Agricultural planning based on local agro-climatology assessment in Bongkot, Purwodadi, Purworejo

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Abstract. Bongkot, located in Purwodadi, Purworejo is a village dominated by wetland ricefield reaching 68% total area, with the majority of its population work as farmers. Climate parameters, especially rain intensity affect crop patterns. Farmers strongly depend on rain intensity to support productivity thus they need climate-based crop patterns. This study aims to plan agricultural calendar and crop patterns based on rainfall and dry patterns analysis. Rainfall data is derived from multi-temporal CHIRPS data. A monthly time series with thirty consecutive years (1990–2019) was used to identify local agro-climatology types. Climate of Bongkot generally has 5–6 consecutive wet months and 5–6 dry months. According to Oldeman criteria, this type belongs to C3, which is adequate to plant crops three times a year, with a couple of period for palawija crops on first and second planting, and one time paddy on November or December. The Oldeman classification can be applied as a climate-based crop adaptation.

1. Introduction
Bongkot is a village in Purwodadi Subdistrict, Purworejo which has an area of 129ha and consists of 4 hamlets namely Sawahan, Baon, Kalangan, and Klodran. Bongkot is dominated by wetland rice fields with an area of 88 hectares while dry land is only 41ha with 7.12 ha as settlements and 31.88ha as drylands/gardens [1]. In line with the wide use of land for agriculture, the main source of livelihood for the inhabitants of Bongkot is farming. The topography of Bongkot is generally flat with a slope of 0 – 2% and the south side of the village is close to shore. An intermittent river flows through Bongkot and is used for irrigation, but due to poor condition of the watershed, the rice fields are still very dependent on rainfall.

Farmers in Bongkot have limited access to groundwater and surface rivers, therefore they depend on rainfall to meet the needs of agricultural waters. Agricultural irrigation in Bongkot experiences the lack of water, causes low agriculture productivity.

This paper aims to analyze local agro-climatology type to plan climate-based crop patterns and calendar to raise agricultural productivity in Bongkot. Besides, this also presents commodities recommendations in line with the agriculture calendar and crop pattern.
2. Methods
This study uses rainfall data from Climate Hazards Group InfraRed Precipitation with Stations (CHIRPS). Local climate analysis in Bongkot village was carried out using monthly rainfall data for thirty consecutive years (1990-2019). Data extracted from CHIRPS provides the monthly rainfall in Bongkot Village. The amount of monthly rainfall was further classified into wet and dry months to determine the agro-climatic zone based on the Oldeman classification. The resulting agro-climatic zone can be used to help farmers determine a climate-based calendar and crop pattern, and adapt to climate conditions.

2.1 CHIRPS data processing (1990-2019)
Climate Hazards Group InfraRed Precipitation with Stations (CHIRPS) data is a global climate data set which incorporates satellite imagery with in-situ station data. CHIRPS data provides gridded rainfall data series of land area (ocean is not included) [2]. The CHIRPS dataset can be used for various purposes, such as for seasonal drought monitoring, environmental change over land monitoring, and rainfall trend analysis [3]. The CHIRPS rainfall data set combines local stations and 0.05° resolution satellite imagery, resulting in rainfall data with good accuracy [4]. CHIRPS data is public data that can be accessed by everyone at Climate Hazard Group (CHG) website of the University of California Santa Barbara (UCSB) (http://chg.geog.ucsb.edu/data/chirps/index.html) [3].

CHIRPS data processing with ArcGIS was first performed by overlaying the chirps data onto the map of the research location. Subsequently, the CHIRPS raster data (which covers the entire world) was cut into the Purwodadi District where Bongkot Village is located. After cutting the chirps data according to the research location map, rainfall data extraction is carried out by converting the CHIRPS raster dataset (.tif) to xyz value. The process of downloading, cutting raster data, and extracting monthly rainfall data is carried out 360 times to get monthly rainfall data for 30 years.

2.2 Rainfall data processing
The results of CHIRPS data processing are monthly rainfall value/data in Purwodadi sub-district. Monthly rainfall data is represented by each of the grid value. Due to the fact that the entire village of Bongkot is located in one grid, the data processing did not require rainfall value interpolation. The grid value was used to analyze Bongkot village’s rainfall patterns and trends. Monthly rainfall data from 1999 until 2019 were processed by calculating the average monthly rainfall for thirty years. Rainfall pattern analysis in Bongkot is carried out by utilizing the three-year simple moving average to acquire a graph of short-term rainfall pattern.

2.3 Oldeman Classification
Oldeman classification is a regional climate classification based on rainfall intensity. According to Oldeman, a wet month is a month with monthly rainfall above 200mm, while the dry month is a month with monthly rainfall below 100m. The Oldeman criteria of wet month and dry month are based on paddy water needs. Monthly rainfall above 200 millimetres is an ideal amount to meet paddy water needs, meanwhile monthly rainfall below 100 millimetres is only good enough for secondary crops [5].

Oldeman classifying the agro-climatology based on the number of consecutive wet month and dry month in a year. The detail of the criteria for each climate classification can be seen in the Table below (Table 1).

| Climate | Classification | Number of Consecutive Wet Month | Number of Consecutive Dry Month |
|---------|----------------|--------------------------------|--------------------------------|
| A       | A1             | >9 wet months                  | 1 dry month                     |
|         | A2             | >9 wet months                  | 2 dry months                    |

Table 1. The Oldeman classification
3. Results and Discussion

3.1 Rainfall analysis

Rainfall data processing carried out in this study yielded information that Bongkot Village has a monsoonal rain pattern. This information is obtained from the curve of the average monthly rainfall in Bongkot which is V-shaped and has one peak of the wet season (Fig. 1). This type or pattern of rainfall is also known as unimodal, a pattern where there is only one rainfall peak with no alternation of humid and dry months within the wet season [6]. The peak of the wet season in Bongkot occurs in December until February, while the worst dry season happens in August. Based on the average monthly rainfall for 30 years, the highest average monthly rainfall in Bongkot occurs in December, with a rain intensity of 381 mm/month, while the lowest monthly rainfall intensity is 26 mm/month.

The rainfall patterns in Bongkot vary within 1990–2019. Peaks and valleys of rainfall shown in Figure 2 are not repetitive, therefore those are difficult to forecast rainfall patterns for the next period. From the graph, it can be concluded that the average annual rainfall of Bongkot reaches up to almost 2400 mm/year.

Figure 1. Average Monthly Rainfall during 1990–2019
Analysis of the annual rainfall in Bongkot shows that in 2010 and 2016 annual rainfall reached its peak, while the lowest annual rainfall occurred in 1997. These three values (both 1997, 2010, and 2016) were strongly influenced by the ENSO incident that occurred in that year. The La Nina events that occurred in 2010 and 2016 resulted in very high annual rainfalls in Bongkot. Meanwhile, in 1997 the drought and low annual rainfall in Bongkot were due to the strong El Nino that year.

3.2 Oldeman classification

| Year/Month | January | February | March | April | May | June | July | August | September | October | November | December |
|------------|---------|----------|-------|-------|-----|------|------|--------|-----------|---------|-----------|----------|
| 1990       | 414     | 222      | 305   | 175   | 130 | 40   | 63   | 35     | 18        | 45      | 353       | 464      |
| 1991       | 375     | 360      | 305   | 175   | 130 | 40   | 63   | 35     | 18        | 45      | 353       | 464      |
| 1992       | 265     | 286      | 273   | 213   | 161 | 62   | 41   | 85     | 70        | 272     | 352       | 416      |
| 1993       | 222     | 712      | 376   | 190   | 162 | 120  | 47   | 9      | 25        | 18      | 241       | 317      |
| 1994       | 356     | 395      | 600   | 116   | 122 | 12   | 15   | 20     | 25        | 19      | 109       | 217      |
| 1995       | 214     | 431      | 371   | 217   | 191 | 95   | 32   | 6      | 34        | 101     | 372       | 327      |
| 1996       | 356     | 350      | 226   | 257   | 193 | 25   | 19   | 5      | 21        | 236     | 301       | 345      |
| 1997       | 264     | 208      | 86    | 135   | 77  | 19   | 9    | 5      | 18        | 117     | 326       | 305      |
| 1998       | 201     | 465      | 685   | 137   | 185 | 151  | 85   | 15     | 23        | 236     | 375       | 273      |
| 1999       | 393     | 234      | 682   | 196   | 91  | 18   | 14   | 22     | 214       | 348     | 464       | 464      |
| 2000       | 316     | 327      | 384   | 297   | 186 | 80   | 27   | 42     | 51        | 273     | 506       | 516      |
| 2001       | 387     | 291      | 311   | 312   | 120 | 122  | 68   | 6      | 143       | 437     | 942       | 615      |
| 2002       | 332     | 401      | 233   | 100   | 92  | 14   | 20   | 0      | 11        | 265     | 353       | 353      |
| 2003       | 261     | 416      | 217   | 369   | 54  | 13   | 13   | 10     | 31        | 150     | 232       | 449      |
| 2004       | 265     | 336      | 375   | 366   | 161 | 53   | 56   | 12     | 10        | 25      | 315       | 433      |
| 2005       | 255     | 226      | 432   | 146   | 117 | 60   | 67   | 45     | 75        | 150     | 252       | 469      |
| 2006       | 235     | 351      | 431   | 210   | 205 | 22   | 17   | 10     | 15        | 7       | 350       | 350      |
| 2007       | 110     | 362      | 687   | 253   | 151 | 49   | 21   | 16     | 14        | 133     | 273       | 749      |
| 2008       | 175     | 408      | 647   | 203   | 58   | 22   | 15   | 21     | 37        | 198     | 431       | 357      |
| 2009       | 258     | 384      | 191   | 208   | 271 | 70   | 19   | 5      | 21        | 84      | 353       | 209      |
| 2010       | 293     | 313      | 423   | 183   | 546 | 111  | 164  | 88     | 258       | 375     | 544       | 483      |
| 2011       | 240     | 311      | 342   | 134   | 163 | 24   | 41   | 6      | 12        | 120     | 337       | 430      |
| 2012       | 310     | 280      | 208   | 197   | 145 | 44   | 215  | 16     | 15        | 120     | 344       | 490      |
| 2013       | 283     | 350      | 277   | 177   | 324 | 151  | 100  | 17     | 20        | 30      | 230       | 554      |
| 2014       | 326     | 332      | 305   | 147   | 100 | 193  | 79   | 11     | 17        | 111     | 333       | 590      |
| 2015       | 224     | 324      | 385   | 210   | 125 | 22   | 13   | 15     | 8         | 171     | 537       | 537      |
| 2016       | 254     | 335      | 375   | 328   | 186 | 263  | 248  | 136    | 234       | 1605    | 915       | 367      |
| 2017       | 343     | 383      | 240   | 225   | 219 | 10   | 24   | 10     | 76        | 222     | 626       | 408      |
| 2018       | 374     | 269      | 243   | 163   | 85   | 16   | 11   | 10     | 16        | 341     | 309       | 309      |
| 2019       | 357     | 330      | 407   | 213   | 48   | 12   | 14   | 26     | 12        | 11      | 30        | 380      |

Note: Wet Month
Dry Month

Bongkot generally has a climate with 5 until 6 wet months in a row, and 5 or 6 consecutive dry months (See Table 2). Rainfall classification of Bongkot village based on Oldeman’s criteria results
that in general Bongkot village has a C3 climate type. The C3 climate type is good enough for three crops per year, with rice crops / paddy being planted only once. Secondary crops or Palawija can be planted twice a year, but the timing for second crops needs to be counted carefully to not fall in dry month. The C3 climate type cannot be planted with rice regularly due to the lack of wet months. In addition, without an irrigation system capable of irrigating rice fields, rice cultivation is quite risky and prone to crop failure.

3.3 Agricultural plan based on local agro-climatology assessment

Agro-climatology analysis is carried out by classifying monthly rainfall data (Table 1) into the Oldeman classification. The classification results show that Bongkot area is generally classified as type C3. That means wetland rice-fields in Bongkot in a year can only plant paddy/rice once and palawija/secondary crops twice. Based on this agro-climatology analysis, the rice planting is recommended to be carried out in the wet month of November or December due to high risk of its initiation in October. After harvesting paddy, planting the first palawija crops should be done in February-March, while the second palawija crops must be carried out carefully not to fall in the dry month. Therefore, the crop pattern that can be applied in Bongkot is Palawija-Palawija-Paddy.

Based on the Oldeman classification, the right commodities are rice in the last planting period (November-December), and secondary crops (palawija) in the first planting period (February-March) and second. Generally recommended crops are corn and soybeans. Still, various types of crops can be tried and later farmers can decide for themselves what crops are the most profitable. Recommendations for paddy, corn, and soybean varieties refer to the data from The Ministry of Agriculture. The recommended varieties are detailed based on the potential for agricultural disasters that occur in Purwodadi District, Purworejo.

![Figure 3. Recommended Paddy Varieties](image1)

![Figure 4. Recommended Corn Varieties](image2)
4 Conclusion

Rice-field field makes up more than 60% of the landuse in Bongkot as the majority of Bongkot local residents work as farmers. Irrigation system that has limited water support, in addition to limited access to groundwater and surface rivers, causing low agriculture productivity in Bongkot. Agriculture in bongkot is strongly influenced by rainfall, therefore adapting to the climate becomes significant. Based on Oldeman's classification, Bongkot has a C3 agro-climatology type. Bongkot, with five until six wet months in a year and five or six consecutive dry months is sufficient to grow crops three times a year, with secondary crops on the first and second planting, and a single period for paddy on November or December. The cropping pattern and calendar based on the Oldeman classification recommended in this study can be applied as a climate-based crop adaptation that farmers in Bongkot Village can do to raise agricultural productivity.

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