Liquefaction Prevention by **Prof. Hideaki Yasuhara** (Ehime University) 2. Environmental Recovery in Fukushima by **Prof. Masaru Mizoguchi** (Tokyo University) 3. Earthquake Risk Reduction in Asia by **Prof. Pennung Warnitchai** (Asian Institute of Technology)
12.15 – 13.15	Break
13.15 – 15.00	Parallel Sessions (ISCEE-1; ISCEE-2; ISCEE-3)
Second day – Tuesday, November 3rd, 2020	
Time	**Activity**
08.00 – 08.30	Enter to Zoom Meeting and Preparation Opening and Greeting, MC: **Ms. Afu Vianti Driantika & Regina Apprilia Zulfikar**
08.30 – 10.00	Invited Speech Panel session, Moderator: **Dr. Ir. Nora H. Pandjaitan, DEA** 1. Zero Runoff System by **Prof. Budi Indra Setiawan** (IPB University) **2.** Drainage Infrastructures for the Prevention of Flooding in Megacities by **Dr. Kamran Emami** (International Commission on Irrigation and Drainage, ICID)
10.00 – 10.15	Break
10.15 – 12.00	Parallel Sessions (ISCEE-1; ISCEE-3; ISCEE-5)
12.00 – 13.00	Break
13.00 – 15.00	Parallel Sessions (ISCEE-1; ISCEE-3; ISCEE-5)
Third day – Wednesday, November 4th, 2020	
Time	**Activity**
08.00 – 08.30	Enter to Zoom Meeting and Preparation Opening and Greeting, MC: Ms. **Afu Vianti Driantika & Regina Apprilia Zulfikar**
08.30 – 10.00	**Company Session,** Moderator: **Prof. Budi Indra Setiawan** and **Prof. Arief Sabdo Yuwono** 1. PT Teknindo Geosistem Unggul by **Azmi Lisani Wahyu, ST., MT** 2. PT Unilab Perdana
10.00 – 10.15	Break
10.15 – 12.00	Parallel Sessions (ISCEE-2; ISCEE-4)
12.00 – 12.15	Closing and Awarding

Parallel Session

First day – Monday, November 2nd, 2020

ZOOM Room A – ISCEE 1 *Disaster mitigation and adaptation; Risk management; Vulnerability Assessment*			
Chair **Co-Chair** **Assistant 1** **Assistant 2**	Dr. Yudi Chadirin, S.TP., M.Agr Titiek Ujianti, ST., MT Dandi Fauzi Rizkillah Muhammad Hilmi		
Time	**Paper ID**	**Presenter**	**Paper Title**
13.15 – 13.30	Enter to Zoom Meeting and Preparation		
13.30 – 13.45	ISCEE – 023	Minson Simatupang	Effectiveness of Lowering Saturation on Residual Shear Strength of Sand Stabilized with Fly-Ash
13.45 – 14.00	ISCEE – 028	Wahyu Gendam	Flood Risk Mapping of The Sukamahi Dam Failure With Overtopping Scenario
14.00 – 14.15	ISCEE – 004	Rian Mantasa S P	River engineering for flooding characteristics in the upper-stream part of Bengawan Solo sub-watershed
14.15 – 14.30	ISCEE – 005	Rian Mantasa S P	Initial investigation of hydraulics engineering for flood mitigation, A case study in Krueng Aceh sub-watershed
14.30 – 14.45	ISCEE – 045	Azzah Balqis Sabbah	Geological And Geotechnical Review of Gas and Mudflow Area as Mitigation Efforts in The Risk of Failure on Toll Road Project, Banten
14.45 – 15.00	ISCEE – 064	Tri Sudibyo	The Vehicle Type Effect to The Mixed Traffic Flow Performance (case of study: Soleh Iskandar road, Bogor, Indonesia)
15.00	Closing		

ZOOM Room B – ISCEE 2 *Environmental management; Environmental engineering and technology*			
Chair **Co-Chair** **Assistant 1** **Assistant 2**	Dr. Eng. Allen Kurniawan, ST., MT Andik Pribadi, S.TP., M.Sc Adan Kamarudin Fatihaturrizky Amelia		
Time	**Paper ID**	**Presenter**	**Paper Title**
13.15 – 13.30	Enter to Zoom Meeting and Preparation		
13.30 – 13.45	ISCEE - 006	Hanifati Dyvia	Analysis of thermal comfort with predicted mean vote (PMV) index using artificial neural network
13.45 – 14.00	ISCEE - 010	Michelle Natali	Development of Ecosystem Health Index in Rural Areas of Java Island: Preliminary Results
14.00 – 14.15	ISCEE - 013	Ardi Nur Armanto	Forest Fires and Carbon Emission Release in Semi-Arid Regions of Indonesia: The Evidence from Medium Resolution of Satellite Imagery
14.15 – 14.30	ISCEE - 025	Hana Afiyanita	Evaluation of Urban Landscape Visual Quality based on Social Media Trends in Bogor City
14.30 – 14.45	ISCEE - 029	M. Husni Kotta	Design Konservation Energy Of Outdoor City The Modified Thermal Comfort The Based Suistanable Environment
14.45 – 15.00	ISCEE - 055	Pryanka Alusvigayana	Nitrogen Dioxide (NO_2) in Ambient Air: Field Measurement Result versus The Stipulated Indonesian Air Pollution Standard Index
15.00	Closing		

ZOOM Room E – ISCEE 5 *Agriculture infrastructure and technology; Water resources engineering*			
Chair **Co-Chair** **Assistant 1** **Assistant 2**	Prof. Dr. Ir. Budi Indra Setiawan, M.Agr Andik Pribadi, S.TP., M.Sc Adan Kamarudin Fatihaturrizky Amelia		
Time	**Paper ID**	**Presenter**	**Paper Title**
13.00 – 13.15	Enter to Zoom Meeting and Preparation		
13.15 – 13.30	ISCEE – 016	Titiek Ujianti Karunia	Effects of Population and Land-use Change on Water Balance in DKI Jakarta
13.30 – 13.45	ISCEE – 048	Chusnul Arif	Developing IT Infrastructure of Evaporative Irrigation by Adopting IoT Technology
13.45 – 14.00	ISCEE – 052	Satyanto Krido Saptomo	Modelling 2D Water Table and Soil Moisture Distribution in a Field Installed with Sub Surface Drainage
14.00 – 14.15	ISCEE – 063	Chusnul Arif	Functional Design of Smart Evaporative Irrigation for Mina Padi System in Indonesia
14.15 – 14.30	ISCEE – 002	Roh Santoso Budi W	Hydrogeology Analysis In Pamagar Sari Village Bogor
14.30 – 14.45	ISCEE – 039	Fadhila Hanayni	Redesign of Urban Drainage System to Implement Zero Runoff as a Flood Control Method in Klitren Urban Village
14.45 – 15.00	ISCEE – 044	Pengki Irawan	The Darcy and Geoelectric Method on the Calculation of Potential Groundwater Reserves in the Ciliwung Watershed for Water Resources Management
15.00	Closing		

Third day – Wednesday, November 4th, 2020

ZOOM Room B – ISCEE 2 *Environmental management; Environmental engineering and technology*			
Chair **Co-Chair** **Assistant 1** **Assistant 2**	Prof. Dr. Ir. Arief Sabdo Yuwono, M.Sc Andik Pribadi, S.TP., M.Sc Adan Kamarudin Fatihaturrizky Amelia		
Time	**Paper ID**	**Presenter**	**Paper Title**
10.15 – 10.30	Enter to Zoom Meeting and Preparation		
10.30 – 10.45	ISCEE – 036	Latief Mahir Rachman	Application of SWAT in selecting soil and water conservation techniques for preparing management recommendation of Cilemer watershed, Banten, Indonesia
10.45 – 11.00	ISCEE – 040	Nuri Ayu	Externalities Aspects of Freight Distribution through the Urban Consolidation Center
11.00 – 11.15	ISCEE – 057	Andi Erwin Syarif	The Region of Lake Matano: Research Values and UNESCO Geopark Concept
11.15 – 11.30	ISCEE – 062	R Purbakawaca	Measurement of PM10 concentration using hybrid cyclone separator and particle counter
11.30 – 11.45	ISCEE – 066	Rizky Uno Ananda	Study of House Design Contribution on Inside Thermal Comfort for Passive Design House and Ordinary House Case Study: Bogor, Indonesia
11-45	Closing		