Potential of Ratoon Rice Farming Development in Central Java Province, Indonesia for Climate Change Adaptation and Mitigation

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Abstract. Ratoon rice farming is the method of harvesting rice for 2-3 times by maintaining and growing the shoots from the previous tillers. In Central Java, Indonesia, ratoon rice is local wisdom in farming called Singgang. Nowadays, almost no farmers are implementing ratoon rice farming, in spite of many advantages for climate change adaptation and mitigation. The objectives of this research are to identify and to map out the current implementation of ratoon rice farming in Central Java; and to formulate the strategies to develop the ratoon rice farming as local wisdom in Central Java. This research was conducted from November 2019 to January 2020, using qualitative research with the FGD method. The research location was chosen by purposive sampling according to three irrigation systems, namely: rainfed rice field in Gondangrejo, Karanganyar Regency; Tidal rice field in Tuntang, Semarang Regency; and technical irrigation rice field in Kebonagung, Demak Regency. The data obtained were analyzed using the SWOT (Strength, Weakness, Opportunities and Threats technique). The results showed that the highest potential to develop ratoon rice farming in Central Java is on rainfed land. Development of ratoon rice for climate change adaptation and mitigation is influenced by the characteristics of farmers, environmental conditions, irrigation systems, the activity of extension workers and farmer groups, the motivation of farmers to innovate. Therefore, the strategies suggested to develop the system are: to increase the role of extension workers and farmer groups, as well as agricultural production facilities, so that the motivation to maintain the local wisdom and accept technological innovations raise; and to minimize the decline in ratoon rice production by intensive farming management and specifically create ratoon rice farming area.

1. Introduction

Rice is one of the main food crops in Indonesia. Rice needs in Indonesia are known to increase with the increasing population of Indonesia. BPS (2018) \cite{1} states that rice production data in 2018 are estimated to reach 32.42 million tons. The national rice consumption in 2018 January the total
domestic rice consumption reached 29.57 million tons. As a result, the rice balance is estimated to have a surplus of 2.85 million tons. However, for the last three months of 2018 rice production is expected to fall and only reach 3.94 million tons while consumption is 7.45 million tons resulting in a deficit of around 3.51 million tons.

The government must have the right way so that rice needs in Indonesia can be met without imports. The agricultural sector is the sector most vulnerable to the phenomenon of climate change. Climate change can cause changes in weather patterns, increase temperatures which can trigger drought and increase the intensity of pests and diseases that can lead to lower yields. The majority of farmers use conventional farming systems with high input which can be negative.

Conventional agriculture causes environmental damage, among others, seen from the loss of land surface, water pollution and loss of biodiversity [2]. Planting rice with a conventional system is known to damage the soil and increase environmental pressures [3,4,5] due to the high use of inputs. This condition encourages the need to increase national rice production [6] without (or reducing) environmental damage. Therefore, more efficient and environmentally friendly methods need to be developed but rice production continues to increase. To overcome these problems, action must be taken to seek various ways, both through innovation and exploring and developing local wisdom. One of the local wisdom in agriculture that has existed for a long time in the Matrix is used to arrange strategies for developing rice ratoon farming in an effort for climate change adaptation and mitigation community but has begun to be abandoned is local wisdom in the form of ratoon rice.

Ratoon rice is one form of local wisdom that has existed since ancient times and is native to Indonesia. In other areas people call it “suli rice”, “padi berlanjut”, “ratun” or “singgang” (Javanese) or “turiang” (Sundanese) and others according to their respective regional languages [7]. The rice ratoon system is the cultivation of rice by utilizing crop cultivation that has been cut after harvest to regrow and can be harvested for the second or third time. So far, ratoon rice has only been used as fodder forage, because the grain produced is not economically profitable [8].

Ratoon rice is known to be more efficient and economical compared to conventional rice cultivation. In the conventional system, initial planting requires a lot of labor for tillage, nursery, transplanting, weeding and the cost of buying seeds. The occurrence of climate change urgently used rice cultivation which must support a more efficient cultivation system. This efficiency is closely related to increasingly limited resources both in quality and quantity. Production costs in the ratoon rice system are lower because there is no need to cultivate land and replanting, fewer fertilizers are needed, shorter harvest life, once planting but can be harvested at least 2 times. Ratoon rice system has advantages such as 40% shorter harvest time, water savings as much as 60%, savings in production inputs as much as 38% [9].

The ratoon rice system has the potential to answer the above problems. With the many benefits of the ratoon rice system, it is increasingly important to carry out this research. The objectives of this research are: 1) to identify and to map out the current implementation of ratoon rice farming in Central Java; and 2) to formulate the strategies to develop the ratoon rice farming as local wisdom in Central Java. This research is expected to have a strategy through SWOT analysis to develop local wisdom of ratoon rice to climate change adaptation and mitigation.

2. Methods

2.1 Materials
The data used in this research are primary data and secondary data. Primary data obtained directly through observation, interviews, discussions and questionnaires by FGDs (Focus Group Discussion) with member of the farmer group. While secondary data were obtained from government agencies such as BPS (Statistics Indonesia), Department of Agriculture, Agricultural Extension Center. The number of samples used for this research was 45 peoples.

2.2 Methods
This research was conducted from November 2019 to January 2020, using qualitative research with the FGD method. The research location was chosen by purposive sampling which means the sample and location of this research has been chosen deliberately according to the type of agricultural land irrigation system. In this research selected three irrigation system, namely: 1) rainfed rice field in Wonosari Village, Gondangrejo, Karanganyar Regency; 2) Tidal rice field in Rowosari Village, Tuntang, Semarang Regency; and 3) technical irrigation rice field in Mangunrejo Village, Kebonagung, Demak Regency. The data obtained were analyzed using the SWOT (Strength, Weakness, Opportunity and Threat technique).

3. Result and Discussion

3.1 Characteristics of Respondent

3.1.1 Rowosari Village
Rowosari Village is located in Tuntang District, Semarang Regency, Central Java Province. Rowosari village has an altitude of +480 meters above sea level and is located at coordinates 7°32'02" and 110°45'50" (BPS 2019) [10]. The area of Rowosari Village is 493.05 Ha while the area for rice fields is 128.65 Ha. Paddy fields in Rowosari Village have an irrigation system with a semi-technical and tidal irrigation system (or called tidal swampland). Cropping patterns in Rowosari Village can only be planted once a year, in July-December. The majority of Rowosari people make a living as farmers and fishermen. In this study the respondents and informants were members of the Sido Makmur II farmer group.

3.1.2 Mangunrejo Village
Mangunrejo Village is located in Kebonagung District, Demak Regency, Central Java Province. The area of Mangunrejo Village has an area of 412 Ha with a field area of 299.5 Ha (BPS, 2019) [11]. The irrigation system in Mangunrejo Village has a technical irrigation system originating from the Kedungombo Reservoir. Planting patterns in Mangunrejo Village 3 times a year, namely rice-rice-mung beans. The majority of Mangunrejo people make a living as farmers and farm laborers. In this research the informants and respondents selected were the Mangun Rahayu Farmer Group.

3.1.3 Wonosari Village
Wonosari Village is located in Gondangrejo District, Karanganyar Regency, Central Java Province. Wonosari has a height of 117 meters above sea level. In accordance with the natural conditions of the mountainous village of Wonosari, most people have a livelihood as farmers both as farmers and farm laborers. The plants that are often grown in Wonosari Village are rice, corn, peanuts and cassava. In addition to being farmers, the community also owns livestock (BPS, 2019) [12]. The area of rice fields in Wonosari Village is 147 Ha with rainfed irrigation systems. But now people are starting to work on irrigation water from underground water pumps. In this research the chosen informants and respondents were the Makmur I Farmer Group.

3.2 Strategies for developing ratoon rice farming

3.2.1 Identification of Internal and External Factors
Based on the research activities of interviews and questionnaires by FGDs, the factors that influence the development of ratoon rice farming are obtained for climate change adaptation and mitigation. The factors that influence the development of ratoon rice farming to climate change adaptation and mitigation include:

a. Internal factors such as farmers age, farming experience, land ownership, access to information, farmers' income, education level, farmers 'attitudes in accepting technological innovations, farmers' knowledge of ratoon rice cultivation.
b. External factors such as irrigation systems, cropping patterns, access to agricultural production facilities, the state of the agro-climate environment, the activity of agricultural extension workers, activity of farmer groups and attacks of the intensity of pests and plant diseases.

3.2.2 *Analysis Faktor Internal dan Eksternal*

| No | Internal Factor | Weight | Rating | weight x rating |
|----|-----------------|--------|--------|----------------|
| 1  | The age of respondent is productive | 0.10   | 4      | 0.4            |
| 2  | High farming experience          | 0.10   | 3      | 0.3            |
| 3  | Landowner farmers               | 0.07   | 3      | 0.21           |
| 4  | Knowledge of local ratoon rice is good | 0.13   | 3      | 0.39           |
| 5  | Information access available     | 0.11   | 3      | 0.33           |
| 6  | Farmer's acceptance of high-tech innovation | 0.12   | 4      | 0.48           |
| 7  | Willingness to practice ratoon rice is high | 0.12   | 4      | 0.48           |
| 8  | Farmers have attended formal education | 0.08   | 3      | 0.24           |
|    | **Sub Total**                |        |        | **2.83**       |

| No  | Weakness (W) | Weight | Rating | weight x rating |
|-----|--------------|--------|--------|----------------|
| 9   | The average non-agricultural income is low | 0.09   | 1      | 0.09           |
| 10  | Agricultural income is used for daily needs | 0.08   | 2      | 0.16           |
|    | **Total**    |        |        | **1.00**       |

| No | **GAP (S-W)** |        |        | **2.58**       |

| No | External Factor | Weight | Rating | weight x rating |
|----|-----------------|--------|--------|----------------|
| 1  | Irrigation system is tidal land | 0.12   | 3      | 0.36           |
| 2  | Access to agricultural production facilities | 0.08   | 3      | 0.24           |
| 3  | Farmer group activeness | 0.12   | 4      | 0.48           |
| 4  | Active role of agricultural extension workers | 0.12   | 4      | 0.48           |
| 5  | Cropping patterns 1 time | 0.08   | 3      | 0.24           |
| 6  | The ratoon rice farming system is more efficient | 0.15   | 4      | 0.60           |
|    | **Sub Total** |        |        | **2.40**       |

| No | Threats (T) | Weight | Rating | weight x rating |
|----|-------------|--------|--------|----------------|
| 7  | The state of agro-climate is difficult to predict | 0.12   | 1      | 0.12           |
| 8  | The intensity of pests and plant diseases increases | 0.13   | 1      | 0.13           |
| 9  | Crop yields ratoon rice decline | 0.08   | 2      | 0.08           |
|    | **Total**   |        |        | **0.41**       |

| No | **GAP (O-T)** |        |        | **1.99**       |

*Source: Primary Data, 2020*

**Table 2.** Analysis of IFAS & EFAS In Mangunrejo Village, Kebonagung Sub-District, Demak Regency
### Strength

| No | Factor                                      | Weight | Rating | Weight x Rating |
|----|---------------------------------------------|--------|--------|-----------------|
| 1  | The age of the respondent is productive    | 0.10   | 4      | 0.4             |
| 2  | High farming experience                     | 0.10   | 3      | 0.3             |
| 3  | Education level of respondents is high      | 0.08   | 3      | 0.24            |
| 4  | Landowner farmers                           | 0.09   | 3      | 0.27            |
| 5  | Information access available                | 0.10   | 3      | 0.3             |
| 6  | Knowledge of local ratoon rice is good      | 0.13   | 3      | 0.39            |
| 7  | Non-agricultural income is moderate to high | 0.08   | 3      | 0.24            |

**Sub Total** 2.14

### Weakness

| No | Factor                                      | Weight | Rating | Weight x Rating |
|----|---------------------------------------------|--------|--------|-----------------|
| 8  | Agricultural income is used for daily needs | 0.08   | 2      | 0.16            |
| 9  | Acceptance of technological innovation is still low | 0.12 | 3      | 0.12            |
| 10 | Willingness to practice ratoon rice is low  | 0.12   | 3      | 0.12            |

**Total**

**GAP (S-W)** 1.00

### External Factor

#### Opportunities (O)

| No | Factor                                      | Weight | Rating | Weight x Rating |
|----|---------------------------------------------|--------|--------|-----------------|
| 1  | Access to agricultural production facilities is easy | 0.07   | 3      | 0.21            |
| 2  | Farmer group activeness                      | 0.13   | 4      | 0.52            |
| 3  | Active role of agricultural extension workers | 0.13   | 4      | 0.52            |
| 4  | The ratoon rice farming system is more efficient | 0.13   | 4      | 0.52            |

**Sub Total** 1.77

### Threats (T)

| No | Factor                                      | Weight | Rating | Weight x Rating |
|----|---------------------------------------------|--------|--------|-----------------|
| 5  | Irrigation system is technical irrigation   | 0.13   | 2      | 0.26            |
| 6  | The state of agro-climate is difficult to predict | 0.12 | 1      | 0.12            |
| 7  | The intensity of pests and plant diseases increases | 0.13 | 1      | 0.13            |
| 8  | Cropping patterns 3 times                   | 0.08   | 1      | 0.08            |
| 9  | Crop yields ratoon rice decline             | 0.08   | 1      | 0.08            |

**Total** 0.67

**GAP (O-T)** 1.00

**Table 3.** Analysis of IFAS & EFAS in Wonosari Village, Gondangrejo Sub-District, Karanganyar Regency

Source: Primary Data, 2020
Farmer's acceptance of high-tech innovation 0.12 4 0.48
Farmers have attended formal education 0.08 3 0.24

Sub Total 2.62

Agricultural income is used for daily needs 0.08 2 0.16
Willingness to practice raton rice farming system is low 0.12 1 0.12

Sub Total 1.00 0.28

GAP (S-W) 2.34

| Opportunities (O) | Weight | Rating | Weight x Rating |
|-------------------|--------|--------|-----------------|
| 1 The irrigation system in rainfed land | 0.10 | 3 | 0.3 |
| 2 Access to agricultural production facilities is easy | 0.07 | 3 | 0.21 |
| 3 Farmer group activeness | 0.13 | 4 | 0.52 |
| 4 Cropping patterns 2 times | 0.07 | 3 | 0.21 |
| 5 The raton rice farming system is more efficient | 0.12 | 4 | 0.48 |
| 6 Farmer use underground water pumps | 0.06 | 3 | 0.18 |

Total 1.9

| Threats (T) | Weight | Rating | Weight x Rating |
|-------------|--------|--------|-----------------|
| 7 Active role of agricultural extension workers | 0.13 | 2 | 0.26 |
| 8 The state of agro-climate is difficult to predict | 0.12 | 1 | 0.12 |
| 9 The intensity of pests and plant diseases increases | 0.12 | 1 | 0.12 |
| 10 Crop yields raton rice decline | 0.08 | 1 | 0.08 |

Total 1.00 0.58

GAP (O-T) 1.32

Source: Primary Data, 2020

3.2.3 SWOT Analysis with SWOT Matrix

To determine the location of the quadrant the x and y-axis formulations are used, where the y-axis is EFAS (opportunity-threat) while the x-axis is IFAS (strength-weakness) [13]. Then the weighting table for IFAS and EFAS analysis results can be seen in table 4. Weighting Rating for IFAS and EFAS Analysis below.

Table 4. Weighting Rating for IFAS and EFAS Analysis

|          | Rowosari | Mangunrejo | Wonosari |
|----------|----------|------------|----------|
| (S-W)    | 2.58     | 1.74       | 2.34     |
| (O-T)    | 1.99     | 1.1        | 1.32     |

Source: Primary Data, 2020
In order to obtain the position of the SWOT Analysis position with the SWOT Matrix for the development of ratoon rice farming can be seen in Figure 1. Based on the SWOT quadrant position in Rowosari Village, Mangunrejo Village, Wonosari Village which is in quadrant I (positive). This position indicates that the development of ratoon rice farming has strong potential and opportunity. The strategy adopted is to encourage all policies aggressively by using all the power they have by utilizing the available opportunities. The SWOT strategy that can be formed with the SWOT matrix for Rowosari Village, Mangunrejo Village and Wonosari Village can be seen in Table 5. SWOT Strategy Matrix below.

**Figure 1. Position Point of SWOT Analysis**

Table 5. SWOT Strategy Matrix

| Internal Factor | Strength (S) | Weakness (W) |
|-----------------|--------------|--------------|
| 1) The age of the respondent is productive | 1) Non-agricultural income is low |
| 2) High farming experience | 2) Willingness to practice ratoon rice is low |
| 3) Landowner farmers | 3) Agricultural income is low |
| 4) Information access available | |
| 5) Knowledge of local ratoon rice is good | |
| 6) There is non-agricultural income | |
| 7) Farmers have attended formal education | |
| 8) Farmer's acceptance of high-tech innovation | |

| External Factor | Strategy S-O | Strategy W-O |
|-----------------|--------------|--------------|
| Irrigation systems support | Using access to information and knowledge of ratoon rice farming, as well as farming experience to utilize the irrigation system (S.2, 4, 5 – O.1) | Increase non-agricultural income by utilizing the activeness of farmer groups through counseling and training of extension workers (W.1 – O.2, 4) |
| The role of agricultural extension workers | Developing expertise in farming experience and formal education knowledge to carry out ratoon rice cultivation together with assistance from agricultural extension workers (S.2, 7 – O 2) | Increase the willingness of the practice of ratoon rice farming by piloting the farming of ratoon rice with the assistance of extension workers and members of farmer groups. (W.2 – S.2) |
| Cropping patterns | Practicing ratoon rice farming with own land to optimize cropping | Increase interest in ratoon rice cultivation by utilizing cropping |
patterns (S.3,4 – O.3)

4) The ratan rice farming system is more efficient
Practicing ratan rice farming because farmers have adequate experience and easy to accept innovations and easy access to information so that farmers can feel the benefits of ratan rice (S.2,4,5,8 – O.4)

Increase farmers' income by utilizing the benefits of ratan rice farming practices because it is more efficient (labor-saving, can reduce operational costs, save water, harvest faster) (W.3-O.4)

5) Farmer group activeness
Improve the ability of farmer groups by utilizing easy access to information between members of farmer groups and agricultural extension workers when conducting ratan rice cultivation (S.2,4,7,8 – O.5)

Increase the activeness of farmer members by counseling and training so that farmer acceptance can increase (W.2,3 – O.5)

| Threats (T)                  | Strategy S-T                                                                 | Strategy W-T |
|-----------------------------|------------------------------------------------------------------------------|--------------|
| 1) The state of agro-climate is difficult to predict | Predict environmental conditions with farmers' experience and knowledge and easy access to information (S.2, 5 – T.1) | Increase the willingness of ratan rice farming practices to take action on climate change adaptation and mitigation (W.2 – T. 1) |
| 2) Crop yields ratan rice decline | Using a technological innovation approach that can increase crop yields (S.3, 5, 8 – T.2) | Increase farmers' income through the practice of ratan rice farming to increase crop yields (W.1,3 – T.2) |
| 3) The intensity of pests and plant diseases increases | Using the experience, knowledge, expertise of farmers, and land ownership and cohesiveness of members of farmer groups to create a ratan rice cultivation area and to suppress pest attacks. (S. 2, 3, 4, 5, 6, 7, 8 – T. 3) | Increase non-agricultural income so that it is used for the purpose of reducing the intensity of pest attacks (W.1, 3 – T.3) |

Source: Primary Data, 2020

Based on Table 5, SWOT Strategy Matrix then the internal factors that become strengths are the age of respondent is productive, high farming experience, landowner farmers, information access available, knowledge farmers of local ratan rice is good, there is non-agricultural income, farmers have attended formal education, farmer's acceptance of high-tech innovation. While internal factors that become weakness, among other non-agricultural income farmers is low, willingness to practice ratan rice is low, agricultural income is low. External factors that become opportunities include irrigation systems support, the role of agricultural extension workers, cropping patterns, the ratan rice farming system is more efficient, farmer group activeness. While external factors that become threats include the state of agro-climate is difficult to predict, crop yields ratan rice decline, the intensity of pests and plant diseases increases.

Based on Table 5, SWOT Strategy Matrix the most powerful ratan rice farming and the opportunity to be developed in tidal land and rainfed land. Ratan rice farming in tidal land has great potential. The characteristic of tidal land in Rowosari Village is the availability of abundant water so that rice fields can only be planted once a year. Under these circumstances practicing ratan rice farming can solve problems such as limited production factors and planting time which is very
dependent on the season [14]. The second location that has the opportunity to apply ratoon rice farming is rain-fed land. Ratoon rice farming is suitable for use in rainfed land by utilizing residual rainwater and limited irrigation water after the first planting season.

Harvesting of rice twice from the same single crop is practiced in the United States, Swaziland, India, Thailand, Taiwan, the Philippines and China [15], Malaysia [16]. Ratoon rice farming can provide benefits for farmers in terms of time to achieve shorter harvests, lower production costs, without tillage, and without seeding [17] [16]. However, The ratoon production was less than 30% of first crop depending on the varieties of first crops and soil conditions [17];[18]; [19]; [20]; [21]. So there are things that must be considered so that the excess cultivation of ratoon rice can be felt by farmers.

The success of developing ratoon rice cultivation is influenced by several things as follows

a. Ratoon rice farming must be with the final technological modification. In the practice of farming there must be appropriate guidelines so that the shortage of ratoon rice farming can be reduced. In West Sumatra, the farming of salibu ratoon rice has been modified with a technological approach considered successful because it has the same harvest as its first crop [22]. Aside from using the technological aspects, the development of ratoon rice farming must also pay attention to social and cultural aspects.

b. The practice of ratoon rice farming must be in the form of an area. The designated location must comply with criteria suitable for the development of ratoon rice farming such as the planting pattern 1 time, not endemic to certain pests and diseases, irrigation water is available. According to Table 4. Weighting Rating for IFAS and EFAS Analysis the most suitable one to develop ratoon rice farming is the tidal location and rainfed area.

c. The active role of agricultural extension. All kinds of technology will succeed if the development of the technology is properly controlled by the desiminator. Desiminator here is an agricultural extension, so the success of the development of ratoon rice will be greatly influenced by the active role of the instructor in assisting and providing counseling and technological guidance. Extension workers should be given more thrust for the spread of technology [23]. With the existence of counseling and technical guidance, it is expected that the attitude of farmers in accepting innovations can increase so that farmers can voluntarily practice these technological innovations.

In general, ratoon rice farming cannot be practiced on all types of land, to be able to receive the benefits of ratoon cultivation it must be considered from several aspects such as technological aspects, social aspects and cultural aspects. Ratoon rice as climate and resource smart technology is a practical way of time and resources such as labour, increasing the rice production per unit area, fertilizer and energy to meet the growing demand for rice need in Indonesia [24]. Ratoon rice farming can be used to anticipate the effects of climate change such as the increasingly limited water availability, irregular weather patterns, floods and drought. Generally the strategies suggested to develop the ratoon rice system are: 1) increase the role of extension workers and farmer groups, as well as agricultural production facilities, so that the motivation to maintain the local wisdom and accept technological innovations raise; 2) to minimize the decline in ratoon rice production by intensive farming management and specifically create ratoon rice farming area.

4. Conclusion
Development of ratoon rice for climate change adaptation and mitigation is influenced by the characteristics of farmers, environmental conditions, irrigation systems, the activity of extension workers and farmer groups, the motivation of farmers to innovate. Based on the SWOT quadrant position is in quadrant I (positive) in Rowosari Village (S-W 2.58; O-T 1.99), Mangunrejo Village (S-W 1.74; O-T 1.1), Wonosari Village (S-W 2.34; O-T 1.32). According to the SWOT Strategy Matrix, the strategies suggested to develop the system are: 1) increase the role of extension workers and farmer groups, as well as agricultural production facilities, so that the motivation to maintain the local wisdom and accept technological innovations raise; 2) to minimize the decline in ratoon rice production by intensive farming management and specifically create ratoon rice farming area.
Acknowledgments

The author are deeply thankful to the Grup Research of Climate Change and Land Resource Management, Faculty of Agriculture, Sebelas Maret University, to funding and support this research.

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