Maize Farming System in The Rainfed Area Base on The Groundwater Management in Timor Indonesia

Yohanes Leki Seran[1,*], *Nelson* Hasty Kario[1] and *Petrus* A. Beding[2]

[1] Research Center for Behavioral and Circular Economy, National Research and Innovation Agency, Indonesia

[2] Research Center for Food Crops, National Research and Innovation Agency, Indonesia

Abstract. Farmer production in the rainfed area faces various challenges as long as the production process is conducted. The main challenge and crucial factor in this area for managing the agriculture sector is water limitation, as we know that rainfed in semi-arid regions significantly depends on the annual rainfall. Successful farming production is determined by the adequacy of rainfall in the rainy season of the year. The objectives of this research are (1) to know the economic aspect of management groundwater for maize farming system and (2) to evaluate the productivity of maize farming system in the rainfed area. This research will be conducted in Naiboat–Kupang during the dry season 2019. They were using demonstration farming methods and applying recommendation technology for maize farming. The result of the research is that farmers use groundwater for irrigating maize farming systems to avoid drought, and maize grows normally. The productivity of maize that apply recommendation technology can reach 8 ton/ha.

1 Introduction

East Nusa Tenggara is dominated by dryland and has short rain every year. Usually, the rainy season starts from December up to April. The maize crop is very adaptable to conditions. Therefore, maize crops are developed largely in this area. However, climate conditions only support farmers to develop maize crops once a year. The majority of people in East Nusa Tenggara Province, particularly people in West Timor Island, develop maize as a staple food. It is indicated by the farmer's management dryland farming system for developing food crops with maize as a main crop. Farmer's practice technology for maize farming in dryland usually applies a simple technology shifting cultivation. The harvesting area of maize farming is vast compared to other commodities like rice, mung bean, and cassava. In 2019, the harvested area of maize crops reached 26,076.7 ha, while rice was 19,639.3 ha, mung bean was 143.7 ha, and cassava 2,306 ha [1].

Generally, the average maize productivity in East Nusa Tenggara is 2.5 tons/ha. This productivity is lower than the National average, which reaches 5.1 tons/ha [1]. The factors influencing the lowest maize productivity are farmers' skills, the use of input production,

[*] Corresponding author: lekialeks@gmail.com

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technology, and climate. Maize availability in local areas is not yet sufficient for local consumption. The increased price locally of maize during off-season time is one indicator of insufficient production of maize in this region.

Maize crops can be developed in another agroecosystem besides dryland agroecosystems, such as rainfed. In the wet season, all the rainfed area is planted with rice crops, but in the dry season, this area is very limited in water, so farmers choose to produce another food crop like maize, mung beans, and vegetables. Maize production in the rainfed area faces various Challenges during the implementation of maize farming in the dry season. The main challenge and crucial factor in this area for managing the agriculture sector is water limitation. As we know, rainfed in semi-arid regions significantly depends on the annual rainfall. So, the success of farming production is determined by the adequacy of rainfall in the rainy season of the year. However, in this research, maize farming was developed during the dry season in rainfed regions by using groundwater for sufficient water irrigation maize farming [2] and according to Heryani et al. [3] and the potential of Groundwater in East Nusa Tenggara as much as 16.7 l/second. It can be used to support agriculture.

The objectives of this research are (1) to know the economic aspect of management groundwater for maize farming system and (2) to evaluate the productivity of maize farming system in the rainfed area. This research will be conducted in Naiboat–Kupang during the dry season of 2019.

2 Material and Method

This research was carried out in Naibonat Village – Kupang District in 2019. The agroecosystem type for this research was rainfed agroecosystem. This research was conducted during the dry season of 2019 and used groundwater for irrigating the maize crop. Some materials used during the implementation of this research are maize seed, fertilizer, planting rope, planting stick, water, insecticide, herbicide, pump, and fuel. This research uses the demonstration farming method and applies recommendation technology and farmer's practice technology for maize farming [4]. This research is divided into two parts, and the treatment of each part is described in Table 1.

Table 1. Description technology in research of maize farming system in rainfed region

Technology	**Recommendation Technology**	**Farmer's Practice technology**
Land Preparation	Without tillage and Clearing rice straw	Without tillage and Clearing rice straw
Variety of maize	Pioner 36 hybrid	Pioner 21
Planting time	July (After the rice harvest)	July (After the rice harvest)
Row planting	80 cm X 40 cm	Planting randomly
Fertilizer: Urea (kg/ha) NPK Ponska(kg/ha)	 200 200	 50 50
Weed control	Apply selection herbicide	Manual
Water management (irrigating time)	One time/week	One time/two week

Variables of this research consist of agronomic variables and economic variables. The agronomic variables included capacity of growing seeds, high plant, and productivity, while economic variables included production cost and labor cost for operating maize farming. The data was collected through farm record keeping and then tabular. Data analysis compared farming system analysis between farmers' practice technology and recommendation technology [5] .An analysis of the benefit-cost ratio of the maize farming system should be done to evaluate the economic value of maize farming that applies different technologies [6,7]. The formula of the BC Ratio is:

$$\frac{B}{C} = \frac{TR-TC}{TC} \tag{1}$$

B = Benefit
C = cost
TR = Total Revenue
TC = Total Cost

The feasibility of technology should be analyzed with the Marginal benefit cost ratio. Its formula is:

$$MBCR = \frac{\pi1-\pi0}{C1-C0} \tag{2}$$

MBCR = Marginal Benefit Cost Ratio
π_1 = Benefit of recommendation technology
π_0 = Benefit of farmer's practice technology
C_1 = cost of recommendation technology
C_0 = cost of farmer's practice technology

If the value of analysis > 1, the introduction technology is feasible and capable of developing on a large scale.

3 Result and Discussion

3.1 Overview Research Location

Naibonat village, as a research location, has a large village reaching up to 22,47 km2, a slope of land of 15%, and an attitude area of 22 meters above the sea. It shows that this village has great potential for agriculture. In this village, farmers develop rice in the wetland and maize crops in the dryland. Rice is planted every year in the rainy season from December until April. The harvesting area for rice commodities reaches 6,661.5 ha. Rice crops develop in two regions that have different irrigation systems. One part of rice developed in regions that have available irrigation systems, and the other part of rice developed in rainfed areas. After harvest, they still have the opportunity to maize crops in the dry season. At the same time or in the wet season, besides rice, Crop farmers develop maize crops in the drylands. The harvesting area of maize crops in Naibonat village reaches 2.651,4 ha [8]. After harvesting maize, the dryland can not develop maize crops. Farmers in this village constantly develop rice and maize every year.

The rice farming system that farmers developed in the research location in Naibonat village is based on permanent irrigation and rice farming based on the annual rainfall in the rainfed area. Usually, rice crops are planted in the wet season, and very few farmers plant in the dry season because the available water for irrigation is very limited during the dry season. So farmers develop other crops like sweet maize, mungbean, and vegetables.

In the rainfed area, farmers themselves had built deep water to prevent limited water during the rainy season. In the dry season, farmers least use deep wells to plant maize, mungbean, and vegetables. So, farmers do not plant rice crops because of insufficient water for irrigating rice crops. The research should be introduced how to use groundwater in the deep wall for planting maize farming systems effect introduced one rainfed regions can be optimized by using groundwater in the deep wall to develop maize Crops as a second commodity to increase farmers' activity during the dry season. However, farmers should spend money to buy fuel for running water pump machines to irrigate maize farming.

Research location as a village of Kupang Timur Subdistrict and Kupang District. Accessing both the subdistrict and the district is effortless. The distance between the Village and the Capital of Kupang Timur subdistrict is only 5 km, and the Capital of Kupang District is 7 km. Connecting transportation is very nice, so it is easy to access.

3.2 Management of Groundwater for crop irrigation and Production Facility Application

Determining the success of a maize farming system depends on how to apply production facilities and how to arrange water irrigation for maize farming. All the stages should be running exactly and on time.

Farmers in Timor Island have been running all the activity in the agriculture sector, which depends on the annual rainfall, including maize farming. This paper describes different types of management of maize farming in the rainfed region. Farmers usually carry out their farming using available rain during season planting. Generally, Crop pattern rice–scrab has been applied for a long time. However, day, the land in the rainfed area should optimize utilization through management of groundwater. Using groundwater for maize is a way to improve crop patterns and increase farmers' income during the dry season in the rainfed region [9,10].

Arrangement of Groundwater from the deep walls for the maize farming system is straightforward. It is described as follows. Groundwater from the deep wall is pulled up using a water pump machine and then distributed regularly into blocks of maize farming. This research applied one-time irrigation every week regularly to the maize farming system block. Implementing system irrigation requires labor, a pump machine, and fuel. As long as the maize farming system is managed better, it is very important to provide it on time. The required material and labor working for irrigating are as follows.

Table 2. Description of Timetable for irrigating in the Raifiel Area at Dry Season 2019

No	Irrigation time	Fuel (ltr)	Labor Working (personal)	Time (day)
1.	One day before planting	10	1	1
2.	One day after planting	10	1	1
3.	Second Week	10	1	1
4.	Third	10	1	1
5.	Fourth	10	1	1
6.	Fifth	10	1	1
7.	Sixth	10	1	1
8.	Seventh	10	1	1
9.	Eighth	10	1	1
10.	Ninth	10	1	1
11.	Tenth	10	1	1
12.	Twelfth	10	1	1
	Total	120	12	12

During the dry season, there is very limited rain, even if there is no rain in the dry season. Table 2 shows that the rainfiled area, especially in the dryland, should need much water for maize growth normally. Twelfth-period irrigation should be done to avoid critical drought for maize crops. During irrigation, farmers need materials like fuel and labor to operate the maize farming system. This table shows that to run effective maize farming, it needs fuel up to 120 liters and 12 laborers working. That way, farmers consistently do it regularly and on time each period. It's very important for farmers to ensure that maize crops are always fresh, normal, and productive. Table 3 presents the description of labor working for applying the production input.

The average depth in this area up to 20 meters, and the water position was being at only five and up to ten meters below ground. So, the water should be lifted with a water pump machine. Each farmer himself is available well depth independently.

Table 3. Description of labor working for applying input production

No	Time Schedule	Labor Working (personal)	Time (day)	Total day working
1.	Land preparation	5	2	10
2.	Planting	10	1	10
3.	Fertilizing I	10	1	10
4.	Insect control	2	1	2
5.	Weed control	2	1	2
6.	Fertilizing II	10	1	10
7.	Harvesting	5	5	25
	Total	44	15	69

Results of the research showed that farmers should spend cash to operate maize farming systems effectively and avoid drought.

3.3 Maize Growth and Productivity

Maize crop growth describes the responsiveness of maize to all put production, which applies to maize crops. The performance of maize crops in this research can be seen in Figure 1.

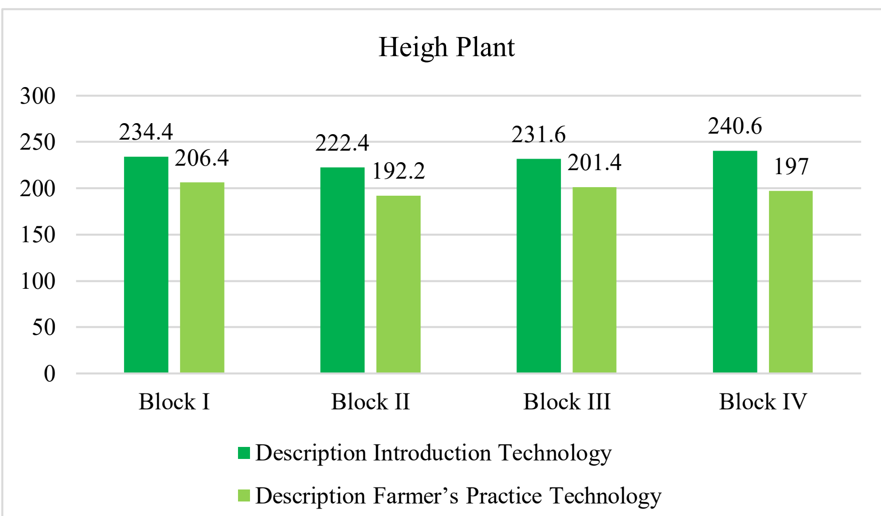

Fig. 1. Heigh Plant of Maize at different Technology of maize farming systems in rainfed

Figure 1 shows that the average of heavy maize at harvest time differs greatly between introduction technology and farmers' practice technology. Heigh maize of introduction technology can reach 222.4 – 240.6 cm, while heigh maize of farmers practice technology only reaches 192.2 – 206.4 cm. Two various technologies show different heavy plants of maize crop. Maize growth in the rainfed area can reach a height of up to 255 cm [11,12]. Determining factors that influence maize growth depends on input production or production facility. This high plant of maize indicates that maize crops avoid permanent drought. Heigh of maize crops that apply farmers' practice technology is lower than Introduction technology.

According to Damaputra [13], using groundwater for the agriculture sector increases the productivity of agriculture.

Yielding maize from a management farming system gives proof that maize can be developed in the rainfed season or the dry season and normally grows and is productive. The average productivity of maize can be seen in Table 4.

Table 4. Productivity of Maize Crop at Different Technology of Maize Farming System in Rainfed Regions 2019

Block/Sample Plant	**Productivity of Maize (ton/ha)**	
	Introduction Technology	**Farmer's Practice Technology**
Block I	7.520	5.575
Block II	6.950	5.900
Block III	8.750	4.850
Block IV	9.250	5.400
Average	8.317	5.383

The average productivity of maize that applies introduction technology can reach 8.3 ton/ha, while maize farming that applies farmer's practice technology reaches 5.4 ton/ha. This one shows the difference in yield between different applied technologies. This production is normal when produced in normal conditions and can reach 8 tons/ha [14,15].

3.4 Economical Analysis

Table 5. Cost of Maize farming system at Different technology in rainfed region 2019

Source of Cost	**Introduction Technology**			**Farmer's Practice Technology**		
	Volume	Cost/unit (IDR)	Total Cost (IDR)	Volume	Cost/unit (IDR)	Total Cost (IDR)
Production Facility						
Seed	20	100,000	2,000,000	20	15,000	300,000
Fertilizer						
Urea (kg)	200	1,900	380,000	50	1,900	95,000
NPK Posca	200	2,300	460,000	50	2.300	115.000
Fuel	120	6.500	780.000	120	6,500	780,000
Insecticide	4	125,000	500,000	2	125,000	250,000
Total			4,120,000			1,540,000
Labor Working						
Land preparation	12	50,000	600,000	12	50,000	600,000
Irrigating	12	50,000	600,000	12	50,000	600,000
Planting	10	50,000	500,000	10	50,000	500,000
Fertilizing	10	50,000	500,000	10	50,000	500,000
Weed controlling	2	50,000	100,000	2	50,000	100,000
Insect controlling	2	50,000	100,000	2	50,000	100,000
Harvesting	25	50,000	1,250,000	25	50,000	1,250,000
Total			3,650,000			3,650,000
Total Cost			7,770,000			5,190,000

All activity in the maize farming system to produce maize yield uses materials as input production and labor working as agent operating. Farmers spend all of it as a cost in running farming systems productively. The cost of operating a maize farming system consists of two parts. One part is the cost of production facilities, and the other part is the cost of labor.

Counting two sources of cost becomes the total cost of maize farming system operation. The total cost is described in Table 5.

Table 5 shows that the production facility cost in operating a maize farming system is up to IDR 4,120,000/ha. Furthermore, the cost of labor working up to 3.650 IDR/ha. The total cost of maize farming system operation can reach IDR 7.770.000/ha.

Table 6. Income of Maize farming system at Different technology in rainfed region 2019

Component	Description	
	Introduction Technology	Farmer's Practice Technology
Cost of Production Facility (IDR)	4,120,000	1,540,000
Cost Labour Working	3,650,000	3,650,000
Total Cost (IDR)	7,770,000	5,190,000
Production (ton/ha)	8,317	5,383
Income (IDR)	33,268,000	21,532,000
Benefit Cost Ratio (B/C) ratio	4.3	4.1
MBCR	4.5	

Maize farming systems that run in the dry season benefit farmers by getting income. Farmers' income that applies Introduction technology gets IDR 33,268,000/ha, and farmers' income that applies farmer's practice technology gains IDR 21,532,000/ha (Table 6). Farmers' income through developing maize in the rainfed area gets IDR 25,200,000/ha [11]. Groundwater is essential to support farmers in developing agriculture [16].

4 Conclusion

Based on the description and analysis above, it can be concluded that

1. Arranging groundwater at the deep wall for irrigating maize farming systems in the rainfed region can support maize growth, usually preventing maize crops from permanent drought, giving high productivity, and reaching up to 8.3 tons/ha.
2. Farmer's income from management maize farming system that applies to the introduction technology reach Rp 33.268/ha and B/C Ratio 4.3 and MBCR 4.1. It shows that the introduction of technology is feasible to develop on a large scale and can change farmers' practice technology.

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