Determining the wet season onset toward crop water availability under the tropical monsoon climate

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Abstract. Climate change has lead to the uncertainty of wet and dry season onset. Season onset is important information for farmers to consider the agriculture activity. Climate policy in Indonesia is authorized by the Indonesian Agency for Meteorology, Climatology and Geophysics (abbreviated as BMKG in Indonesian), which determine the initial of the season based on ten-days rainfall (decadal). Water availability in the soil is not just influenced by rainfall, but also soil characteristics. This research aims to determine the season onset based on rainfall and soil moisture availability for crops under the tropical monsoon climate. Climatic and soil moisture data were collected from Karanganyar District, Province of Central Java, Indonesia in October 2016 to February 2018. Soil moisture data collected by soil moisture logger. The result found that the wet season onset for agricultural activity was different than based on climatic data.

1. Introduction
Climate change has caused weather changes in various parts of the world, one of the impacts is the shift in rainfall patterns. The intensity of rainfall and uncertainty of wet and dry season onset had changed due to climate change [1]. Indonesia has two seasons, namely dry and wet seasons. Determination of season onset is very important for the Indonesian people who mostly make a living as farmers. This will have an impact on income and food security [2]. Climate change causes a shift in the rain pattern which will impact the beginning of the wet season. The dry season becomes irregular, hence leads to difficulties in determining the time for sowing. Extreme climate events mostly resulting in crop and harvest failure [3]. The season onset in Indonesia is authorized by the Indonesian Agency for Meteorology, Climatology and Geophysics (abbreviated as BMKG in Indonesian). The agency determines season onset using meteorological data. Another method that can be adapted to determine the beginning of the planting season is by observing soil moisture data (agronomic data).

Soil moisture is an important factor for agriculture, plantations, horticulture, crops and forestry. Information about soil moisture is needed in crop cultivation for planning, management and monitoring activities. Soil moisture is used for water resource management, early drought warnings, irrigation scheduling and weather forecasts. Accurate and timely measurement of soil moisture is very important to monitor natural disasters, especially floods and droughts. Soil moisture also closely relates to precipitation.
Researches regarding determining the wet season onset based on rainfall and soil moisture are not many found. Hence the purpose of this study was to determine the season onset of the in Karanganyar Regency, Central Java, Indonesia based on rainfall and soil moisture. The determination of planting time is very important to guarantee the plant growth and yield. Calculation the determination of wet season onset using both rainfall (meteorology) and soil moisture (agronomy) information increase the validity. This study is expected can be a reference and information for season onset information. Therefore, this study aimed at determining season onset through meteorological and agronomic methods.

2. Materials and Methods
This study used rainfall and soil moisture data from November 2016 to February 2018, taken from climatology laboratory of Jumantono, Central Java, Indonesia. This study used quantitative exploratory methods. The study was conducted from November 2016 to February 2018. Rainfall data were obtained from Automatic Weather Station (AWS) in the UNS Climatology Laboratory which recorded the data every 1-hour. Soil moisture data obtained from soil moisture sensor produced by Decagon Devices type EC-5 that was located at a depth of 10 cm. Soil moisture was recorded in the logger every 10-minutes. Rainfall and soil moisture information interval were converted to decadal.

3. Results and Discussion
Decadal rainfall and soil moisture at the research site can be seen in Figure 1.

![Figure 1. Graphic of decadal rainfall and soil moisture](image)

Figure 1 shows that according to rainfall, wet season occurred from November 2016 to May 2018. Decadal rainfall shows that almost every day rainfall was more than 50 mm. The highest rainfall occurred in 2nd decadal of November (386 mm). The most frequent rainfall occurred from December to February. This is in accordance with Hermawan [4], that the peak of rainfall due to the Monsoon Wind system is in December, January to February. Rainfall patterns indicate a monsoonal pattern where the beginning of the wet season begins in November [5]. Whereas for the onset of the dry season was in May to 2nd decadal of November. The peak of the dry season occurred in August because of no rain. The 3rd decadal of November is the onset of the wet season again. The number of wet days starting from November 2016 to February 2018 was 214 days.

According to agronomic data, the wet season onset started in December 2017 to 2nd decadal of March 2018. Available water is the water that is held by the soil between field capacity and permanent wilting points. Field capacity is the maximum water content that can be held by the soil after water is saturated. The field capacity depends on the soil texture, soil structure, type of soil mineral and the content of organic matter in the soil [6]. The soil moisture of field capacity is equivalent to 0.3 atm or pF 2.53 [7].
Permanent wilting point is the soil moisture content in which plant leaves show wilting conditions that cannot be recovered, or equal to the potential water content of -15 bar or pF value of 4.2 [6]. Soil moisture between field capacity and permanent wilting points can be absorbed by plants partly. Landon [6] estimated only 66% of the total available water that can be absorbed by plants. Availability of water is an important phase for the plant growth cycle. About 70-90% of the plant's weight is liquid but only about 0.01% is needed in photosynthesis. In plants, water is a solvent from inorganic salts, sugars, and some organic compounds. Determination of planting time must be based on climatic conditions, especially rainfall so that plants can obtain water for growth and production [8]. Determining the potential for planting starts if rainfall has exceeded 35 mm per day for three consecutive days starting in September [9]. Table 1 is summarizing the season class based on rainfall (meteorological) and soil moisture (agronomic).

| Data        | 2016 | 2017 | 2018 |
|-------------|------|------|------|
| Meteorological |     |      |      |
| Agronomic   |      |      |      |

Source: Primary data
Information:  
- = Wet season
- = Dry season

According to Table 1, in November 2016 the soil moisture content was still below permanent wilting points (PWP) level, although rainfall was high. This occurred because the area experienced rather long dry season, so when rain fell it only soaks the soil but has not yet reached the field capacity. In the 3rd decadal of March, an agronomic drought occurred because of soil moisture below the permanent wilting point. March to May shows that even though rain fell but soil moisture was still below the permanent wilting point. Soil moisture content very closely relates to rainfall, evapotranspiration and plants circumstance. For example, water required to grow peanut is different at each phase. The optimal soil moisture for plant growth is at field capacity. The need for water by peanuts during its growth is controlled by climate factors, agronomy, and varieties [10].

Furthermore, a short drought/ dry spell occurred from March to May. Short drought is a situation where there is a short dry season. Short drought occurs due to changes in rainfall patterns caused by climate change [11]. Analysis of rainfall, flow, and soil moisture has shown an increasing trend of drought in the 21st century.

Soil moisture decreases gradually during the day and rises again afterward. This condition is thought to be related to the phenomenon of high transpiration during the day and low at night. This contributes to increasing the potential of plant tissue water to the root tissue in the upper soil layer that has dried up [12]. This situation also affects soil moisture. Decreased soil moisture due to the evapotranspiration process tends to be greater in the topsoil, so that if there is an improvement in soil moisture more clearly visible than the layer below it [13].

To determine the wet and dry season onset, the availability of complete and accurate rainfall data is important. Determining planting date is an important phase for plant development. The accurate determination of the planting time is the cheapest and most efficient way to increase crop productivity [14]. Determining an accurate planting period can minimize the risk of drought stress (water stress) in the critical phase. That is, also effective to know the volume of water that must be applied to achieve the desired index of water needs, as well as optimizing cropping intensity [15]. Planting time can be started when water balance is surplus [1].

Water is a limiting factor for crops production in areas which do not have enough rainfall to meet crop demand [16]. Information on soil moisture can also be used for water resource management, early drought warnings, irrigation scheduling, and weather forecasts. In addition, soil moisture is important
for agricultural experts. Deficits in soil moisture can lead to plant wilt and appropriate action through irrigation can save the crops [17].

Hermawan [4] argues that rainfall in Indonesia, especially Java Island is influenced by the Asian-Australian Monsoon system which causes this region to have one maximum rain peak, namely in January, February or December. The direction of monsoon wind changes between summer and winter due to differences in nature between land and sea [18]. The influence of Monsoon in Indonesia has become so complex because Indonesia has an equatorial location and consists of many mountains. The changes of monsoon wind can also be influenced by the El Nino and La Nina phenomena. The El Nino phenomenon caused the beginning of the delayed wet season and the dry season to become longer. While the La Nina phenomenon causes earlier wet season occurrence with a longer period [19].

The criteria for determining the wet and dry season onset is differed from place to place [20] and are still controversial. This relates to the point of view, for example, the climatological point of view is different from the hydrological and agronomic point of view [21]. According to BMKG, the wet season onset in Indonesia indicates by the occurrence of sequential rain intensity 50 mm 3 times a day. So the dry season onset is indicated as the opposite [22]. However, according to Suaydhi [19], the BMKG’s criteria are rigid because rainfall varies greatly.

4. Conclusion
The wet season onset can experience a shift, either delay or earlier. There are differences in wet and dry season onset determination according to rainfall (meteorological) and soil moisture (agronomic) data. In meteorological perception, the wet and dry season onset was November 2016 and June 2017, respectively. The wet and dry season onset varied according to the agronomic concept. Determination of the season onset will be more valid if using both meteorological and agronomic perception so that it can provide benefits to farmers.

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