Evaluation of conservation application in dryland maize farming in Central Java Province, Indonesia under climate change

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Abstract. Climate change affects soil degradation, water, and crop. Thus, the adaptation of land management and crop rotation to minimize the impact of climate change is needed. Maize is an important commodity in Indonesia. Central Java province contributes to national production amounted to 40.07\% during 2003-2015. In order to increase maize production, dryland farming becomes a good alternative. However, dryland is sensitive to erosion and a lack of nutrients. Thus, an adaptation of climate change can be made by applying the conservation of both mechanic and vegetative. This study aims to evaluate the implementation and recommend alternative conservation improvement efforts on farming dryland maize in Central Java. The study was conducted in Central Java by using 270 respondents of dryland maize farm households in Wonogiri, Kendal, Tegal, Grobogan, Wonosobo, and Banjarnegara districts. Conservation Activity Index (CAI) is applied to describe the habits that have been carried out by farmers to preserve their farmland. The results showed that the CAI of maize farmers on dryland in Central Java Province is in the range of 43.5\% to 95.7\%, with an average conservation application of 75.08\%. About 68.9\% of farmers are in the medium of the CAI category. Evaluation result showed that conservation activities that are still weak in its application are vegetative conservation methods. Thus, we recommend increasing the cultivation of land cover and annual crops, and the use of mulch to enhance the conservation of dryland maize farming.

1. Introduction

Maize is a valuable food commodity. National maize production was 27.95 million tons in 2017, an increase of 18.53\% compared to 2016 [1,2]. Maize cultivation both monoculture and intercropping is mostly done in dryland because it loses priority compared to rice in paddy fields. The cost of renting dryland is cheaper compared to paddy fields, so the cultivation of maize on dryland provides higher profits than on paddy fields [3]. The BEP of maize cultivation is achieved when the area of farming is 0.41 hectares [4].

Dryland will become the future agricultural land because the conversion of paddy fields to non-agriculture becomes increasingly difficult to control. Data from the Directorate General of Facilities and Infrastructure of the Ministry of Agriculture noted that the rate of conversion of productive agricultural land to non-productive is around 100,000 ha per year. Of this number, 80\% of them occur in Java, which is the center of rice production. [1] With a conversion rate of 2000-2015, the 2015 paddy field area of 8.1 million ha, is predicted to shrink to only around 5.1 million ha by 2045.

Several constraints of production on dryland are limited farmers' land, minimal infrastructure and technology, competing for water use with other major crops, and potential threats of climate change [5].
Climate change may have beneficial as well as detrimental consequences for agriculture. Marginally increasing temperature during summer and winter in Ethiopia would significantly reduce crop net revenue per hectare whereas marginally increasing precipitation during spring would significantly increase net crop revenue per hectare [6] shifting rain distribution is more unpredictable, so determine the time of planting is difficult and more risk of crop failure [7]. Therefore proper management of dryland that leads to a sustainable increase in production is necessary, namely through conservation farming. Soil conservation will succeed at the level of small-scale farming if the farmer is the first approach and farmer friendly [8]. Limited biophysical land, farmers' land ownership, and economic infrastructure make conservation farming technology expensive for dryland farmers.

Factors that influence the adoption of soil conservation technology according to [9] are (a) Personal factors: education, experience, attitude, (b) Institutional factors: extention, cost sharing, (c) Physical factors: slope, land size/ surface area, erodibility and (d) Economic factors: farm income, debt, interest rates, land tenure status, non-farm income, risk. [5] states the steepness of field, land status, and the number of adult family members, Research [10] regarding the application of CLS (Crop Livestock System) technology increases soil conservation efforts (17.21%), maize productivity (78.48% -112%). Whereas [6] mentioned the application of farmer conservation techniques participating in the terrace rehabilitation project in the Wonogiri Reservoir Catchment Area in the third year reached 91% with an increase in production of 36% and an increase in income of 40% compared to non-project participants.

Based on the argument above, this study aims to: (1) Explain the implementation of conservation in maize farming in dryland in Central Java Province, (2) Compare the implementation of conservation among several districts in Central Java Province, and (3) Identify the alternative efforts to increase conservation

2. Materials and Methods

The basic method used in this study is descriptive analytical method [10]. The research location was determined with multistage sampling based on the highest maize production from each residency in Central Java. From each district, two sub-districts were chosen with the same criteria. The research sample is farm households that cultivate maize on dryland.

Table 1. Location and number of research sample

| District  | Sub-district | Village                  | Total |
|-----------|--------------|--------------------------|-------|
| Wonogiri  | Pracimantoro | Tubokarto and Trukan     | 45    |
|           | Girowoyo     | Girikikis and Guwotirto  |       |
| Kendal    | Patean       | Sidodadi and Sidokumpul  | 45    |
|           | Sukorejo     | Bringinsari and Gentinggunung |   |
| Tegal     | Wanireja     | Kedungjati and Sigentong | 45    |
|           | Margosari    | Karangdawa and Jatilaba  |       |
| Grobogan  | Geyer        | Karanganyar and Ngrandu  | 45    |
|           | Toroh        | Dimono and Boloh         |       |
| Wonosobo  | Mojotengah   | Deroduwur and Slukatan   | 45    |
|           | Kalikajar    | Butuh and Butuhkidul    |       |
| Banjarnegara | Purwanegara | Purwonegoro and Kalitengah | 45 |
|           | Pejawaran    | Darmayasa and Pejawaran  |       |

Data collection techniques were carried out by interview, recording and observation methods. The type of data used includes primary data and secondary data. Calculation of Conservation Activity Index (CAI) [10]

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\text{CAI} = \frac{\text{acquired score}}{\text{maximum score}} \times 100\% \hspace{1cm} \text{…………………………………………………………… (1)}
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3. Results and discussion
Climate change has been proven to reduce maize production in Trenggalek from 4,246.06 kg/ha (in 2009) to 2,269.76 kg/ha (in 2010). The income of maize farmers in 2010 (Rp. 1,741,098.7) was lower than in 2009 (Rp. 1,617,789) [11].

However, rainwater harvesting/soil conservation techniques, intercropping, growing of short duration/early maturing maize varieties, crop diversification for crop production can mitigate further the impacts of climate change[6].

3.1 The implementation of conservation in maize farming in dryland in Central Java Province
The Conservation Activity Index (CAI) is an approach used to determine the extent of conservation carried out by farmers. CAI describes the habits that have been carried out by farmers to preserve their land since farming. CAI activities include 23 items. In each item, there are three answers with a score of 1, 2, and 3. The more concerned about conservation activities, the greater the score (score 3).
Table 2. Distribution of CAI scores on maize farming in Central Java Province

| Item                                                                 | Banjarnegara | Grobogan | Kendal | Tegal   | Wonogefähr | Wonoobo  | Central Java |
|----------------------------------------------------------------------|--------------|----------|--------|---------|------------|----------|--------------|
| 1. Suitability of the type of terrace with land                      | 3.00         | 2.87     | 2.38   | 1.69    | 2.71       | 2.91     | 2.59         |
| 2. Terrace Quality                                                   | 2.71         | 2.67     | 2.16   | 1.62    | 2.51       | 2.60     | 2.38         |
| 3. Maintenance                                                       | 2.78         | 2.67     | 2.09   | 1.60    | 2.56       | 2.53     | 2.37         |
| 4. Condition of drainage                                             | 2.53         | 2.40     | 2.22   | 1.96    | 2.27       | 2.42     | 2.30         |
| 5. Maintenance of water way                                          | 2.53         | 2.33     | 1.89   | 1.93    | 2.00       | 2.31     | 2.17         |
| 6. Frequency of contour processing                                   | 2.51         | 2.84     | 2.76   | 2.89    | 3.00       | 2.73     | 2.79         |
| 7. Long application of contour processing                            | 2.82         | 2.98     | 2.87   | 2.91    | 3.00       | 2.84     | 2.90         |
| 8. Percentage of terrace reinforcing grass                           | 1.98         | 2.22     | 2.16   | 1.76    | 2.16       | 1.89     | 2.03         |
| 9. The duration of the application of terrace reinforcing grass       | 2.49         | 2.49     | 2.76   | 2.18    | 2.87       | 2.64     | 2.57         |
| 10. Percentage of ground cover plants                               | 1.47         | 1.42     | 2.27   | 2.27    | 1.27       | 1.78     | 1.74         |
| 11. Duration of the application of ground cover plants               | 1.47         | 1.49     | 2.47   | 2.51    | 1.44       | 2.20     | 1.93         |
| 12. Types and number of annual crops                                 | 1.60         | 1.29     | 2.32   | 2.29    | 0.93       | 1.57     | 1.65         |
| 13. Duration of the application of annual Crops                      | 2.16         | 1.58     | 2.16   | 2.42    | 1.20       | 1.93     | 1.91         |
| 14. Cutting of annual crops                                          | 1.93         | 1.78     | 2.65   | 2.31    | 1.53       | 2.05     | 2.02         |
| 15. Percentage of contour-directed Cultivation                       | 2.42         | 2.89     | 2.73   | 2.82    | 3.00       | 2.64     | 2.75         |
| 16. Duration of the application of contour-directed cultivation      | 3.00         | 2.98     | 2.87   | 2.82    | 3.00       | 2.91     | 2.93         |
| 17. Type and time of annual crops rotation                           | 2.44         | 2.36     | 2.84   | 2.42    | 2.00       | 2.53     | 2.43         |
| 18. The duration of the application of annual crops rotation          | 2.98         | 2.42     | 3.00   | 2.51    | 2.47       | 2.89     | 2.71         |
| 19. Percentage of mulch                                              | 1.18         | 1.07     | 1.00   | 1.02    | 0.96       | 1.18     | 1.07         |
| 20. The duration of the application of mulch                         | 1.31         | 1.09     | 1.31   | 1.11    | 1.31       | 1.53     | 1.28         |
| 21. Organic fertilizer ratio : chemical                               | 2.33         | 1.67     | 2.29   | 1.60    | 2.76       | 2.69     | 2.22         |
| 22. Amount of manure                                                  | 2.33         | 1.67     | 2.29   | 1.76    | 2.91       | 2.69     | 2.27         |
| 23. The duration of the application of Manure                         | 3.00         | 2.73     | 3.00   | 2.84    | 2.96       | 3.00     | 2.92         |
| CAI                                                                  | 76.78        | 72.30    | 77.65  | 71.37   | 73.62      | 78.78    | 75.08        |

Source : Primary Data Analysis

From Table 2, it can be seen that the maize farmers in Tegal District do not prioritize the quality of terraces and drainage channels. This is likely due to the relatively flat topography of the area and more varied people occupation, including farmer. The purpose of farming is to earn income and not yet to preserving land. In contrast to Banjarnegara District, which is dominant in the uplands, it requires farmers to pay more attention to conservation buildings in the form of terraces and drainage channels.

Table 2. also shows that farmers have no experience in cultivating annual crops. Farmers often cut annual crops which indicate that annual crop management is more likely for economic reasons, not for conservation purposes.

Farmers have long recognized the importance of using organic fertilizer, although they do not yet fully believe in the benefits of organic fertilizer. That can be seen from the dominant use of chemical fertilizers.

The CAI items at the Central Java Province level that need attention are the type, number, and maintenance of ground cover and annual plants. Farmers assume that the use of mulch will provide additional costs, so that only a few farmers use it. It is important to realize that mulch is not only a plastic mulch that is purchased from a production input store. The low score for mulch use can be circumvented by using organic mulch that will provide a double benefit, which is low cost and more environmentally friendly.

This result is in line with literature [10] that efforts to reduce the negative effects of climate change are adapted to local conditions (better local adaptation to climate change). It is because climate change
will not only increase the risk of food shocks from world maize production but that these crop failures could occur simultaneously [2].

Global climate changes threaten the sustainability of maize production and maize consumption. Early maturing, high yielding hybrid maize varieties could be used as an adaptive measure to the climate changes. The national breeding program had released two hybrid varieties, Bima 7 and Bima 8, with a yield potential of more than 10 t/ha and matures in 90 days after planting [12].

3.2 Comparison of the implementation of conservation among several districts in Central Java

Table 3. Comparison of the Implementation of CAI in Central Java

| Districts     | Average CAI | Minimum CAI | Maximum CAI |
|---------------|-------------|-------------|-------------|
| Banjarnegara  | 76.78       | 65.22       | 94.20       |
| Grobogan      | 72.30       | 44.90       | 95.70       |
| Kendal        | 77.65       | 43.50       | 92.80       |
| Tegal         | 71.37       | 47.80       | 87.96       |
| Wonogiri      | 73.62       | 42.00       | 80.00       |
| Wonosobo      | 78.78       | 62.30       | 84.10       |
| Central Java  | 75.08       | 43.50       | 95.70       |

Source: Primary Data Analysis

Table 3 shows that, on average, farmers in Wonosobo District are more concerned and intensive in preserving their farmland (CAI 78.78). The short-range of CAI values (ranging from 62.30 to 78.78) indicates that farmers have a similar understanding and apply conservation. This is because most farmers in Wonosobo cultivating their own land so that they have more awareness and ownership, reflected in a similar CAI value. It is different in Grobogan Regency. In addition to cultivating on their own land, many farmers cultivate maize under PERHUTANI’s forest stand land (as pesanggem farmers). As a result, conservation efforts by farmers are also more varied. That needs to be improved because the efforts to maintain soil fertility and water availability will be more effective if they are done together.

3.3 Identification of the alternative efforts to increase conservation

From Table 2, it can be seen that some items show low scores and thus need to be improved, consisting of items no. 10, 11, 12, 13, and 19, which are related to ground cover crops, annual crops, and mulch use. These items are worth recommending in line with the results of previous researchers. Increasing the number of annual crops with alley cropping has been proven to be able to maintain soil quality, increase production yields and reduce erosion [13]. Aisle farming with leguminoseae plants is recommended because it can break the force at rain water and surface flow and provide symbiotic N [14]. Annual plant-based land use is proven to be more effective in reducing erosion than annual crops [5]. Lamtoro strips, manure, mulch, and rorak also need to be combined because they are able to improve the growth and production of dry shells [14].

The selection of annual crop types and ground cover crops that will be cultivated should be adjusted to the conditions of each area. It has strived that planting cover crops and annual crops do not interfere with the main crop (maize), can maintain and improve soil fertility, as well as preserve land while providing economic benefits for farmers, likewise, with annual plants.

Some recommended types of conservation plants are albisia (sengon), acacia, gamelina, and mahogany. To restore soil nutrients, legume/leguminous plants such as kemlandingan/lamtoro, gamal, and turi can be used. The choice of legume plants is due to a large number of seeds and the spread of the seeds which can be far and easy to germinate. The leaves are compound, thin, and easily decomposed, and will form a microclimate under a stand which is a place to live micro-decomposing organisms.
4. Conclusion
The implementation of conservation in maize farming in dryland in Central Java Province is still low with an average CAI score of 75.08. The districts with the lowest to highest CAI in sequence are Tegal, Grobogan, Wonogiri, Banjarnegara, Kendal and Wonosobo. The efforts to improve conservation are carried out with increasing the cultivation of land cover and annual crops, and the use of mulch. The effort is expected to reduce the impact of climate change on maize production in Central Java.

References
[1] Deshaliman, Nurhayanti Y, Irnawati, Nuraeni D, Widyapuri D, Ismaryati E, Novia D, Yanto M, Wisnuwardhani J, Susanto T T and Wahyuningsih A 2018 Surplus, RI Ekspor Jagung Bulletin Pasokan dan Harga Pangan (Jakarta: Badan Ketahanan Pangan Kementrian Pertanian RI)
[2] Wernick A 2018 The global corn crop is vulnerable to the effects of climate change Living on Earth [online] available https://www.pri.org/stories/2018-07-15/global-corn-crop-vulnerable-effects-climate-change
[3] Sulaiman A A, Kariyasa I A, Hoerudin, Subagyono K, and Bahar F A 2018 Cara Cepat Swasembada Jagung (Bogor : IAARD Press)
[4] Nurdin 2008 Optimalisasi Produktifitas Lahan Kering melalui Pengembangan Sistem Usahatani Konservasi Tanaman Jagung di Provinsi Gorontalo Jurnal Ilmiah Agropotan 1 1-15
[5] Tala’ohu S H, Abas A, dan Kurnia U 2003 Optimalisasi Produktivitas Lahan Kering Beriklim Kering melalui Penerapan Sistim Usahatani Konservasi Prosiding Kongres Nasional VIII Himpunan Ilmu Tanah Indonesia (HITI), Padang, 21-23 Juli 2003 pp 166-177
[6] Li X, Takahashi T, Suzuki N, and Kaiser H M 2014 Impact of Climate Change on Maize Production in Northeast and Southwest China and Risk Mitigation Strategies APCBEE Procedia 8 11-20
[7] Fahmuddin A, Soebarjo D, and Sulaiman Y 2014 Konservasi Tanah Menghadapi Perubahan Iklim (Jakarta: IAARD Press)
[8] Arsyad S 2006 Konversi Tanah dan Air (Bogor: IPB Press)
[9] Asafu-Adjaye J 2008 Factors Affecting the Adoption of Soil Conservation Measures: A Case Study of Fijian Cane Farmers Journal of Agricultural and Resources Economics 33 99-117
[10] Triastono J 2006 Pengaruh Penerapan Teknologi Konservasi Crop Livestock System CLS terhadap Usahatani Tanaman Pangan di DAS Serang Hulu Kabupaten Boyolali. Disertasi (Yogyakarta: Universitas Gadjah Mada)
[11] Santoso H, Koerniawati T, and Layli N 2011 Dampak Perubahan Iklim Terhadap Produksi Dan Pendapatan Usahatani Jagung (Zea Mays L) AGRISE 11 151
[12] Azrai M 2013 Jagung Hibrida Genjah : Prospek Pengembangan Menghadapi Perubahan Iklim IPEK Tanaman Pangan 8 90-6
[13] Vadari T and Agus F. 2003. Pengelolaan Lahan dan Hubungannya dengan Hasil Sedimen dan Hasil Air pada Skala Tampung Mikro. Dalam Prosiding Kongres VIII Himpunan Ilmu Tanah Indonesia (HITI), Padang 21-23 Juli 2003. Hal 187-195.
[14] Gutteridge R C 1994 The Perennial Sesbania Spesies Forage Tree Legumes in Tropical Agriculture (Wallingford, UK: CAB Internasional) chapter 2.3

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