Cropping calendar analysis for dry season 2020 in Indonesia

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Abstract. Indonesia has various rainfall characteristics that result in variations in the initial planting time and cropping patterns. The Integrated Cropping Calendar Information System is a guidance for planting rice, maize, and soybean at the right time with sufficient water availability conditions. This paper aimed to analyse the planting schedule and potential planting area of rice, maize, and soybeans in the dry season 2020 at 7,062 sub-districts in Indonesia. Input data were rainfall prediction, spatial-based ETP, soil water availability, wetland area, and rice cropping index. The results illustrated that the mean rainfall intensity and rainfall intensities of <60 and 200-300 mm mo<sup>-1</sup> were predicted as the widest rainfall coverages in April-June and July-September. The potential planting areas for rice, maize, and soybean were 5,259,661, 1,263,575, and 559,545 ha, respectively. Rice and maize initial planting periods were mainly in April II-II, while soybean in July III-August. Potential planting area for rice can be expanded to become 6,674,428 ha by applying additional water supply from alternative sources at the potential areas of maize and soybean.

1. Introduction

Indonesia is an archipelago that has rainfall conditions with various characteristics, ranging from dry to wet, and has monsoonal, local, equatorial and multimodal rainfall patterns. These varying conditions of the amount and distribution of rainfall have resulted in variations in the initial planting time and cropping patterns in various regions in Indonesia [1]. To apply the initial planting under the various rainfall conditions, farmers and extension workers need guidance so that they can plant at the right time with minimum risk [2,3].

The Integrated Cropping Calendar Information System (Sistem Informasi Kalender Tanam Terpadu) is a guidance that can assist extension workers and farmers in planting rice, maize, and soybeans at the right time with sufficient water availability conditions. Information that can be obtained by users through this information system includes information on rainfall prediction, estimated planting time and potential planting area for rice, maize, soybeans, the potential damage from floods, drought, and pests, various recommendations, fertilizer and fertilization recommendations, and other information stipulated by considering the conditions for predicting rainfall in paddy fields [4]. Information is presented to the sub-district, district/city, and provincial levels and covers all the 7,062; 514; and 34 respectively, of them throughout Indonesia [5].

The Integrated Cropping Calendar Information System has been designed and developed since 2007, and initialsed in the form of The Atlases of Cropping Calendar of Rice, Maize, and Soybean in Paddy Fields. In 2011, it began to be developed into a more dynamic information system by considering the monitoring of rainfall prediction information. The authors of this information system...
were from the IAARD supported by data from the Directorate General of Food Crops of the Ministry of Agriculture, BMKG, and LAPAN as partner institutions. The Management of The Integrated Cropping Calendar Information System was a Cropping Calendar Team consisting of the Central Katam Team domiciled at Balitbangtan Jakarta, Bogor, and Tangerang, and the Task Force Team domiciled at the Provincial BPTP [5].

The Integrated Cropping Calendar Information System has been published through the website at the address www.katam.litbang.pertanian.go.id. The information of Integrated Cropping Calendar has also been able to be accessed via Android-based smartphones through several applications, namely (1) “Kalender Tanam Terpadu Balitbangtan”, (2) “PETANI”, (3) “RiTx”, and (4) “S.C” [6]. The Integrated Cropping Calendar Information System was regularly updated at least twice times yearly, each dealing with rainy and dry seasons, and harmonizing the publication of predicted season information from BMKG [7,8]. To face the dry season for the period of April-September 2020, the Integrated Cropping Calendar had been updated and published in SI Katam Terpadu version 3.1 [9].

The objectives were (1) to analyse the planting time and determine the potential planting area of rice, maize, and soybeans in the dry season 2020 in 7,062 sub-districts throughout Indonesia based on the rainfall prediction, and (2) to analyse the increase of potential rice areas through a scheme of adding water from alternative sources at maize and soybean areas.

2. Methodology

2.1. Data collecting

The input data consisted of collected information on rainfall prediction for the period March-August 2020 from BMKG the starts of rainy season and predicted dry season dry season 2019/2020 and 2020, spatial-based ETP and soil water availability, and sub-district-based paddy data on official field area and average cropping index [4]. Rainfall prediction in the form of ten-daily predictive data from BMKG represented each predicted rainfall zone. Likewise, evaluation information on of the starts of rainy and predicted dry seasons of 2019/2020 and 2020 represented the rainfall prediction zone [8]. Evapotranspiration data obtained from the Climate Research Unit (CRU) for the period of 1990-2019 were in a grid-based spatial with a resolution of 0.5O x 0.5O [9]. Soil water availability data also in grid-based raster with a resolution of 0.002O x 0.002O were obtained from soilgrid [10]. Evapotranspiration and soil water availability data were collected from observational and satelite data. Paddy field area and crop index data in the form of sub-district-based tabular data covered 7,062 sub-districts throughout Indonesia.

2.2. Analysis on rainfall and predicted start season data

Information on predicted rainfall and evaluation of the rainy and predicted dry season starts of 2019/2020, and 2020 based on the predicted rainfall zone was converted into sub-district-based information. A sub-district can consist of several zones and a zone can also consist of several sub-districts [8]. For a sub-district consisting several zones, the value that represents one sub-district was calculated using the arithmetic mean [11]. For a zone which consist several sub-districts, the value that represented one sub-district was the same as the value in the zone, so that several sub-districts can have same values in rainfall, initial rainy season or dry seasons. The predicted rainfall information was then stated as the rainfall value for paddy fields in a particular sub-district.

2.3. Water balance calculation to determine rice, maize, or soybean planting schedule

The planting season periods of rice, maize, or soybeans were started with planting and ended with harvesting time, when water availability was sufficient for plant requirement such as evapotranspiration, soil preparation, or even for inundating in paddy fields. Planting season information was obtained based on the results of soil water balance calculations [12]. The soil water balance calculation used the bookkeeping system from Thornthwaite and Mather [13] which modified for an interval of 10-days through the following equation:
\[ CH + I = ETP + \Delta KAT + Li \]

where CH = decadal rainfall, I = irrigation, ETP = potential evapotranspiration, \( \Delta KAT \) = change in soil water availability, and Li = soil water surplus or deficit [12].

The calculation was carried out for 7,062 sub-districts in Indonesia. Input data used in water balance analysis were predicted rainfall, evapotranspiration and soil water availability. The calculation of the soil water balance resulted in predicted values in soil water content fluctuations, soil water surplus, and deficits. As an effort to facilitate the looping automation in the calculation of soil water balance, it was determined that the first planting was 2 decades after the rainy season starts. Furthermore, the beginning of the next planting season, followed the harvest of the previous planting season. The selection of commodities was determined based on the sufficiency of water for the evapotranspiration requirement.

2.4. Determination of potential planting area

The potential planting area was the area of rice, maize, or soybean that have potential to be used for planting paddy fields rice based on the planting time resulted from the calculation of the soil water balance. Determination of the potential value of planting area (LT) in one sub-district used historical data on the rice planting index (IP, in %) multiplied by the value of official rice-field area (LBS), following the following rules:

1. If the recommended commodity is rice, then the potential planting area (LT) = (IP/100) x LBS.
2. If the recommended commodity is maize or soybeans, then the planting area (LT) = (IP/100) x LBS
3. If the recommended commodity is rice but the mean value of rainfall during the growing season is between 75-150 mm mo\(^1\), in addition to the recommendation for rice, there are parts of the fields potential to be planted with maize, as follows:
   a. If the IP value is > 80%, then the potential planting area for maize (LT) = 0
   b. If the IP value is between 50-80%, then the potential planting area for maize (LT) = (1-IP)/100 x LBS
   c. If the IP value is <50%, then the potential planting area for maize (LT) = 0.5 x (1-IP)/100 x LBS
4. If the recommended commodity is rice but the mean value of rainfall during the growing season is between 60-75 mm mo\(^1\), in addition to the recommended for rice, there are parts of the fields potential to be planted with soybeans, as follows:
   a. If the IP value is > 80%, then the potential planting area for soybean (LT) = 0
   b. If the IP value is between 50-80%, then the potential planting area for soybean (LT) = (1-IP)/100 x LBS
   c. If <50%, then the potential planting area for soybean (LT) = 0.5 x (1-IP)/100 x LBS

The potential planting area was displayed as its units in hectare (ha) and proportion to the national official rice-field area in percent (%).

2.5. The increasing potential planting area through using alternative water sources

The information produced in the Integrated Cropping Calendar Information System was the estimated condition for planting schedule of the crops predicted to have a high probability to be harvested because, under the predicted rainfall conditions, the water availability level was sufficient. If an alternative water source was available in the study location, the potential for planting area could be increased, and even recommended commodities requiring less water, such as soybeans or maize, could be converted to rice provided that a certain amount of additional water was required. In the dry season 2020, it will also be assessed the area of soybean and maize plants can be converted into rice if an alternative water sources is available.
3. Results and discussion

3.1. Rainfall prediction in dry season 2020

Rainfall conditions in the dry season 2020 in Indonesia presented in table 1 describe in terms of the distribution of rainfall classes according to the raw wetland area in various provinces. An easier way to get an overview of rainfall conditions and their changes is by dividing the dry season period into two sub-season periods, namely April-May-June (AMJ) and July-August-September (JAS). In the AMJ sub-season or the beginning dry season, the dominant rainfall intensity is a mean value of \(<60\) mm mo\(^{-1}\) or a very low category spreading over 2,872,536 ha rice fields or 38.5\% of the NRA (National Official Rice-field Area).

The very low rainfall intensity generally occurs in Java, Bali, Nusa Tenggara, and southern Sulawesi islands. The next dominant rainfall intensity is a mean value of 100-150 mm mo\(^{-1}\) or a moderate category spreading over 1,094,753 ha or 14.7\% NRA, as well as rainfall with an average intensity of 200-300 mm mo\(^{-1}\) or a high category spreading over 991,252 ha or 13.3\% NRA. Judging from the distribution of rainfall classes, the islands of Java, Bali, and Nusa Tenggara experience with very low, low, and moderate rainfall intensities of \(<60, 60-100\) and 100-150 mm mo\(^{-1}\). The Sumatra island experiences with moderate, high, and very high rainfall intensities of 100-200, 200-300, and \(>300\) mm mo\(^{-1}\). The islands of Kalimantan, Sulawesi, Maluku, and Papua experience with moderate, high, and very high rainfall intensities of 100-200, 200-300, and \(>300\) mm mo\(^{-1}\). In some areas of South and Southeast Sulawesi, and southern Papua also experience with very low and low rainfall intensities.

In the JAS sub-season or the end of dry season, there is a shift in the dominant rainfall intensity category, where the dominant mean rainfall intensity at the end of dry season 2020 is 200-300 mm mo\(^{-1}\) or a high category, covering rice fields area of 4,365,241 ha or 58.5\% NRA. This high rainfall intensity spreads in every province throughout Indonesia. The next dominant rainfall is an average intensity of \(>300\) mm mo\(^{-1}\) or a very high category spreading over 2,148,941 ha or 28.8\% NRA. Judging from the distribution of rainfall classes, the islands of Sumatra, Kalimantan, Sulawesi, Maluku, and Papua generally experience high and very high rainfall intensities with mean values of 200-300 and \(>300\) mm mo\(^{-1}\). Meanwhile, in Java, Bali, Nusa Tenggara, and South Sulawesi Provinces, the mean rainfall intensity is low (60-100 mm mo\(^{-1}\)) or moderate (100-150 mm mo\(^{-1}\)).

3.2. The Information of cropping calendar on dry season 2020

Table 2 provides a summary of the planting schedule and the potential for rice planting in Indonesia during the dry season 2020. Planting periods in the dry season are grouped into nine 20-day intervals or 9 planting schedules, such as March III-April I, April II-III, May I-II, May III-June I, June II-III, July I-II, July III-August I, August II-III, and September I-II. It can be seen that the most dominant rice planting periods were in April II-III, March III-April I, and May III-June I covering areas of 1,212,678; 1,151,531; and 1,138,619 ha or 16.3,15.4, and15.3\% NRA, respectively. The total potential area for rice field planting time in dry season 2020 was 5,259,661 ha or 70.5\% NRA. Looking at the characteristics of the area in the northern part of Sumatra Island, rice could be planted throughout the dry season 2020, because the area had an equatorial rainfall pattern having two wet peaks with high rainfall intensities, or this region had rainfall characteristics difficult to determine the dry season due to high monthly rainfalls. In the southern region of Sumatra and Java, the dominant rice planting time was in March III-April I or July III-August I. In several provinces, their planting schedule covered no large area, or even in some provinces there was no planting schedule. In Kalimantan, Sulawesi, Maluku, and Papua islands, their planting schedules were at the beginning and in the middle of the dry seasons, and at the end of the planting season there was no recommended planting period. Mainly due to the form of local rainfall patterns, the East Sulawesi and Maluku regions experienced a wet peak at the beginning to the middle dry season 2020 and usually low rainfall conditions being not suitable for planting rice at the end of dry season. In Bali and Nusa Tenggara, planting time was only in June II-III.
and even no planting schedule for rice commodities due to the low rainfall conditions in East Nusa Tenggara.

Table 3 presents a summary of the planting schedule and the potential for maize planting areas in Indonesia during the dry season 2020. It can be seen that the most dominant planting schedules for maize were in August II-III, July III-August I, and April II-III covering total areas of 467,221; 288,134; and 220,323 ha or 6.3, 3.9, and 3.0 % NRA, respectively. The total potential area for planting maize in dry season 2020 was 1,263,575 ha or 16.9% NRA. Several provinces potential to grow maize were parts of the eastern Sumatra region with planting schedule in the middle or end dry season. In Java, the planting schedule were at various periods during the dry season 2020. Several provinces in Kalimantan and Sulawesi islands were potential to be planted with maize in the middle to the end of dry season 2020.

Table 4 presents a summary of the planting schedules and the potential areas for planting soybean in Indonesia during the dry season 2020. It can be seen that the most dominant planting periods for soybeans were in July III-August I and August II-III covering 193,538 and 20,890 ha or 2.6 and 1.6% NRA. The total potential area for planting soybean in dry season 2020 was 559,545 ha or 7.5% NRA. Some of the potential areas for planting soybeans were located in all Java provinces, and Central, South, and Southeast Sulawesi, North Maluku, and Papua provinces.

3.3. The change of recommendation of cropping calendar

The recommended planting schedule and potential planting area presented in tables 2, 3, and 4 inform that the potential planting area for rice, maize, and soybean on rice-field area during dry season 2020 were 5,259,661; 1,263,575; and 1,263,575 ha, respectively. The planting schedule for each commodity was a recommendation considering the adequacy of soil water availability as the output of the soil water balance calculation. Each planting schedule had various values of mean average rainfall during the planting periods, where some had average rainfall values of < 60, 60-75, or 75-100 mm mo⁻¹, or even 100-150 and >150 mm mo⁻¹ according to the water needs of each commodity. According to the minimum requirement for rice plants, if the lands recommended for soybean or maize plants having average rainfalls of 75-100 or 75-100 and 100-150 mm mo⁻¹, their recommendations could be changed to become rice if the water supplied to the land is as much as 25 mm mo⁻¹.

Table 5 presents a summary of the planting schedule and the potential area for planting rice in rice-fields if the location of maize or soybeans (with a mean rain intensities of 75-100 and 100-150 mm mo⁻¹) received an additional water supply of 25 mm mo⁻¹ from alternative sources. It could be seen that the increase in planting area was as much as 1,414,767 ha so that the potential for rice planting area changed to become 6,674,428 ha during dry season 2020. The largest increases in planting area occurred during planting periods of August II-III and July III-August I covering areas of 472,252 and 342,045 ha.

3.4. Introducing the technology needed to change the cropping calendar recommendations

There are at least 4 technologies of water infrastructure that can be applied to meet water requirement so that the recommendation from soybean or maize plants is changed to rice planting recommendations [14], namely:

1. Utilization of pumps on open alternative sources to lift water from and transfer to paddy fields.
2. Provision of trench dams to remove water from small rivers to be used for rice plants in paddy fields.
3. Construction of ‘embung’ or water reservoirs around the rice fields. It would be better if the ‘embung’ or water reservoir was made on land located not far from the spring as the source of supplement water.
4. Making ‘long water storage’, especially in irrigated areas that have drainage channels where the water is still sufficient to be used for planting.
Table 1. Distribution of wetland area (ha) based on a group of predicted rainfall on periods of April-June and July-September 2020.

| Province            | Total of rice-field area | April-June 2020 (mm mo<sup>−1</sup>) | July-September 2020 (mm mo<sup>−1</sup>) |
|---------------------|--------------------------|--------------------------------------|------------------------------------------|
|                     | <60  | 60-100 | 100-150 | 150-200 | 200-300 | >300  | <60  | 60-100 | 100-150 | 150-200 | 200-300 | >300  |
| Aceh                | 213,294 | -     | -     | -     | -     | -     | 213,294 | -     | -     | -     | -     | -     |
| Sumatera Utara      | 308,241 | -     | -     | -     | -     | -     | 59,348  | -     | -     | -     | -     | -     |
| Sumatera Barat      | 194,270 | -     | -     | -     | -     | -     | 133,387 | -     | -     | -     | -     | -     |
| Riau                | 62,869   | -     | -     | 39,207 | 210,442 | 58,593 | -     | -     | -     | -     | -     | -     |
| Jambi               | 68,314   | -     | -     | 7,195  | 73,688  | 113,387 | -     | -     | -     | -     | -     | -     |
| Sumatera Selatan    | 470,738  | -     | -     | 7,195  | 73,688  | 113,387 | -     | -     | -     | -     | -     | -     |
| Bengkulu            | 50,758   | -     | -     | 3,301  | 40,812  | 6,645   | -     | -     | -     | -     | -     | -     |
| Lampung             | 360,207  | -     | -     | 255,887 | 104,320 | -     | -     | -     | -     | -     | -     | -     |
| Kepulauan Bangka    | 22,402   | -     | -     | 18,927 | 3,475   | -     | -     | -     | -     | -     | -     | -     |
| Belitung            | 1,394    | -     | -     | 515    | 376    | 504    | -     | -     | -     | -     | -     | -     |
| Kepulauan Riau      | 414      | -     | -     | 414    | -     | -     | -     | -     | -     | -     | -     | 414    |
| DKI Jakarta         | 927,843  | 444,317 | 256,064 | 227,462 | -     | -     | 104,697 | 400,066 | 423,080 | -     | -     | -     |
| Jawa Barat          | 1,048,830 | 709,764 | 321,803 | 17,263  | -     | -     | 12,321  | 853,837 | 182,672 | -     | -     | -     |
| Jawa Tengah         | 76,312   | 64,940  | 11,372  | -     | -     | -     | 62,869  | 13,443  | -     | -     | -     | -     |
| Jawa Timur          | 1,215,128 | 1,174,966 | 26,044  | 14,117  | -     | -     | 201,513 | 941,906 | 71,709  | -     | -     | -     |
| Banten              | 204,338  | -     | 149,003 | 55,335  | -     | -     | -     | -     | -     | -     | -     | 115,177 |
| Bali                | 70,984   | -     | 33,403  | 20,235  | 17,346 | -     | -     | -     | -     | -     | -     | 115,177 |
| Nusa Tenggara Barat| 234,532  | 234,532 | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     |
| Nusa Tenggara Timur| 155,520  | 155,520 | -     | -     | -     | -     | 12,644  | 42,132  | 70,160  | 30,584 | -     | -     |
| Kalimantan Barat    | 242,988  | 242,988 | -     | -     | -     | -     | -     | -     | -     | -     | -     | 214,923 |
| Kalimantan Tengah   | 136,556  | -     | -     | 623    | 106,120 | 29,813  | -     | -     | -     | -     | -     | -     |
| Kalimantan Selatan  | 291,076  | -     | -     | 40,713 | 233,766 | 14,231  | 2,366   | -     | -     | -     | -     | -     |
| Kalimantan Timur    | 41,406   | -     | -     | 35,225 | 6,181   | -     | -     | 40,755  | 651    | -     | -     | -     |
| Kalimantan Utara    | 11,922   | -     | -     | 466    | 11,456  | -     | -     | 8,257   | 3,665  | -     | -     | -     |
| Sulawesi Barat      | 47,042   | -     | -     | 642    | 45,520  | 880    | -     | -     | -     | -     | -     | -     |
| Sulawesi Tengah     | 116,857  | -     | -     | 78,322 | 38,265  | -     | -     | 85,024  | 26,672 | -     | -     | -     |
| Sulawesi Selatan    | 654,605  | 55,094  | 73,370  | 157,564 | 61,790 | 194,644 | 112,144 | 1,809   | 262,728 | 236,644 | 153,425 |
| Sulawesi Tenggara   | 82,117   | 2,270  | 3,728  | 28,400 | 34,627  | 13,091 | 27,523  | 54,594  | -     | -     | -     | -     |
| Gorontalo           | 33,047   | -     | -     | -     | -     | -     | 33,047  | -     | -     | -     | -     | -     |
| Sulawesi Barat      | 39,456   | -     | -     | 581    | 16,511  | 22,364 | -     | -     | -     | -     | -     | -     |
| Maluku              | 18,283   | -     | -     | 17,349 | 935    | -     | -     | 10,955  | 7,328  | -     | -     | -     |
| Maluku Utara        | 13,542   | -     | -     | 185    | 13,358  | -     | -     | 185    | 13,358 | -     | -     | -     |
| Papua Barat         | 8,860    | -     | -     | 1,579  | 7,281   | -     | -     | 239    | 8,621  | -     | -     | -     |
| Papua               | 36,195   | -     | 30,258 | 1,870  | 1,112   | 2,954  | -     | -     | -     | -     | -     | 3,041  |
| Indonesia<sup>*)</sup> | 7,459,891 | 2,872,536 | 890,834 | 1,094,753 | 910,291 | 991,252 | 700,225 | 12,644  | 103,502 | 829,562 | 4,365,241 | 2,148,941 |

*The percent value shows the proportion of the national official rice-field area (NRA).
Table 2. Distribution of official rice-fields area (ha) based on the estimation of planting time of rice on Dry Season 2020.

| Province       | Total of wetland area | Planting time | Total |
|----------------|-----------------------|---------------|-------|
|                | Mar III-Apr I | Apr II-III | May I-II | May III-Jun | Jun I-II | Jul I-II | Jul III-Aug I | Aug II-III | Sep I-II |
| Aceh           | 213,294     | 14,816     | 16,408   | 12,516    | 79,606   | 18,597   | 13,582    | 9,031      | 48,344   | 7,433    | 220,332  |
| Sumatera Utara| 308,241     | 48,528     | 36,074   | 12,438    | 75,823   | 41,979   | 39,501    | 66,092     | 22,528   | 4,446    | 347,409  |
| Sumatera Barat| 194,270     | 28,242     | 37,825   | 17,604    | 30,485   | 47,945   | 32,170    | 25,729     | 35,361   | 16,18     | 271,678  |
| Riau           | 62,689      | 29,713     | -        | 1,639     | 1,964    | 2,788    | -         | 20,981     | 16,418   | -        | 73,503   |
| Jambi          | 68,314      | 27,537     | 3,261    | 6,973     | -        | 294      | 27,884    | 19,338     | 2,405    | -        | 87,692   |
| Sumatera Selatan| 470,738 | 708        | 20,497   | 298,202   | 10,821   | 13,166   | 41,029    | 238,234    | -        | -        | 384,423  |
| Bengkulu       | 50,758      | 28,540     | -        | 1,247     | -        | 10,866   | 20,843    | -          | 61,496   | -        | 122,244  |
| Lampung        | 360,207     | 18,418     | 181,669  | 8,199     | 139,572  | -        | 18,418    | 134,959    | 8,399    | -        | 509,634  |
| Kepulauan Bangka| 22,402 | 3,270      | 618      | -         | 17,895   | -        | 1,998     | 441        | -        | 24,222   | -        |
| Belitung       | 1,394       | 140        | -        | -         | 34       | 212      | -         | 40         | 100      | 152      | 678      |
| Kepulauan Riau | 414         | -          | -        | -         | -        | -        | -         | -          | -        | -        | -        |
| DKI Jakarta    | 927,843     | 474,863    | 133,271  | -         | 21,405   | 176,541  | 52,519    | 858,600    | -        | -        | -        |
| Jawa Barat     | 1,048,830   | 141,753    | 211,697  | 3,046     | 141,347  | 16,409   | 58,949    | 88,140     | 9,950    | -        | 671,292  |
| Jawa Tengah    | 76,312      | 1,350      | 3,957    | -         | 4,980    | 7,013    | -         | 454        | 1,558    | -        | 19,312   |
| DI Yogyakarta  | 1,215,128   | 75,052     | 157,936  | -         | 230,922  | 10,590   | -         | 32,643     | 66,855   | 8,042    | 582,040  |
| Jawa Timur     | 204,338     | 24,168     | 43,319   | 31,795    | 7,495    | 2,138    | 9,405     | 21,698     | 14,379   | -        | 154,396  |
| Banten         | 70,984      | -          | -        | 9,639     | 3,062    | -        | -         | 983        | 13,684   | -        | -        |
| Bali           | 234,532     | -          | -        | -         | 61,948   | -        | -         | -          | 61,948   | -        | -        |
| Nusa Tenggara Barat | 155,520 | -        | -        | -         | -        | -        | -         | -          | -        | -        | -        |
| Nusa Tenggara Timur | 242,988 | 103,071   | -        | -         | 75,294   | 41,437   | -         | -         | -        | -        | 219,802  |
| Kalimantan Barat | 136,556 | 30,785   | 51,515   | -         | -        | -         | -         | -          | -        | -        | 82,300   |
| Kalimantan Tengah | 291,076 | 45,402   | 86,572   | -         | 211,094  | 2,110    | 112       | 4,641      | 472      | -        | 136,887  |
| Kalimantan Selatan | 41,406 | 1,944     | -        | -         | 1,226    | 701      | -         | -          | -        | 2,801    | -        |
| Kalimantan Utara | 11,922  | 875       | -        | -         | 17,011   | 2,890    | 7,549     | -         | -        | -        | 27,557   |
| Sulawesi Utara | 47,042      | 106       | -        | -         | 17,011   | 2,890    | 7,549     | -         | -        | -        | 27,557   |
| Sulawesi Tengah | 196,587 | 4,781     | 7,386    | 7,428     | 28,579   | 11,190   | 4,648     | -         | -        | 60,373   | -        |
| Sulawesi Selatan | 654,605 | 49,185    | 194,492  | 11,754    | 2,469    | 8,544    | 3,474     | -         | -        | -        | 269,919  |
| Sulawesi Tenggara | 82,117  | 13,672    | 22,502   | 3,639     | -        | 7,100    | -         | -          | -        | -        | 46,912   |
| Gorontalo      | 33,047      | -          | 5,759    | 9,996     | 213      | 1,976    | 970       | -          | -        | 18,913   | -        |
| Sulawesi Barat | 39,456      | 52        | 11,630   | 7,982     | -        | 850      | -         | -          | -        | -        | 20,514   |
| Maluku         | 18,283      | -          | -        | -         | -        | 14,135   | -         | -          | -        | -        | 14,135   |
| Maluku Utara   | 13,542      | -          | 29       | -         | 195      | 2,582    | -         | -          | -        | -        | 2,805    |
| Papua Barat    | 8,860       | 71        | -        | 1,076     | 2,231    | -        | -         | -          | -        | -        | 3,378    |
| Papua          | 36,195      | 134       | 11       | 338       | 1,283    | -        | -         | -          | -        | 1,765    | -        |
| Indonesia *)   | 7,459,891   | 1,151,531  | 1,212,678| 141,092   | 1,138,619| 325,129  | 173,004   | 495,814    | 549,288  | 72,506   | 5,259,661|

*) the percent value shows the proportion of the national official rice-fields area.
Table 3. Distribution of official rice-fields area (ha) based on the estimation of planting time of maize on Dry Season 2020.

| Province            | Total of wetland area | Mar III-Apr I | Apr II-III | May I-II | May III-Jun I | Jun II-III | Jul I-II | Jul III-Aug I | Aug II-III | Sep I-II | Total |
|---------------------|-----------------------|---------------|------------|----------|---------------|------------|---------|---------------|------------|---------|-------|
| Aceh                | 213,294               | -             | -          | -        | -             | -          | -       | -             | -          | -       | 1,127 |
| Sumatera Utara      | 308,241               | -             | -          | -        | -             | -          | -       | -             | -          | -       | 691   |
| Sumatera Barat      | 194,270               | -             | -          | -        | -             | -          | -       | -             | -          | -       | 852   |
| Jambi               | 62,689                | -             | -          | -        | -             | -          | -       | -             | -          | -       | 3     |
| Sumatera Selatan    | 470,738               | -             | 598        | 938      | -             | -          | -       | -             | -          | -       | 4,166 |
| Bengkulu            | 50,758                | -             | -          | -        | -             | -          | -       | -             | -          | -       | 628   |
| Lampung             | 360,207               | -             | -          | -        | -             | -          | -       | -             | -          | -       | 2,065 |
| Kepulauan Bangka    | 22,402                | -             | -          | -        | 218           | -          | -       | -             | -          | -       | 355   |
| Belitung            | 1,394                 | -             | -          | -        | -             | -          | -       | -             | -          | -       |       |
| DKI Jakarta         | 414                   | -             | -          | -        | -             | -          | -       | -             | -          | -       | 29    |
| Jawa Barat          | 927,843               | 56,170        | 30,672     | -        | -             | -          | -       | -             | -          | 704     | 225,365|
| Jawa Tengah         | 1,048,830             | 31,054        | 73,732     | 3,308    | -             | -          | -       | -             | -          | -       | 111,176|
| DI Yogyakarta       | 76,312                | 479           | 495        | -        | -             | -          | -       | -             | -          | -       | 26,643 |
| Jawa Timur          | 1,215,128             | 22,369        | 47,837     | -        | -             | -          | -       | -             | -          | -       | 107,002|
| Banten              | 204,338               | 19,341        | 11,995     | 1,384    | -             | -          | -       | -             | -          | -       | 5,060 |
| Bali                | 70,984                | -             | -          | -        | 60            | 552        | -       | -             | -          | -       | 612   |
| Nusa Tenggara Barat| 234,532               | -             | -          | -        | -             | -          | -       | -             | -          | -       |       |
| Nusa Tenggara Timur| 155,520               | -             | -          | -        | -             | -          | -       | -             | -          | -       |       |
| Kalimantan Barat    | 242,988               | -             | -          | -        | -             | -          | -       | -             | -          | -       |       |
| Kalimantan Tengah   | 136,556               | -             | -          | -        | -             | -          | -       | -             | -          | -       | 41,470 |
| Kalimantan Selatan  | 291,076               | -             | -          | 3,319    | 57,995        | 19,751     | -       | -             | -          | -       | 81,065 |
| Kalimantan Timur    | 41,406                | -             | 166        | 5,067    | -             | -          | -       | -             | -          | -       | 10,293 |
| Kalimantan Utara    | 11,922                | -             | -          | 221      | -             | -          | -       | -             | -          | -       | 221   |
| Sulawesi Utara      | 47,042                | -             | 1,190      | -        | 3,499         | -          | -       | -             | -          | -       | 4,689 |
| Sulawesi Tengah     | 116,587               | -             | 3,421      | 1,851    | -             | -          | -       | -             | -          | -       | 5,272 |
| Sulawesi Selatan    | 654,605               | 48,239        | 3,088      | -        | 5,089         | 21,040     | 201,559 | -             | -          | 7,299  |
| Sulawesi Tenggara   | 82,177                | 392           | 1,970      | -        | 4,217         | 11,781     | 17,933  | -             | -          | 23,013  |
| Gorontalo           | 33,047                | -             | -          | -        | 1,290         | 645        | 4,178   | -             | -          | -       | 16,993 |
| Sulawesi Barat      | 39,456                | -             | -          | -        | -             | -          | -       | -             | -          | -       |       |
| Maluku              | 18,283                | -             | -          | 2,456    | -             | -          | -       | -             | -          | -       | 2,456 |
| Maluku Utara        | 13,542                | -             | -          | -        | 2,462         | -          | -       | -             | -          | -       |       |
| Papua Barat         | 8,860                 | -             | -          | -        | -             | -          | -       | -             | -          | -       |       |
| Papua               | 36,195                | -             | -          | -        | -             | -          | -       | -             | -          | -       |       |

Indonesia*)

|                | 7,459,891          | 111,198        | 220,323     | 19,382    | 67,148        | 13,229      | 15,267   | 288,134      | 467,221    | 61,674   | 1,263,575|

*) the percent value shows the proportion of the national official rice-fields area.
Table 4. Distribution of official rice-fields area (ha) based on the estimation of planting time of soybean on Dry Season 2020.

| Province                  | Total of wetland area | Mar III-Apr I | Apr II-III | May I-II | May III-Jun I | Jun II-III | Jul I-II | Jul III-Aug I | Aug II-III | Sep I-II | Total |
|---------------------------|-----------------------|---------------|------------|----------|---------------|------------|----------|---------------|------------|----------|--------|
| Aceh                      | 213,294               | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Sumatera Utara            | 308,241               | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Sumatera Barat            | 194,270               | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Riau                      | 62,689                | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Jambi                     | 68,314                | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Sumatera Selatan          | 470,738               | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Bengkulu                  | 50,758                | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Lampung                   | 360,207               | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Kepulauan Bangka          | -                     | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Belitung                  | 22,402                | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Kepulauan Riau            | 1,394                 | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| DKI Jakarta               | 414                   | -             | -          | -        | -             | 18         | -        | -              | -          | 158      | 176    |
| Jawa Barat                | 927,843               | 10,790        | -          | -        | -             | 28,040     | 27,275   | -              | -          | 66,105   | -      |
| Jawa Tengah               | 1,048,830             | 19,971        | 24,066     | 8,311    | 14,856        | 278        | 69,221   | 15,396        | -          | 152,100  | -      |
| DI Yogyakarta             | 76,312                | 4,842         | -          | -        | -             | 1,657      | 705      | -              | 7,204      | -        | -      |
| Jawa Timur                | 1,215,128             | 13,780        | 8,659      | 1,400    | 3,411         | 4,945      | 11,349   | 32,721        | 56,001     | 30,960   | 154,226|
| Banten                    | 204,338               | -             | -          | -        | 4,676         | -          | 9,670    | 1,770         | 1,012      | -        | 1,912  |
| Bali                      | 70,984                | -             | -          | -        | -             | -          | 4,676    | 1,770         | 1,912      | -        | 1,912  |
| Nusa Tenggara Barat      | 234,532               | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Nusa Tenggara Timur       | 155,520               | -             | 2,905      | 5,168    | -             | 15,187     | -        | 1,720         | 1,227      | -        | 26,208 |
| Kalimantan Barat         | 242,988               | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Kalimantan Tengah        | 136,556               | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Kalimantan Selatan       | 291,076               | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Kalimantan Timur         | 41,406                | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Kalimantan Utara         | 11,922                | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Sulawesi Utara           | 47,042                | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Sulawesi Tengah          | 116,587               | -             | -          | -        | 4,518         | 4,206      | 4,676    | 1,770         | 1,912      | -        | 8,724  |
| Sulawesi Selatan         | 654,605               | 13,361        | 11,021     | 2,314    | 2,510         | 3,886      | 39,662   | 11,299        | 10,085     | 85,140   | -      |
| Sulawesi Tenggara        | 82,117                | -             | -          | -        | -             | 5,517      | 7,397    | 12,915        | -          | -        | -      |
| Gorontalo                 | 33,047                | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Sulawesi Barat           | 39,456                | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Maluku                    | 18,283                | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Maluku Utara             | 13,542                | -             | -          | -        | -             | -          | -        | -              | -          | -        | -      |
| Papua Barat              | 8,860                 | -             | -          | -        | -             | 18,155     | -        | -              | 28,609     | -        | -      |
| Indonesia*               | 7,459,891             | 73,198        | 43,747     | 14,930   | 25,945        | 9,918      | 36,598   | 193,538       | 120,890    | 40,781   | 559,545|

* the percent value shows the proportion of the national official rice-fields area.
Table 5. Distribution of rice-fields area (ha) based on the planting time of rice on Dry Season 2020 after adding water from alternative sources.

| Province               | Total of wetland area | Planting time          |                |                |                |                |                |                |                |                |
|------------------------|-----------------------|------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                        | Mar III-Apr I         | Apr II-III             | May I-II        | May III-Jun I   | Jun III-II      | Jul I-II        | Jul III-Aug I   | Aug II-III      | Sep I-II        | Total          |
| Aceh                   | 213,294               | 15,943                 | 16,408          | 12,516          | 79,606          | 18,597          | 13,582          | 9,031           | 48,344          | 7,433          |
| Sumatera Utara         | 308,241               | 48,528                 | 36,074          | 12,438          | 75,823          | 41,979          | 40,192          | 66,092          | 22,528          | 4,446          |
| Sumatera Barat         | 194,270               | 28,242                 | 37,825          | 17,604          | 30,485          | 47,945          | 32,170          | 26,581          | 35,361          | 16,318         |
| Riau                   | 62,689                | 29,713                 | 1,639           | 1,964           | 2,791           | 20,981          | 16,418          | -               | -               | 73,506         |
| Jambi                  | 68,314                | 27,537                 | 3,858           | 7,911           | 29,538          | 20,314          | 2,405           | 91,858          | -               | -               |
| Sumatera Selatan       | 470,738               | 708                    | 20,497          | 360,591         | 10,821          | 13,166          | 41,029          | 446,812         | -               | -               |
| Bengkulu               | 50,758                | 28,540                 | 1,495           | 10,866          | 20,843          | -               | 61,744          | -               | -               | -               |
| Lampung                | 360,207               | 18,418                 | 181,669         | 8,199           | 139,572         | -               | 18,418          | 153,663         | 13,248          | 533,187        |
| Kepulauan Bangka       | 22,402                | 3,270                  | 618             | 18,113          | -               | -               | 1,998           | 578             | 24,576          | -               |
| Belitung               | 1,394                 | 140                    | -               | -               | -               | -               | -               | 152             | 678             | -               |
| DKI Jakarta            | 414                   | -                      | -               | -               | -               | -               | -               | -               | -               | 47              |
| Jawa Barat             | 927,843               | 541,823                | 163,943         | -               | 22,109          | 286,613         | 74,221          | 1,088,709       | -               | -               |
| Jawa Tengah            | 1,048,830             | 192,777                | 285,429         | 5,415           | 141,347         | 17,849          | 132,999         | 205,115         | 9,950           | 990,881        |
| DI Yogyakarta          | 76,312                | 6,672                  | 4,452           | 4,980           | 7,013           | 574             | 2,528           | 26,219          | -               | -               |
| Jawa Timur             | 1,215,128             | 111,201                | 205,772         | 1,400           | 230,922         | 10,590          | 69,552          | 94,586          | 18,065          | 742,089        |
| Banten                 | 204,338               | 24,168                 | 62,660          | 43,789          | 8,879           | 4,676           | 2,138           | 23,130          | 36,836          | 29,816          |
| Bali                   | 70,984                | -                      | -               | -               | 9,639           | 3,062           | -               | -               | 983             | 13,684         |
| Nusa Tenggara Barat   | 234,532               | -                      | -               | -               | 61,948          | -               | -               | -               | 61,948          | -               |
| Nusa Tenggara Timur    | 155,520               | -                      | -               | -               | -               | -               | -               | -               | -               | -               |
| Kalimantan Barat       | 242,988               | 103,071                | -               | -               | 75,294          | 41,437          | -               | -               | -               | 219,802        |
| Kalimantan Tengah      | 136,556               | 30,785                 | 51,515          | -               | -               | -               | 2,160           | 39,310          | -               | 123,770        |
| Kalimantan Selatan     | 291,076               | 45,402                 | 86,572          | -               | -               | 8,233           | 57,995          | 19,751          | -               | 217,952        |
| Kalimantan Timur       | 41,406                | 9                     | 1,944           | 2,110           | 278             | 9,681           | 472             | 5,060           | -               | 19,554         |
| Kalimantan Utara       | 11,922                | 875                    | -               | 1,226           | 922             | -               | -               | 3,022           | -               | -               |
| Sulawesi Utara         | 47,042                | 106                    | -               | 18,202          | 2,890           | 11,048          | -               | -               | -               | 32,245         |
| Sulawesi Tengah        | 116,587               | 4,741                  | 3,786           | 7,428           | 28,579          | 14,610          | 6,500           | -               | -               | 65,645         |
| Sulawesi Selatan       | 654,605               | 62,546                 | 242,731         | 14,842          | 4,980           | 13,633          | 7,360           | 38,515          | 201,559         | 586,167        |
| Sulawesi Tenggara      | 82,117                | -                      | 13,679          | 22,895          | 5,609           | 7,100           | -               | 30,411          | 79,686          | -               |
| Gorontalo              | 33,047                | -                      | 5,759           | 9,996           | 213             | -               | 3,265           | 1,615           | 4,217           | 11,781         |
| Sulawesi Barat         | 39,456                | 52                     | 11,630          | 7,982           | -               | 850             | -               | -               | -               | 20,514         |
| Maluku                 | 18,283                | -                      | -               | -               | -               | 16,591          | -               | -               | -               | 16,591         |
| Maluku Utara           | 13,542                | -                      | 29              | -               | 195             | -               | -               | 111             | -               | 2,916          |
| Papua Barat            | 8,860                 | 71                     | -               | 1,076           | 2,231           | -               | -               | -               | -               | 3,378          |
| Papua                  | 36,195                | 10,588                 | 11              | 338             | 1,283           | -               | -               | -               | -               | 12,220         |

Indonesia *1) 7,459,891 1,335,928 1,433,001 160,935 1,208,277 340,164 191,606 837,859 1,021,540 145,118 6,674,428 100.0% 17.9% 19.2% 2.2% 16.2% 4.6% 2.6% 11.2% 13.7% 1.9% 89.5%

*1) the percent value shows the proportion of the national official rice-fields area.
4. Conclusions

Wetland area in Indonesia predicted to have very dry condition during early dry season 2020 was indicated by the dominant rainfall intensity of <60 mm mo\(^{-1}\) spreading over 38.5% of the national official rice-fields area. Otherwise, at the end of dry season 2020, rainfall condition predicted to become wetter was indicated by dominant rainfall intensity of 200-300 mm mo\(^{-1}\) spreading over 58.5% of the national official rice-fields area. Total potential area for rice planting at rice-fields during dry season 2020 was 5,259,661 ha with the dominant planting time in April II-III. The total potential area for planting maize was 1,263,575 ha with the dominant planting time within August II-III. The total potential area for planting soybean was 559,545 ha with start planting time mainly in July III-August I.

Recommendation of planting schedule and potential planting for maize and soybean can be changed to rice recommendation by additional water supply of 25 mm mo\(^{-1}\) from alternative sources. The potential area for maize and soybean could be increased to 1,414,767 ha so that the potential for rice planting area changed to become 6,674,428 ha during dry season 2020. The largest increase in planting area occurred during planting time in August II-III and July III-August I.

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