Shifting cropping shifts by efficient irrigation water to produce maximum rice productivity

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Abstract. Agriculture is the main support of the economy in Indonesia so that the sustainability of the productivity of paddy fields must be maintained properly. Rice fields rely heavily on irrigation water supplies from technical rigs. Continuity of water flow must be maintained in accordance with water requirements and cropping patterns in each paddy field. In connection with changes in conditions lately there has been a shift in the rainy season and the dry season which results in erratic discharge of surface water both in quantity and on time so that the use of irrigation water must be done wisely and efficiently to maintain the productivity of the yield of paddy fields. From the results of the implementation of the cropping pattern set by the relevant agency there has been a deviation of 13.81%, which means that it is necessary to improve the implementation of cropping patterns and adjust the time of rain so that rice productivity remains maximal.

1. Introduction

The provision of irrigation water for agriculture needs to be managed in a wise and sustainable manner so that its existence and functions are maintained, one of which is to provide benefits in agriculture. The Irrigation Area (DI) Molek is one of 44 Irrigation Areas in the Malang-Indonesia Regency area which has 3,983 hectares of paddy fields. Maintenance of irrigation network is also very important in order to ensure continuity of irrigation water allocation. [1] Planting planning is outlined in the planting document called the Global Planting Plan (RTTG). From year to year, the method of preparing this Global Planting Plan has not changed even though the current situation and conditions are different.

The duration of the rainy and dry seasons is not fixed, sometimes the rainy season lasts less than 6 (six) months and sometimes more, as well as the dry season [2]. This condition causes the availability of surface water to become erratic and if the surface water is affected, the water discharge conditions are also affected so that it needs to be done by adjusting the surface water adaptation to climate change [3]. Climate change is projected to have a significant impact on conditions affecting agriculture [4].

From the results of the evaluation of the Global Planting Plan presented in Table 1 attached below, it can be concluded that there has been a deviation in the pattern of cropping arrangements of 13.81%, meaning that the implementation of the Global Planting Plan is not in accordance with the plan and needs to develop a new Global Planting Plan applicative and dynamic and keep up with the progress of the rain discharge conditions.
Table 1. Evaluation of the global planting plan

| Irrigation / Raw Rice Field Area (Ha) | RTTG (Ha) | Realization of Planting Patterns Rice Special (Ha) | Compliance with RTTG (%) | Deviation (%) |
|-------------------------------------|-----------|-------------------------------------------------|--------------------------|---------------|
| DI Molek 3983                       | 3974      | 3425                                            | 86.11                    | 13.81         |

From the problems that occur, make the background and rationale for doing research to produce an appropriate analysis of water needs as a basis for determining the Global Planting Plan.

All stakeholders involved in the planning and implementation of the allocation of irrigation water understand climate change situations and conditions that are very influential on surface water and irrigation water so they argue that the Global Planting Plan arrangement must be adapted to climate change conditions to avoid the possibility of crop failure. [5].

More and more research shows that the world is warming and will continue to warm up when greenhouse gas concentrations increase in the future [6]. Productivity is influenced by a number of climate change variables including rainfall patterns, temperature increases, changes in sowing and harvesting, water availability and land suitability [7]. One of the most important impacts of climate change is the change in water available at the regional and local levels [8].

2. Materials and methods

Administratively, Molek Irrigation Area is located in Malang Regency. The average annual rainfall is 1,500 mm. Water sources Molek Irrigation Area originates from Mount Arjuno which flows through Brantas River which is channeled through the 12.44 Km Molek canal. The research framework is as in Table 2.

Table 2. Study framework

| No | Stages of Calculation / Analysis | Data source | Calculation / analysis method | Results |
|----|--------------------------------|-------------|-------------------------------|---------|
| 1  | Data Quality Test              | Historical rainfall and discharge data | Rescaled Adjusted Partial Sums Method | Analysis requirements are accepted (still within consistent limits) if the values of Q / (n0.5) and R / (n0.5) count smaller than the values of Q / (n0.5) and R / (n0.5) |
| 3  | Mainstay Debit Debit Data      | Debit Data  | Weibull Method Pr = m / (n+1) * 100 % | Debit of Wet Season , Normal Season, Dry Season |
| 4  | Mainstay Rainfall Historical rainfall data | Rainfall formula \( R_{80} = \frac{n}{5} + 1 \) \( (reliability 80 \%) \) \( R_{50} = \frac{n}{2} + 1 \) \( (reliability 50 \%) \) | Mainstay Rain Pattern |
| 5  | Effective Rainfall Historical rainfall data | Frequency Analysis Formula | rice : \( R_e = (0.70 \times R_{80})/day \) secondary crops : \( R_{e} = R_{50}/day \) |
| 6  | Evapotranspiration Climatology Data | Modified Penman | Eto , mm/day |
| 7  | Water Needs for Soil Processing and Nursery | The duration of the tillage | Determined | Land preparation = 30 days Soil processing + Nursery = 250 mm/day |
Table 2. Study framework (cont.)

| No | Stages of Calculation / Analysis | Data source                                                                 | Calculation / analysis method                                                                 | Results                                      |
|----|----------------------------------|------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------|
| 8  | Percolation                      | Soil sample data and map of soil type distribution                          | Soil Test in the Laboratory to determine permeability numbers                                  | Percolation Numbers                          |
| 9  | Water Requirements for Land Preparation | Potential Evapotranspiration of the Penmann Modification Method, Percolation Calculation | Suyono + Takeda C PL = C land preparation x extensive planting ratio                           | IR, mm/day                                  |
| 10 | Water Level Requirement          | Estimated soil fertility                                                     | Determined                                                                                      | Change of Water Layer = 50 mm/month          |
| 11 | Irrigation Efficiency            | Debit Intake                                                                 | Water loss in Primary, Secondary and Tertiary channels                                        | Irrigation Efficiency Rainy Season          |
|    |                                  |                                                                              |                                                                                                 | Irrigation EfficiencyDry Season 1          |
|    |                                  |                                                                              |                                                                                                 | Irrigation EfficiencyDry Season 2          |
| 12 | Balance sheet needs and availability of water | Regional Irrigation of Irrigation Water Needs Molek | Water balance concept                                                                        | Comparison of the value of the amount of availability to needs |
| 13 | Planting Pattern Simulation      | Data and Simulation                                                          | Relative Crops Factor - Area of Relative Palawija                                             | Irrigation Water Needs and Extensive Planting Area are optimal for Wet Season Year, Normal Season Year and Dry Season Year. |
| 14 | Preparation of a Global Planting Plan | Simulation Results                                                          | Rainy Season Early Planting Dry Season 1 Early Planting Dry Season 2 Early Planting          | Wet Season Year Dry Season Year Normal Season Year |

3. Results and discussion

The results of the analysis of the data and observations can produce the following result as shown in Table 3, Table 4, Table 5 and Table 6.

Table 3. Rainfall data consistency results

| Station Name  | Number | Coefficient Determination (%) |
|---------------|--------|--------------------------------|
| Sumber Pucung | 36     | 99.89                          |
| Kepanjen      | 39     | 99.59                          |
| Kali Pare     | 40     | 99.80                          |
| Pagak         | 64     | 99.21                          |
Table 4. Analysis of availability of irrigation intake discharge

| Opportunity (80%) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 80                | 4.80| 5.97| 6.47| 6.47| 6.42| 6.15| 5.85| 5.04| 4.89| 4.54| 5.69| 5.69|
| 90                | 3.52| 3.63| 5.00| 3.65| 3.49| 3.22| 3.09| 2.98| 2.88| 2.91| 4.35| 3.14|
| 25                | 7.26| 7.38| 7.43| 7.38| 7.40| 7.46| 7.42| 7.37| 7.16| 6.99| 6.71| 7.35|

Table 5. Mainstay rainfall 80% and 50%

| Month         | Period | R 80 (mm) | R 50 (mm) | Month | Period | R 80 (mm) | R 50 (mm) |
|---------------|--------|-----------|-----------|-------|--------|-----------|-----------|
| January       | 1      | 72.09     | 77.66     | July  | 1      | 0.00      | 1.41      |
|               | 2      | 29.32     | 55.80     |       | 2      | 0.00      | 0.00      |
|               | 3      | 98.04     | 95.02     |       | 3      | 0.00      | 0.00      |
| February      | 1      | 71.77     | 121.63    | August| 1      | 0.00      | 0.00      |
|               | 2      | 122.96    | 61.68     |       | 2      | 0.00      | 0.00      |
|               | 3      | 71.19     | 102.42    |       | 3      | 0.00      | 0.00      |
| March         | 1      | 123.02    | 37.64     | September| 1      | 0.00      | 0.00      |
|               | 2      | 87.31     | 84.56     |       | 2      | 0.00      | 0.06      |
|               | 3      | 26.13     | 192.76    |       | 3      | 0.00      | 2.94      |
| April         | 1      | 82.52     | 119.91    | October| 1      | 0.00      | 20.56     |
|               | 2      | 63.62     | 99.42     |       | 2      | 0.00      | 41.37     |
|               | 3      | 46.64     | 0.01      |       | 3      | 24.31     | 43.02     |
| May           | 1      | 24.43     | 47.22     | November| 1      | 11.54     | 73.98     |
|               | 2      | 32.68     | 31.43     |       | 2      | 41.77     | 58.50     |
|               | 3      | 0.00      | 0.49      |       | 3      | 72.52     | 73.59     |
| June          | 1      | 0.00      | 5.39      | December| 1      | 30.26     | 210.53    |
|               | 2      | 0.00      | 14.12     |       | 2      | 43.95     | 15.88     |
|               | 3      | 0.00      | 0.49      |       | 3      | 122.86    | 92.94     |

Table 6. Effective rainfall analysis

| Month    | Period | R 80 (mm) | Re rice (mm/day) | Re Secondary Plant (lt/sec/ha) |
|----------|--------|-----------|------------------|-------------------------------|
| January  | 1      | 72.09     | 5.05 0.59        | 77.66 7.77 0.90                |
|          | 2      | 29.32     | 2.05 0.24        | 55.80 5.58 0.65                |
|          | 3      | 98.04     | 6.86 0.80        | 95.02 9.50 1.10                |
| February | 1      | 71.77     | 5.02 0.58        | 121.63 12.16 1.41              |
|          | 2      | 122.96    | 8.61 1.00        | 61.68 6.17 0.72                |
|          | 3      | 71.19     | 4.98 0.58        | 102.42 10.24 1.19              |
| March    | 1      | 123.02    | 8.61 1.00        | 37.64 3.76 0.44                |
|          | 2      | 87.31     | 6.11 0.71        | 84.56 8.46 0.98                |
|          | 3      | 26.13     | 1.83 0.21        | 192.76 19.28 2.24              |
| April    | 1      | 82.52     | 5.78 0.67        | 119.91 11.99 1.39              |
|          | 2      | 63.62     | 4.45 0.52        | 99.42 9.94 1.15                |
|          | 3      | 46.64     | 3.26 0.38        | 0.01 0.00 0.00                 |
| May      | 1      | 24.43     | 1.71 0.20        | 47.22 4.72 0.55                |
|          | 2      | 32.68     | 2.29 0.27        | 31.43 3.14 0.36                |
|          | 3      | 0.00      | 0.00 0.00        | 0.00 0.05 0.01                 |
| June     | 1      | 0.00      | 0.00 0.00        | 0.00 0.05 0.01                 |
|          | 2      | 0.00      | 0.00 0.00        | 0.00 0.05 0.01                 |
|          | 3      | 0.00      | 0.00 0.00        | 0.00 0.05 0.01                 |
| July     | 1      | 0.00      | 0.00 0.00        | 0.00 0.05 0.01                 |
|          | 2      | 0.00      | 0.00 0.00        | 0.00 0.05 0.01                 |
|          | 3      | 0.00      | 0.00 0.00        | 0.00 0.05 0.01                 |
Table 6. Effective rainfall analysis (cont.)

| Month   | Period | R 80 (mm) | Re rice (mm) | Re Secondary Plant (mm) |
|---------|--------|-----------|--------------|-------------------------|
|         |        | (mm/day)  | (lt/sec/ha)  | (mm/day)                | (lt/sec/ha) |
| August  | 1      | 0.00      | 0.00         | 0.00                    | 0.00        |
|         | 2      | 0.00      | 0.00         | 0.00                    | 0.00        |
|         | 3      | 0.00      | 0.00         | 0.00                    | 0.00        |
| September | 1   | 0.00      | 0.00         | 0.00                    | 0.00        |
|         | 2      | 0.00      | 0.00         | 0.00                    | 0.00        |
|         | 3      | 0.00      | 0.00         | 0.00                    | 0.00        |
| October | 1      | 0.00      | 0.00         | 0.00                    | 0.00        |
|         | 2      | 0.00      | 0.00         | 0.00                    | 0.00        |
|         | 3      | 24.31     | 17.02        | 1.70                    | 0.20        |
| November| 1      | 24.31     | 17.02        | 1.70                    | 0.20        |
|         | 2      | 41.77     | 29.24        | 2.92                    | 0.34        |
|         | 3      | 72.52     | 50.76        | 5.08                    | 0.59        |
| December| 1      | 30.26     | 21.19        | 2.12                    | 0.25        |
|         | 2      | 43.95     | 30.76        | 3.08                    | 0.36        |
|         | 3      | 122.86    | 86.00        | 8.60                    | 1.00        |
| Total   |        | 1741.25   | 909.27       | 90.93                   | 10.55       |

Climatology data and Potential Evaporation for calculating irrigation water requirements is shown in Table 7.

Table 7. Climatology data and ETo (Potential Evaporation)

| Month  | Average Temperature °C | Humidity% | Wind velocity km/day | Duration of solar radiation hour | Radiation MJ/m²/day | ETo (Potential Evaporation) mm/day |
|--------|------------------------|-----------|----------------------|----------------------------------|---------------------|-----------------------------------|
| January| 22.9                   | 76        | 95                   | 6.1                              | 19.3                | 3.81                              |
| February| 23.2                   | 76        | 94                   | 5.5                              | 18.5                | 3.73                              |
| March  | 23.2                   | 76        | 76                   | 6.3                              | 19.3                | 3.77                              |
| April  | 23.4                   | 71        | 83                   | 6.6                              | 18.5                | 3.66                              |
| May    | 23.1                   | 68        | 91                   | 7.8                              | 18.6                | 3.58                              |
| June   | 23.3                   | 69        | 98                   | 7.8                              | 17.7                | 3.42                              |
| July   | 22.4                   | 69        | 102                  | 7.9                              | 18.2                | 3.46                              |
| August | 22.2                   | 70        | 102                  | 8.3                              | 20.2                | 3.78                              |
| September | 22.7               | 72        | 102                  | 8.6                              | 22.3                | 4.20                              |
| October| 23.0                   | 70        | 94                   | 8.2                              | 22.5                | 4.34                              |
| November| 23.4                   | 68        | 91                   | 8.2                              | 22.5                | 4.43                              |
| December| 22.8                   | 73        | 89                   | 7.0                              | 20.5                | 4.02                              |

The duration of land preparation is 30 days. Water requirements for tillage and nursery are 250 mm which consists of 200 mm used for saturation and 50 mm for nursery. To estimate the water requirements for land preparation, the percolation value in the study area must be known. The percolation value is shown in Table 8.

Table 8. Magnitude of Percolation Value

| No  | Kinds of Land | Vertical percolation (mm/day) |
|-----|---------------|-----------------------------|
| 1   | Sandy loam    | 3 – 6                       |
| 2   | Loam          | 2 - 3                       |
| 3   | Clay          | 1 – 2                       |

Then the water requirements for land preparation can be calculated which the results which are shown in Table 9.


Table 9. Water requirements for land preparation

| Month   | Eto mm/day | Eo mm/day | P mm/day | M mm/day | S mm | T days | K | IR mm/day |
|---------|------------|-----------|----------|----------|------|--------|---|-----------|
| January | 3.810      | 4.191     | 4.5      | 8.691    | 250  | 30     | 1.0429 | 13.42     |
| February| 3.730      | 4.103     | 4.5      | 8.603    | 250  | 30     | 1.0324 | 13.36     |
| March   | 3.770      | 4.147     | 4.5      | 8.647    | 250  | 30     | 1.0376 | 13.39     |
| April   | 3.660      | 4.026     | 4.5      | 8.526    | 250  | 30     | 1.0231 | 13.31     |
| May     | 3.580      | 3.938     | 4.5      | 8.438    | 250  | 30     | 1.0126 | 13.25     |
| June    | 3.420      | 3.762     | 4.5      | 8.262    | 250  | 30     | 0.9914 | 13.14     |
| July    | 3.460      | 3.806     | 4.5      | 8.306    | 250  | 30     | 0.9967 | 13.17     |
| August  | 3.780      | 4.158     | 4.5      | 8.658    | 250  | 30     | 1.0390 | 13.40     |
| September| 4.200    | 4.620     | 4.5      | 9.120    | 250  | 30     | 1.0944 | 13.71     |
| October | 4.340      | 4.774     | 4.5      | 9.274    | 250  | 30     | 1.1129 | 13.81     |
| November| 4.430      | 4.873     | 4.5      | 9.373    | 250  | 30     | 1.1248 | 13.88     |
| December| 4.020      | 4.422     | 4.5      | 8.922    | 250  | 30     | 1.0706 | 13.58     |

Water Level Requirement is estimated at 50 mm. When using a 10 day period, the Water Level Requirement (WLR) of 50 mm is divided into 30 days, which is equal to 1.67 mm / day.

Irrigation efficiency is a comparison between the water discharge that arrives at the agricultural land and the water discharge coming out of the take-up gate. Before arriving at the paddy field, water must be flowed from the source through the main, secondary and tertiary canals.

Irrigation Efficiency is calculated based on water loss during the drainage process along the channel. Irrigation efficiency can be shown in Table 10.

Recapitulation of water balance conditions for existing planting can be shown in Table 11.

Table 10. Calculation of Irrigation Efficiency

| Season  | Month   | Primary Loss (m3/sec) | Secondary Loss (m3/sec) | Irrigation Efficiency (%) |
|---------|---------|-----------------------|-------------------------|--------------------------|
| Rainy   | November| 28.05                 | 17.64                   | 66.38                    |
| Season  | December| 20.30                 | 16.65                   | 71.26                    |
|         | February| 20.82                 | 21.33                   | 68.22                    |
|         | March   | 19.36                 | 20.74                   | 69.39                    |
|         | April   | 22.35                 | 16.42                   | 70.21                    |
| Dry     | May     | 28.80                 | 19.81                   | 66.67                    |
| Season 1| June    | 25.28                 | 19.05                   | 67.05                    |
|         | July    | 25.74                 | 19.29                   | 66.67                    |
| Dry     | August  | 30.17                 | 19.64                   | 64.21                    |
| Season 2| September| 33.35               | 23.08                   | 60.93                    |

Table 11. Recapitulation of Water Balance Conditions for Existing Planting

| Month   | Period | Irrigation Needs Intake (m3/sec) | Dry Season River Discharge (m3/sec) | Wet Season River Discharge (m3/sec) |
|---------|--------|---------------------------------|-----------------------------------|-----------------------------------|
| January | 1      | 7.06                            | 3.52                              | 4.80                              | 7.26                            |
|         | 2      | 7.93                            | 3.52                              | 4.80                              | 7.26                            |
|         | 3      | 5.35                            | 3.52                              | 4.80                              | 7.26                            |
| February| 1      | 5.32                            | 3.63                              | 5.97                              | 7.38                            |
|         | 2      | 3.30                            | 3.63                              | 5.97                              | 7.38                            |
|         | 3      | 4.91                            | 3.63                              | 5.97                              | 7.38                            |
| March   | 1      | 3.41                            | 5.00                              | 6.47                              | 7.43                            |
|         | 2      | 4.39                            | 5.00                              | 6.47                              | 7.43                            |
|         | 3      | 6.31                            | 5.00                              | 6.47                              | 7.43                            |
Table 11. Recapitulation of Water Balance Conditions for Existing Planting (cont.)

| Month | Period | Irrigation Needs Intake (m³/sec) | Dry Season River Discharge (m³/sec) | Information | Normal Season River Discharge (m³/sec) | Information | Wet Season River Discharge (m³/sec) | Information |
|-------|--------|---------------------------------|------------------------------------|-------------|----------------------------------------|-------------|------------------------------------|-------------|
| April | 1      | 4.54                            | 3.65                               | Not enough  | 6.47                                   | Enough      | 7.38                               | Enough      |
|       | 2      | 5.32                            | 3.65                               | Not enough  | 6.47                                   | Enough      | 7.38                               | Enough      |
|       | 3      | 6.32                            | 3.65                               | Not enough  | 6.47                                   | Enough      | 7.38                               | Enough      |
| May   | 1      | 6.39                            | 3.49                               | Not enough  | 6.42                                   | Enough      | 7.40                               | Enough      |
|       | 2      | 6.08                            | 3.49                               | Not enough  | 6.42                                   | Enough      | 7.40                               | Enough      |
|       | 3      | 6.61                            | 3.49                               | Not enough  | 6.42                                   | Not enough  | 7.40                               | Enough      |
| June  | 1      | 5.98                            | 3.22                               | Not enough  | 6.99                                   | Enough      | 7.46                               | Enough      |
|       | 2      | 5.58                            | 3.22                               | Not enough  | 6.99                                   | Enough      | 7.46                               | Enough      |
|       | 3      | 5.77                            | 3.22                               | Not enough  | 6.99                                   | Enough      | 7.46                               | Enough      |
| July  | 1      | 6.65                            | 3.09                               | Not enough  | 5.85                                   | Not enough  | 7.42                               | Enough      |
|       | 2      | 6.67                            | 3.09                               | Not enough  | 5.85                                   | Not enough  | 7.42                               | Enough      |
|       | 3      | 6.67                            | 3.09                               | Not enough  | 5.85                                   | Not enough  | 7.42                               | Enough      |
| August| 1      | 6.60                            | 2.98                               | Not enough  | 5.04                                   | Not enough  | 7.37                               | Enough      |
|       | 2      | 7.04                            | 2.98                               | Not enough  | 5.04                                   | Not enough  | 7.37                               | Enough      |
|       | 3      | 7.86                            | 2.98                               | Not enough  | 5.04                                   | Not enough  | 7.37                               | Not enough  |
| September | 1     | 8.61                            | 2.88                               | Not enough  | 4.89                                   | Not enough  | 7.16                               | Not enough  |
|       | 2      | 8.48                            | 2.88                               | Not enough  | 4.89                                   | Not enough  | 7.16                               | Not enough  |
|       | 3      | 7.66                            | 2.88                               | Not enough  | 4.89                                   | Not enough  | 7.16                               | Not enough  |
| October | 1    | 6.85                            | 2.91                               | Not enough  | 4.54                                   | Not enough  | 6.99                               | Enough      |
|       | 2      | 6.22                            | 2.91                               | Not enough  | 4.54                                   | Not enough  | 6.99                               | Enough      |
|       | 3      | 5.64                            | 2.91                               | Not enough  | 4.54                                   | Not enough  | 6.99                               | Enough      |
| November | 1   | 4.68                            | 4.35                               | Not enough  | 5.69                                   | Enough      | 6.71                               | Enough      |
|       | 2      | 4.16                            | 4.35                               | Not enough  | 5.69                                   | Enough      | 6.71                               | Enough      |
|       | 3      | 3.56                            | 4.35                               | Enough      | 5.69                                   | Enough      | 6.71                               | Enough      |
| December | 1  | 4.52                            | 3.14                               | Not enough  | 5.69                                   | Enough      | 7.35                               | Enough      |
|       | 2      | 5.32                            | 3.14                               | Not enough  | 5.69                                   | Enough      | 7.35                               | Enough      |
|       | 3      | 4.37                            | 3.14                               | Not enough  | 5.69                                   | Enough      | 7.35                               | Enough      |

Considering that the planting in one year is divided into 3 (three) seasons, namely the Rainy Season (MH), Dry Season 1 (MK1) and Dry Season 2 (MK2), and based on the effective rainfall pattern, the rainy month is November to April. Good months of start the planting is as the follows.

- Schedule for early planting of November period I
- Schedule for early planting of November period II
- Schedule for early planting of November period II
- Schedule for early planting of December period I
- Schedule for early planting of December period II
- Schedule for early planting of December period III
- Schedule for early planting of January period I
- Schedule for early planting of January period I
- Schedule for early planting of January period II
- Schedule for early planting of January period III
- Schedule for early planting of February period I
- Schedule for early planting of February period II
- Schedule for early planting of February period III

4. Conclusion
This shift in planting time was generated from simulations of rise planting area and secondary crops which produced the most optimal planting area.

Based on the research, shifting planting schedule that produces maximum production is as follows.
Table 12. Conclusion

| Season        | Global Planting Plan of Existing | New Global Planting Plan of Wet Season Year | New Global Planting Plan of Normal Season Year | New Global Planting Plan of Dry Season Year |
|---------------|---------------------------------|--------------------------------------------|-----------------------------------------------|-------------------------------------------|
| Rainy Season  |                                 |                                            |                                               |                                           |
| Group I       | 10 December                      | 1 December                                 | 20 February                                  | 20 February                               |
| Group II      | 15 December                      | 10 December                                | 1 March                                      | 1 March                                   |
| Group III     | 20 December                      | 20 December                                | 10 March                                     | 10 March                                  |
| Dry Season 1  |                                 |                                            |                                               |                                           |
| Group I       | 21 March                         | 1 April                                   | 20 June                                      | 20 June                                   |
| Group II      | 25 March                         | 10 April                                  | 1 July                                       | 1 July                                    |
| Group III     | 30 March                         | 20 April                                  | 10 July                                      | 10 July                                   |
| Dry Season 2  |                                 |                                            |                                               |                                           |
| Group I       | 20 August                        | 1 August                                  | 20 October                                   | 20 October                                |
| Group II      | 25 August                        | 10 August                                 | 1 November                                   | 1 November                                |
| Group III     | 30 August                        | 20 August                                 | 10 November                                  | 10 November                               |

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