

Climate Change Impact to Potato Farming in the Java of Indonesia in the Mountain Range of Batu, East Java of Indonesia

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ABSTRACT

The objective of this study was to analyze the effect of climate change to the productivity of potato farming in Batu city. This research conducted in Sumber Brantas Village, Bumiaji District, Batu City, East Java Province of Indonesia which was as one of the potato production centre in high land of East Java. Research has been carried out from February until August 2011. The methodology consisted of proposional random sampling on 44 farmers and the data was collected by directly interview to the potato farmers. In depth analysis, data was analyzed ny using benefit function, R/C and B/C ratio, and multiple linear regression. Results showed that potato farming in Batu city before and after climate change were as follow: the income was each of Rp. 53,762,500.00 and Rp. 29,797.500.00; the R/C ratio was each of 2.58 and 1.33; farming was the most feasible to be carried out in the down slope. The B/C ratio was 5.6 and there was productivity decreasing of 28.99%. Employers, pesticide, and anorganic manure was significantly influenced potato production, but seed, organic manure, and the other cost was not influenced the potato production

KEYWORDS: climate change, potato farming, productivity.

INTRODUCTION

Climate change is difficult to be ignored and it gives impact to some aspects of life. Extreme impact of climate change is mainly on the change of uncertainly climate pattern. From 1991, climate pattern has begun irregularly and it was sufficient to disturb self-supplying the national food on some food production for fulfilling demand inside of country and Indonesia is still importing. On dry season, climate has dry trend with trend of rainy becomes decreasing. The climate change impact to agriculture generally is light on the short term, but it is more harming by the development of time and the potential harmless of production has reached 25% for some crops [1]. In Indonesia, the effort of mitigation and adaptation due to climate change has really been started from 1990, although Indonesia does not have a duty to fulfil the decreasing target of GRK emission. For strengthening the implementation of mitigation and adaptation due to climate change on agriculture in Indonesia, it is needed the national strategy on mitigation and adaptation of climate change. In the whole regions with highly rare area and water and the pressure of world globalization, incoming period of agriculture intrinsically is related to the better water resources management. By the accurate infestation and incentive, friendly environmental agriculture and service of watershed can be used for protecting the variety of biology [2]

Since the happening of industrial revolution, in 1750, the concentration of carbon dioxide was increasing of 290-380 ppm. Effect of concentration increasing on the glass house gas was being felt since the last 14 years in the entire world and there was the hottest of 13 years since the beginning recorder of climate. The main effect was the decreasing of water supply and short period of winter for potato production [3]. In further, it was described that climate change will take the decreasing of day number with frozen dew and the occurrence of lengthening on cropping season. This problem will be related with more rainfall intensity in winter and less in summer. For potato production during summer will decrease as the impact of the accurate cropping period becomes shorter. Optional adaptation as regulating the cropping period or the use of crop rotation can be implemented for fulfilling the yield decreasing that will be happened [4][5]. Reality at this moment that climate pattern has been changed was marked by the changes of some climate unsure like air temperature, rainfall pattern, etc. [6][7]. The change of climate pattern will be much influenced the agricultural pattern mainly mountainous agriculture (high land) like potato which has very limited plantation [8]. It was supported by the research of Hijmans [8] which presented that climate change globally influenced potato production and it was indicated by the increasing of average temperature between 2.1⁰ and 3.2⁰ C. For this period, the potency of potato production globally was decreasing of 18% until 32% (without adaptation) and 9% until 18% (with adaptation). In high land, global heating had possibility to be going to cause the change on cropping schedule,

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cultivar use, and location moving of potato production. In many regions, the change of potato production was relatively low [8].

Climate change might be going to influence agriculture productivity [9]. Then Holden [10] said that climate change impact to the potato production would be clearer in non-irrigated area where crop growth would be depended on high rainfall. The use of climate would shorten the stage of vegetative growth but it would lengthen the stage of reproduction growth and growth period of the whole potato [11]. In some region, there were needed irrigation water of 150 and 300 mm every year, but it had to be balanced with the decreasing of nitrogen input [10]. This research intended to analyse the effect of climate change due to the productivity of potato plantation in Batu city.

MATERIALS AND METHODS

This research was conducted in Sumber Brantas village, Bumiaji District, Batu city. Research location was purposively determined that this village was as one of the potato production centre in the high land of East Java province. This research was carried out from February 2011 until August 2011.

Description of research location

The area number of Sumber Brantas is approximate to 541.1564 ha. Sumber Brantas village consists of three little villages (such as Krajan, Lemah Putih, and Jurang Kual) and 34 Neighbour Groups (RT). The boundary of Sumber Brantas village is as follow: forest of Mojokerto regency in north side, forest of Arjuno mountain in east side, Wonorejo small village of Tulungrejo village in south side, and forest of Anjasmoro mountain in west side. Map of location is as in Figure 1.

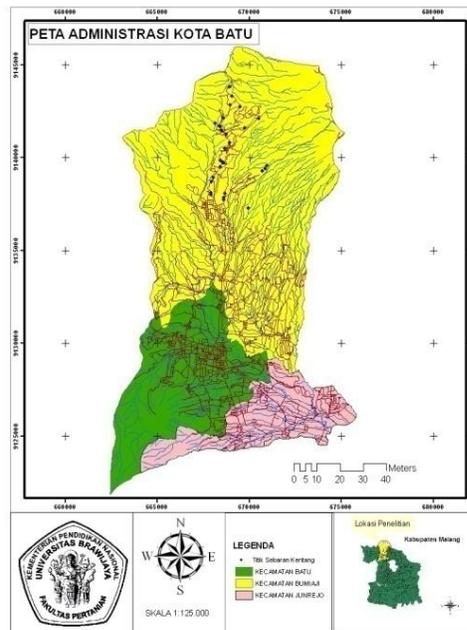


Figure 1 Map of location

Sumber Brantas village is falling on the south longitude of $7^{\circ}44'8''$ to $7^{\circ}46'35''$ to $112^{\circ}31'21''$ and east longitude of $112^{\circ}31'21''$ to $112^{\circ}33'2''$ and it is as high land with the elevation from sea level of 1,600 until 1,850 dpl. The climate is dry and rainy season. Dry season is occurred from May until October, but rainy season is happened from November until April. The air temperature is cold enough such as between 12° until 24° C. Sumber Brantas village is included in Bumiaji District, the distance from district governmental centre is about 13 km, from city government is about 18 km, from province government is about 144 km, and from country city centre is about 23 km.

The distribution of area use in Sumber Brantas village si as follow: 318.3234 ha of agriculture, 134.5710 ha of residence, 51.6320 ha of yard, 1.5 ha of grave, 1.1 ha of field, 0.8 ha of school, 22 ha of recreation place or arboretum, 1.1 ha of small mosque, 0.07 ha of mosque, 0.5 ha of TPQ, 0.02 ha of church, and 10,000 ha is belonged to PT Karya Kompos Bagus for mushroom plantation.

Generally, the farmers in Sumber Brantas village have carried out the potato plantation more than 5 years. The potato plantation in this village was as hereditary activity. All of female as well as male family members was following to help in working on their parents' plantation. In determining the suitable cropping schedule, the farmers attended rainy and dry season. On rainy months, the farmers begin to crop potato. By the season moving, the farmers feel difficult to determine the accurate time schedule to crop potato.

Population of this research are the whole potato farmers in Sumber Brantas village. Sample was taken by using proportional random sampling due to the consideration that the population consisted of 3 groups such as the farmers of upstream, middle, and downstream slide. The number of upstream population was 97 persons, middle were 78 persons, and downstream were 48 persons. The minimum quantity of samples was determined as 20%. The sample number of each sample was determined by using the formula as follow [12]:

$$nh = \frac{Nh}{N} . n$$

Note:

n= minimum sample that has to be taken ; N = number of population; Nh= number of population oh group-h; nh= minimum sample that has to be taken from group-h

By using the formula, it was obtained the number of group-1 was 19 persons, group-2 was 15 persons, and group-3 was 10 persons. Therefore, total of samples were 44 persons. This research was as the kind of survey and data that was used was as cross section. Research data was collected by direct interview to the potato farmers which cropped potato in 2005 and 2011. Data that were needed in this study were potato plantation data in 2005 and 2011 which included Production facility, seed, inorganic manure, pesticide, and working people or employers.

Method of data analysis

Income and efficiency of potato plantation in Batu city is estimated by using the profit function as follow:

$$\mu = TR - TC$$

Note:

μ = profit; TR= total revenue; TC= total cost

The criteria of decision are as follow: If $\mu > 0$, it means there is profitable; If $\mu < 0$, it means there is non profitable and If $\mu = 0$, it means there is the condition of BEP (break event point)

Then, to know the efficiency of potato plantation in Batu city, it is estimated with R/C ratio such as by comparing the value of TR and TC with the formula of R/C ratio = TR/RC. The norm of decision is as follow: If R/C ratio > 1 , it means efficient; If R/C ratio < 1 , it means non efficient and If R/C ratio = 0, it means the condition of BEP (break event point).

To know which slide is as the best plantation, it is estimated by using B/C ratio such as by comparing the plantation on downstream slide, middle slide, and upstream slide as follow:

$$B/C \text{ ratio} = \frac{TR \text{ upstream} - TR \text{ middle}}{TC \text{ downstream} - TC \text{ middle}}$$

The norm of decision is as follow: If $B/C > 1$, it means that upstream slide plantation is feasible; If $B/C < 1$, it means that middle slide plantation is feasible and If $B/C = 1$, it means that upstream and middle slide are the same feasible to be carried out

To analyse the production factors that is influenced to the potato production in Batu city is estimated with analysis of linear regression as being explained in regression model as follow:

$$Y = \beta_0 + \beta_1 \text{ Production facility} + \beta_2 \text{ employer} + \beta_3 \text{ seed} + \beta_4 \text{ organic manure} + \beta_5 \text{ inorganic manure} + \beta_6 \text{ pesticide} + \beta_7 \text{ others}$$

Note:

Y = production of potato plantation

To know how far the independent variable (x) explains production (y) of potato plantation in Batu city, the model is evaluated together by using R square [13]: Then, for knowing the influence of each independent variable to the potato plantation, there is carried out partial test of t-test as follow:

$$t - \text{calculated} = \frac{\beta_i}{se(\beta_i)} t - \text{table } (\alpha / 2)(n - k) db$$

Note:

β_i = variable regression coefficient of i se β_i = standart error of logit regression coefficient variabel of i = variant of β_i

RESULTS AND DISCUSSION

In the last 5 years, the potato farmers in Sumber Brantas village has planted the potato in the end of rainy season by being hoped that when the growth period there was enough water and when tap-root forming there was no stagnant water. The intensity of potato plantation was twice or three time a year. Potato plantation schedule was from February to June, and August. Intensity of plantation was influenced by area location. In upstream and middle slide like the area of Brak Seng, Watu Tumpuk, Cangar, and Jurang Kual Lor, the farmers had a trend to plant only on rainy season. However, in downstream slide like the area of Bon Siji, Bon Wolu, and Bon Limolas, the farmers was usually to plant in rainy and dry season. The income average of potato plantation in 3 slides of Batu city was presented as in Table 1, 2, and 3.

Table 1. Income average of potato plantation per-hectare (Rupiah/ ha) in upstream slide area (± 1900 m dpl) before and after climate change

Description	Before climate change	After climate change
Production (kg)	24,300	18,200
Price (Rp)	2,500	5,800
Acceptation (Rp)	60,000,000	105,160,000
Seed (Rp)	5,500,000	11,700,000
Employer (Rp)	13,800,000	31,300,000
Production facility (Rp)	12,200,000	27,200,000
Firm cost (Rp)	580,000	1,170,000
Total cost (Rp)	44,300,000	98,700,000
Income (Rp)	27,900,000	33,700,000
R/C Ratio	1.87	1.47

Source: primary data, analyzed in 2011

Table 2. Income average of potato plantation per-hectare (Rupiah/ ha) in middle slide area (± 1600 m dpl) before and after climate change

Description	Before climate change	After climate change
Production (kg)	22,400	15,000
Price (Rp)	2,500	6,000
Acception (RP)	55,900,000	89,700,000
Seed (Rp)	5,600,000	12,900,000
Employer (Rp)	13,500,000	30,400,000
Production facility (Rp)	12,300,000	25,500,000
Firm cost (Rp)	537,000	1,120,000
Total cost (Rp)	44,300,000	95,300,000
Income (Rp)	23,900,000	19,900,000
R/C Ratio	1.75	1.29

Source: Primary dat, analyzed in 2011

Table 3 Income average of potato plantation per-hectare (Rupiah/ ha) in downstream slide area (± 1300 m dpl) before and after climate change

Description	Before climate change	After climate change
Production (kg)	24,400	18,200
Price (Rp)	2,550	6,350
Acceptation (Rp)	62,600,000	114,770,000
Seed (Rp)	5,800,000	13,800,000
Employer (Rp)	13,700,000	31,650,000
Production facility (Rp)	12,600,000	26,700,000
Firm cost (Rp)	550,000	1,160,000
Total cost (RP)	45,150,000	100,100,000
Income (Rp)	30,000,000	41,400,000
R/C Ratio	1.92	1.57

Source: Primary data, analyzed in 2011

Income and efficiency of potato plantation in Batu city

The income of potato plantation in upstream slide of Batu city before climate change was Rp. 27,900,000.-, but after climate change was Rp. 33,700,000.-; in middle slide before climate change was Rp. 23,900,000.-, but after climate change was Rp. 19,900,000.-; and in downstream slide before climate change was Rp. 30,000,000.- and after climate change was Rp. 41,400,000.-.

Generally, it was concluded that the income of potato plantation in 3 slides (upstream, middle, and downstream) in Batu city was profitable before as well as after climate change. Before climate change, the highest income of potato plantation was in the downstream slide and the lowest was in the middle slide. However, the highest income of potato plantation after climate change was in the downstream slide and the lowest was in the middle slide. Based on the field observation, it was indicated that in downstream slide often accepted nutrition unsure from upstream so the content of nutrition unsure would increase. If the nutrition unsure increased, the potato production would increase too as described in Table 1, 2, and 3. Table 4 presented the income of potato plantation in Batu city.

Table 4 Income average of potato plantation per-hectare (Rupiah/ ha) in Batu city before and after climate change

Description	Before climate change	After climate change
Production (kg)	25,000	16,000
Price (Rp)	3,250	5,750
Acception (Rp)	87,500,000	99,000,000
Seed (Rp)	13,500,000	11,500,000
Employer (Rp)	9,837,500	15,602,500
Production facility (Rp)	9,900,000	36,400,000
Firm cost (Rp)	500,000	700,000
Total Cost (Rp)	33,737,500	69,202,500
Income (Rp)	53,762,500	29,797,500
R/C Ratio	2.58	1.33

Source: primary data, analyzed in 2011

Batu city is one of the potato plantation centre in high land of East java, Indonesia. Income average of potato plantation in Batu city before and after climate change was described as in Table 4. Table 4 presented that the income of potato plantation before climate change was Rp. 53,762,500.- but after climate change was Rp. 29,797,500.0.

If it was seen from the efficiency, potato plantation in the downstream, middle, and upstream slide of Batu city produced the different B/C ratio. Based on the Table 4, it could be concluded that potato plantation in upstream, middle, and downstream slide before as well as after climate change was efficient. It was indicated by the value of B/C ratio was more than 1. However, potato plantation in downstream slide was the most efficient due to the value of efficiency.

Efficiency is one of the tools for knowing how far the ability of cost can cover the goods production for giving the return. Analysis result indicated that efficiency of potato plantation in Batu city before climate change was 2.58 and after climate change was 1.33 and it meant that before as well as after climate change was efficient. The R/C ratio of potato plantation in Batu city after climate change was 1.33, it meant that per-unit cost input for producing the potato was able to return the acception of 1.33.

The efficiency decreasing of potato plantation in Batu city before and after climate change was caused by the increasing of employers almost to 60%, so production facility cost increased almost 3 times if compared with before climate change. The production facility cost included the cost of organic and an-organic manure, and pesticide. In one side, there was cost increasing, but in production side there was decreasing which the production before climate change reached 25 ton/ha, but after climate change became 15 ton/ha. The occurred price increasing has not been able to balance the cost output of potato plantation.

Feasibility study of potato plantation in Batu city

Batu city has variety of topography and has an unique enough of agro climate, so Batu city of course has comparative specialty. One of the specialty crops in Batu city is apple with any types such as Rome Beauty, Ana, and Manalagi. Some kinds of vegetables and fruits are also suitable being cropped in Batu city. However, the potato plantation is not losing to be attractive one. Potato plantation in Batu city was planted in some slides such as upstream, middle, and downstream. Therefore, it was analysed the most feasible slide type for potato plantation.

This analysis was carried out because in this research there was observed the plantation based on the different topography and it was divided into 3 slides such as upstream, middle, and downstream. Analysis result indicated that between upstream and middle slides produced the B/C ratio of 4.56; between middle and

downstream slides was 5.25; and between upstream and downstream slide was 6.92. It was concluded that among the three slides of potato plantation indicated that the upstream one was the most feasible.

The influence of agro climate change to the potato plantation productivity in Batu

Agro climate is as the most important of production factors for production process of potato plantation because this factor influenced tap root production as well as the growth of potato infection. Based on the field observation, it showed that in last few years there was happened agro climate change. The agro climate change caused the use change of potato production factor and effected the different production. Analysis result indicated that the productivity of potato plantation in Batu city in 2005 was 15,589 ton/ha but in 2011 was 11,070 ton/ha. The decreasing of productivity in this period was 28.99%. This decreasing was high enough, almost 30% in the period of 5 years. Based on the research of Brassard and Singh [14][15], the change of harvest yield could be varied due to the climate scenario, type of crop, and agricultural area. The option on the available adaptation and response of climate and the related uncertainty with suitability projection of region were as the implication and change of climate to the potato [16][17]. The impact of climate condition (high CO₂, temperature, and humidity) to the photo synthesis and potato production was as the reason to suggest the strategy of adaptation and mitigation for maintaining crop productivity [18].

Climate change caused the decreasing of agricultural productivity mainly the potato plantation in Sumber Brantas village, Bumiaji District of Batu city. The productivity of potato had a trend of decreasing being compared with before climate change. Total average decreasing of potato productivity reached 36%. Before climate change, potato farmers produced in average of 25,000 kg per-hectare, but after climate change the productivity was only 16,000 kg per-hectare. There were many factors that influenced the productivity level of potato commodity in the research location. Extreme season like rainfall and temperature out of the condition range of potato growth gave many impacts of damaged potato plant. The decreasing of potato productivity caused the price had a trend to be up. Generally, the increasing on the concentration of CO₂ was followed by air temperature increasing and it would produce growth, cycle decreasing of development, low harvest productivity, and the increasing of potato infection. A strategy for minimizing the effect of global heating on potato was to develop cultivar which was tolerant to high temperature, adaptation of crop schedule in every location, and to widen crop areal for suitable region [19]. Productivity loosing was in average of 23 to 44 % for potato because of the drought and heating stress [20]

The productivity factor effect to the potato productivity in Batu city

Estimation model of productivity factors that influence potato productivity are analysed with Multiple Linear Regression. The value of F calculated was 28.19 with p value of 0.000 and less than $\alpha = 0.01$. It means that H₀ is not accepted and it accepts H₁, it means that there does not accept H₀ and accepts H₁ and the 6 variables of potato productivity factor all together can explain potato production. R² illustrates how far the productivity factor can explain potato production. In this study, the R² was 0.821 (82.1%). It meant that the 6 potato productivity factors were able to explain potato production of 82.1% and the rest of 17.9% was as the variables that did not included in the model. Analysis result on regression function of potato plantation was as follow:

$$Y = -12,816 + 0.515 \text{ seed} + 4,385.4 \text{ organic manure} \\ + 1,367 \text{ inorganic manure} + 211, 26 \text{ pesticide} + 270, 2 \text{ other cost} + 278.43 \text{ employer}$$

The result showed that the whole variables of potato productivity factor had positive relation to the potato production, it meant that if there were the use increasing of productivity factor, it would increase potato production. Factors of potato productivity which were analysed were seed, organic manure, inorganic manure, pesticide, the other cost, and employer. Then, the 6 variables of potato productivity factor were expressed to be significantly influenced to potato production such as organic manure, inorganic manure, pesticide, and employer. However, the other 2 variables were not significantly influenced to potato production such as seed and the other cost. Organic manure was significantly influenced to potato production with the level of significant of 85%. The regression coefficient was positive of 4,385.4. The positive mark meant that if there was the adding of organic manure use, it would increase potato production and the value of regression coefficient (4,385.4) meant that the adding of 1 unit on organic manure would increase 4,385.4 unit of potato production.

Organic manure was also significantly influenced to potato production on the significant level of 95%. The regression coefficient was positive of 1,367. and the positive mark meant that if there was the adding of inorganic manure use, it would increase the potato production. The value of regression coefficient meant that if there was the adding of 1 unit on inorganic manure, it would increase 1,367 unit of potato production.

Pesticide was also significantly influenced potato production with significant level of 95%. The regression coefficient was positive of 211.26 and the positive mark meant that if there was the adding of pesticide use, it would increase the potato production. The value of regression coefficient meant that if there was the adding of 1 unit on inorganic manure use would increase 211.26 unit of potato production.

Employer was significantly influenced potato production with the significant level of 95%. The regression coefficient was positive of 278.43 and the positive mark meant that if there was the adding of employer use would increase the potato production. The value of regression coefficient meant that if there was the adding of 1 person on employer would increase 278.43 unit of potato production.

CONCLUSION

1. Income of potato plantation in Batu city before and after climate change was each of Rp. 53,762,500,- and Rp. 29,797,500,-. The value of B/C ratio before and after climate change was each of 2.58 and 1.33.
2. Plantation in the downstream slide was the most feasible with the B/C ratio of 5.6.
3. Decreasing of productivity was 28.99%.
4. Organic and inorganic manure, pesticide, and employer were significantly influenced the potato production, but seed and the other cost were not significantly influence the potato production.

SUGGESTION

1. There was needed the adaptation to climate change through the application of used accurately technology such as temperature change is fulfilled by using mulga, the more rainfall is fulfilled by regulating crop model and the use of verities that was holding to climate change.
2. There was needed policy of the related institution due to the supply of pesticide and inorganic manure so that the potato farmer obtain the ease in carrying out their plantation.

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