Effect of changes in climatological parameters on water flow

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Abstract. The existence of rivers in an area is essential because it is often used by the community for daily needs. In addition to the availability of raw water, it is also used for agricultural purposes. Cipalebuh River with 42 km2 of river flow area is a river in the southern part of Garut Regency; this river is used for drinking water supply and for irrigating 1016 ha of the rice field area. The purpose of this study was to determine the magnitude of changes in the Cipalebuh river flow due to changes in climatological parameters such as average air temperature, average relative humidity, average wind speed, duration of solar radiation, air pressure, and solar radiation. The rainfall stations in the Cipalebuh river basin are Pameungpeuk and Cisompet rainfall stations. Calculation of discharge using simulation method from F.J. Mock, while calculating evapotranspiration with the Penman-Monteith method. The apparent need for water in the rice fields is 1.4 lt/sec/ha. Based on the results of the calculation of the effect of changes in climatology parameters significantly influence the flow of water in the Cipalebuh river, so that the availability of raw water and irrigation is not much disturbed.

1. Introduction
The wealth of natural resources owned by Indonesia is the initial capital in carrying out development in all fields. Indonesia is a tropical country because it is located on the equator and is located between 60 LU - 110 LS and 950 BT - 1410 BT. Indonesia has had an essential role as a food producer in the world. Food production, especially rice, has not been able to meet the needs of its large population. Consequently, Indonesia must import rice from neighboring countries. At present, there are around 265 million Indonesians who need large amounts of rice. Change in human mind set and life style with more demand of comfort and to reduce man power needed in farming [1]. Since there is high population along the river basin, it will become a major contribution towards the rate of surface run-off and discharge into the river and the risk of flood occurrence at the study area [2]. As the population continues to increase, infrastructure needs continue to grow. So that many agricultural areas are shifting functions, especially for settlements. The aim was to project the future land use in accordance with the historical changes and planned urban development [3].

Garut Regency is one of the districts in Indonesia located in West Java Province. The area of rice fields in Garut Regency is 48,153 ha (BPS Garut Regency, 2016). Garut Regency is one of the districts with the highest yield in West Java Province (Office of Food Crops and Horticulture).

The availability of water to meet the rice field area is absolutely necessary so that it will produce the expected crop. Conjunctive use of surface water and groundwater for irrigation should plays an important role both as a source of recharge to the groundwater [4]. The Pameungpeuk sub-district which is part of the southern Garut Regency has an area of 1127 ha of rice fields. One of the irrigation areas in
this sub-district is the Cipalebuh Irrigation Area. This Irrigation Area floods the area of 1016 ha of land with water sources from the Cipalebuh River which empties into the Indian Ocean.

Pameungpeuk Subdistrict is a tourist area frequented by domestic tourists, so the development of infrastructure is quite rapid. Every year, the Cipalebuh River discharge fluctuates in addition to rainfall due to land conversion in the sub-district. The environmental conditions such as the increasing urbanization and the occurrence of natural hazards like flood and landslides may affect the homogeneity and the continuity of rainfall data [5]. The results of this study can help convince policymakers in providing water for the benefit of the community.

2. Method

The methodology used in this study is secondary data collection, namely 20 years of rainfall data, starting in 1998 - 2007 and 2009 - 2018. Climatology data of 20 years, watershed area. Climatological data calculated from 1998 to 2018, 2008 data not taken into account are used for delimiting. Climatology data was obtained from the National Aeronautics and Space Institute (LAPAN), Pameungpeuk District, Garut Regency. The research location was in Cipalebuh Weir, Pameungpeuk District, Garut Regency. Cipalebuh Weir irrigates a land area of 1016 ha. This weir is under the authority of the West Java Provincial Government because the service area is more than 1000 ha.

The method of calculating evapotranspiration is calculated by the Penman-Monteith method. Rainfall stations located in the watershed are LAPAN Pameungpeuk station and Kebun Bunisari station, Lendra. Calculation of average rainfall is calculated by the familiar algebraic formula. Calculation of monthly debit simulation is used by F.J. Mock with data input, namely, monthly average precipitation, evapotranspiration, soil moisture, and groundwater storage.

Climatological parameters are taken into account, namely temperature, wind speed, relative humidity, and duration of solar radiation. Climate change can severely impact on hydrological process, including an increase in rainfall, particularly during extreme events [6]. The four climatological parameters are used to calculate the amount of evapotranspiration. Another setting as a variable is land use change, namely the percentage of open land. The effect of changes in the amount of evapotranspiration is used as the final result in determining the amount of discharge in the Cipalebuh Weir. The discharge value is calculated by the F.J Mock simulation. This is sorted from the largest to the smallest to obtain a positive discharge value that will be used as the basis for flooding the area of rice field area of 1016 ha. The height and volume of water flow in each watershed usually fluctuates according to weather events and variables [7]. The physical, chemical and biological parameters of groundwater determine its suitability for the intended purpose [8].

3. Result and discussion

3.1. Result
The area of the Cipalebuh river basin is measured from the weir to upstream, which is 42 km2 with a river length of about 55.38 km. The city of paddy fields flooded by Cipalebuh dam is 1016 ha with the clear need for water in the paddy fields around 1.4 lt/sec/ha. Based on the calculation of simulation discharge, the rice field area is still able to be flooded by river discharge.

The average rainfall in the Cipalebuh watershed from two rain stations, Bunisari and LAPAN station, Pameungpeuk for 10 years for the period 1998-2007 and the period 2009-2018, calculated by the standard algebraic method used as one of the inputs for calculating simulation discharge. The average rainfall for the period 1998-2007 is 363 mm/month, while the period 2009-2018 is 419 mm/month. Extreme rainfall events are expected to occur each year at the sites located in areas with tropical climate, which indirectly affected by the impact of monsoons [9]. Another parameter calculated is the number of monthly average rainy days. The number of rainy days in the period 1998-2007 was 11 days/month, and the period 2009-2018 was 14 days/month. Rainfall information is useful for runoff prediction and hydrographs analysis and their impact on surface water impoundments, flood and groundwater recharge works [10].
In addition to rainfall and the number of rainy days, other parameters that affect it are evapotranspiration. Climate change has been recognized as one of the greatest influences stressing water resources, but the quantitative estimate of geomorphic change is also essential for understanding the potential water resource management [11]. Calculation of the amount of evapotranspiration \( ETO \) is used by the Penman-Monteith method. The amount of evapotranspiration is calculated in the period 1998 - 2007 and the period 2009 - 2018. Table 1 and Table 2 show the magnitude of the evapotranspiration period 1998 - 2007 and the period 2009-2018, with an average quantity of 3.53 mm/day and 3.63 mm/day. The separation of evapotranspiration into its surface evaporation and transpiration components remains a challenge despite its importance for linking water and carbon cycles, for water management [12].

### Table 1. Evapotranspiration period 1998-2007.

| Month    | Min Temp \(^{\circ}C\) | Max Temp \(^{\circ}C\) | Humidity % | Wind km/day | Sun hours | Rad MJ/m\(^{2}\)/day | ETo mm/day |
|----------|------------------------|------------------------|------------|-------------|-----------|---------------------|------------|
| January  | 22.1                   | 30.6                   | 85         | 176         | 4.7       | 17.0                | 3.77       |
| February | 22.0                   | 30.6                   | 85         | 248         | 4.2       | 16.4                | 3.77       |
| March    | 21.9                   | 30.6                   | 85         | 212         | 4.3       | 16.2                | 3.67       |
| April    | 21.8                   | 30.7                   | 86         | 182         | 4.7       | 15.8                | 3.47       |
| May      | 21.5                   | 30.6                   | 86         | 174         | 5.3       | 15.3                | 3.30       |
| June     | 21.3                   | 30.5                   | 85         | 226         | 5.0       | 14.2                | 3.22       |
| July     | 21.0                   | 29.8                   | 84         | 287         | 4.6       | 13.9                | 3.30       |
| August   | 20.5                   | 30.0                   | 81         | 352         | 3.9       | 14.0                | 3.70       |
| September| 21.8                   | 29.6                   | 83         | 356         | 3.9       | 15.1                | 3.72       |
| October  | 21.7                   | 29.9                   | 85         | 219         | 4.1       | 16.0                | 3.60       |
| November | 22.0                   | 30.0                   | 87         | 167         | 3.6       | 15.3                | 3.36       |

The calculation of the discharge around the weir is done in a simulation; the amount of the release is shown in Table 3. From the calculation results, the monthly debit for the period 2009-2018 is higher than the monthly statement for the period 1998-2007. Figure 1 shows the comparison of the discharge periods 1998 - 2007 and 2009-2018. From the calculation of the simulation discharge, in the period 2009-2018, there was an increase in the release by 13.82%.

### Table 2. Evapotranspiration period 2009-2018.

| Month    | Min Temp \(^{\circ}C\) | Max Temp \(^{\circ}C\) | Humidity % | Wind km/day | Sun hours | Rad MJ/m\(^{2}\)/day | ETo mm/day |
|----------|------------------------|------------------------|------------|-------------|-----------|---------------------|------------|
| January  | 23.9                   | 30.0                   | 86         | 331         | 3.8       | 15.7                | 3.67       |
| February | 23.7                   | 29.9                   | 86         | 276         | 4.2       | 16.4                | 3.71       |
| March    | 23.6                   | 30.3                   | 85         | 208         | 5.0       | 17.3                | 3.83       |
| April    | 23.7                   | 30.3                   | 86         | 182         | 5.3       | 16.7                | 3.62       |
| May      | 23.6                   | 30.3                   | 86         | 279         | 5.4       | 15.4                | 3.47       |
| June     | 22.9                   | 29.8                   | 86         | 299         | 5.4       | 14.7                | 3.30       |
| July     | 22.5                   | 29.1                   | 86         | 357         | 5.7       | 15.4                | 3.39       |
| August   | 22.4                   | 29.1                   | 84         | 464         | 6.1       | 17.2                | 3.93       |
| September| 20.8                   | 28.8                   | 84         | 460         | 5.1       | 17.0                | 3.89       |
| October  | 23.4                   | 29.1                   | 86         | 368         | 4.8       | 17.1                | 3.75       |
| November | 23.8                   | 29.5                   | 87         | 219         | 3.5       | 15.1                | 3.37       |

### Table 3. Cipalebuh weir simulation discharge.

| Discharge (m\(^{3}\)/s) | Period 1998-2007 | Discharge (m\(^{3}\)/s) | Period 2009-2018 |
|--------------------------|------------------|--------------------------|------------------|
| Jan                      | 3.67             | 3.84                     |
| Feb                      | 4.07             | 4.55                     |
| Mar                      | 6.06             | 6.59                     |
| Apr                      | 5.01             | 5.85                     |
| May                      | 6.19             | 6.56                     |
| Jun                      | 3.46             | 4.07                     |
| Jul                      | 3.35             | 4.21                     |
| Aug                      | 3.48             | 3.65                     |
| Sep                      | 5.16             | 5.84                     |
| Oct                      | 6.13             | 6.61                     |
| Nov                      | 7.24             | 9.23                     |
| Dec                      | 3.73             | 4.53                     |
3.2. Discussion
Cipalebuh River is the largest river that divides Pameungpeuk Sub-district, Garut Regency. Until now, the Cipalebuh River is still a mainstay of the local community in utilizing river water for their daily needs, especially for irrigating rice fields and household needs.

Cipalebuh Irrigation Area is the only irrigation area in Pameungpeuk Sub-district, Garut Regency which is the responsibility of the West Java Provincial Government. From the results of the simulation debit calculation, the availability of water for irrigation is still surplus so that the river water can also be used for household needs. The availability and sustainability of water resources is very important for economic development, improving the ecological environment, and social progress of the community [13]. Two rain stations in the Cipalebuh watershed are located in the basin, one station upstream and another station downstream. Based on available data, 2008 was not included in the calculation and made a limitation of comparison. Rain station Kebun Bunisari, Lendra is the most significant contributor to rainfall.

Based on ETo reference plant evapotranspiration procedure, the Penman-Monteith method is the best method in calculating the reference plant evapotranspiration rate. The average evapotranspiration for each period is 3.53 mm / day and 3.63 mm / day. This effect of climatological parameters, especially wind speed, solar radiation, relative humidity, and the temperature does not have much impact on changes in discharge. The study shows that there will be no appreciable changes in total irrigation water requirement due to climate change [14]. Climate change is anticipated to worsen this situation by jeopardizing existing water resources [15]. Rainfall and land use change are still the dominant factors in changing Cipalebuh river discharge. The contributions of climate fluctuations and human activities to the streamflow changes are quantitatively determined [16].

4. Conclusion
The Cipalebuh irrigation area irrigates an area of 1016 ha of rice fields, with 1.4 lt / sec / ha of water in the fields, the available discharges are still able to irrigate the rice fields in the irrigation area. The amount of evapotranspiration in the 2009-2018 period increased by 2.83%. Rainfall, especially in the upstream region, is higher than the rain in the downstream area. This is the most significant contributor to changes in discharge other than factors in land use change while other climatological factors are less significant for changes in release in the Cipalebuh river.

Acknowledgments
Authors wishing to acknowledge Sekolah Tinggi Teknologi Garut that supports and funds this research publication.
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