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Dry Land Agriculture Development due to Water-Balanced Land

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Abstract: To support environmental conservation and food security, efficient and effective use of limited water resources is required. However, effective use of water resources is needed to assist planning and policymaking for crop water requirement analysis for dry lands in Bali. Farmers naturally need some information about how to effectively use rainfall from the available rain season or groundwater for planting in the fixed phase of plant growth. The research simulated alternative crop rotation patterns to maximize annual profit. The methodology consists of assessing dry land potency at the research location, developing the water balance in dray land, estimating crop water requirements in dry land, and developing a schedule of alternative cropping rotation patterns in a year. This research was conducted in several areas in Bali: Sanur, Padangbai, Banjar Bunutan, Kubut, Buleleng, Seririt, Celukan Bawang, Banyuwedang, and Gilimanuk. The results show that the intercropping revenue of cassava + maize – groundnut is 25.3% larger than that of the monoculture of cassava. October: the groundnut, maize, and sweet potatoes can be cropped from 3rd February to 17th February; cassava can be cropped from October 22 to October 29; and the crop rotation intercropping pattern of cassava + maize – groundnut can be cropped from October 22 to June 21. Fresh tuber yields of cassava intercropped with maize and groundnut are 22.54 t per hectare. Water balance analysis using Thornthwaite and Mather's method revealed a surplus from January to April and a deficit from May to November. Intercropping patterns like cassava + corn-peanut are recommended for Bali farmers.

Keywords: monoculture, agriculture, dry land.

土地水分平衡促进旱地农业发展

摘要：为了支持环境保护和粮食安全，需要高效和有效地利用有限的水资源。然而，需要有效利用水资源来协助规划和制定巴厘岛旱地作物需水分析政策。农民自然需要一些关于如何在植物生长的固定阶段有效利用雨季降雨或地下水进行种植的信息。该研究模拟了替代作物轮作模式，以最大化年利润。该方法包括评估研究地点的旱地潜力、开发旱地的水分平衡、估计旱地作物需水量以及制定一年内替代作物轮作模式的时间表。这项研究在巴厘岛的几个地区进行：沙努尔、巴丹拜、班贾尔布努坦、库布特、布莱伦、塞里里特、塞卢坎巴旺、巴纽温丹和吉利马努克。结果表明，木薯+玉米-花生间作收入比木薯单一栽培高出 25.3%。10 月：花生、玉米、红薯可于 2 月 3 日至 2 月 17 日种植；木薯可于 10 月 22 日至 10 月 29 日种植；木薯+玉米-花生轮作间作模式可于 10 月 22 日至次年 6 月 21 日种植。木薯与玉米和花生间作的鲜块茎产量为每公顷 22.54 吨。使用桑斯韦特和马瑟方法进行的水分平衡分析

显示，1 月至 4 月盈余，5 月至 11 月亏空。建议巴厘岛农民采用木薯+玉米-花生的间作模式。

关键词：单一栽培、农业、旱地.

1. Introduction

Managing dry land agriculture hinges on soil water storage capability, which is influenced by rainfall and affects soil moisture availability. Limited soil moisture and low fertility present biophysical and socioeconomic obstacles to developing dry land farming in Indonesia. Optimizing crop production per unit of water is crucial. Upton et al. showed a complex relationship between plant yields and available water. A relationship between yield and water demand was also found in [1] and [2]. Agung highlighted additional challenges like uneven rainfall, soil erosion, high temperatures, and socioeconomic constraints such as ignorance, weak infrastructure, and poverty.

Munandar highlighted the lack of reliable water sources in dry lands as a significant barrier to farming. This scarcity leads to low yields and crop failures, making intensification challenging for farmers. The resulting low cropping patterns and productivity contribute to low incomes and poor welfare among farmers. Consequently, farmers struggle to access adequate production inputs because of their limited skills and knowledge, hindering the adoption of advanced agricultural technology. As noted in [3] and [4], low farmer participation in agricultural development efforts intensifies constraints on existing farming infrastructure and facilities.

The exploitation of natural resources increases along with humans and population needs, which also increase. A development paradigm that focuses on economic growth encourages excessive use of natural resources, leading to scarcity and a decline in the quality of natural resources. Water and land, critical resources for development and life, are vulnerable to chemical and physical degradation due to agricultural activities and pollution. Agriculture that does not pay attention to ecosystem sustainability causes changes in the function of air pockets. According to [5], development increases erosion, thereby adding sediment downstream and reducing land productivity. Critical land is difficult to use as productive agricultural land, and maintaining groundwater availability on damaged land is also difficult. According to [6], damaged soil cannot store air during the rainy season, causing most of the rainfall to become runoff and resulting in surface erosion.

In general, Bali has a longer rainy season than a dry season. The highest rainfall occurred in January and the lowest in August. According to [7], almost the entire northern and eastern coasts, as well as part of the western coast of Bali, have a D3 climate type (3-4 wet months and 4-6 dry months), except for Tejakula, which has a D4 climate type (3-4 wet months and 7-9 dry months). Most of the southern region of Bali has a C3 climate type (5-6 wet months and 4-6 dry months), except for Kuta Beach (C4: 5 wet months and 7 dry months) and Dawan (E4: 0-2 wet months and 7-9 dry months). According to [8], intercropping can only be performed by farmers once a year due to water shortages. The second crop often fails if planted twice a year; thus, farmers do not plant in the third growing season. As stated in [9], dry land farmers only plant annual crops during the rainy season, with the current crop rotation patterns being cassava, corn + soybeans - fallow and cassava, corn + peanuts - fallow. To address water shortage issues in the second and third growing seasons, it is necessary to design efficient and high-quality cropping patterns.

Analyzing crop water requirements for dry lands aids South Bali in planning and policymaking, optimizing limited water resources for environmental preservation and food security. Farmers seek guidance on effective rainwater use. The need to adjust the crop growth phases according to available water was highlighted in [10]. Challenges include erratic rainfall and low soil fertility, which impact productivity. Identifying potential land for profitable agricultural development is essential because farmers are yet to adopt new crops. Field experiments or simulations are needed to determine groundwater availability for crops.

Today, farmers cultivate annual crops like cassava, soybeans, peanuts, and corn. Intensive efforts are required to determine cropping schedules and suitable plant rotation patterns. The key issues to analyze include planting patterns, cropping schedules, plant water requirements, dry land water balance, and the identification of suitable dry land. Future agricultural activities require intensive management. According to [11], five essential aspects must be met: promoting sustainable regional economic growth, being environmentally safe, motivating farmers without conflict, being economically beneficial for rural areas, and aligning with local agro-ecological conditions.

2. Materials and Methods

2.1. Concept of Dry Land Development

Dry land development faces socioeconomic constraints, biotic factors, year-round water scarcity, and low soil fertility. Limited rainfall is typically the only water source for crops, and poor water management means that farming often occurs only once a year. Munandar notes that this monoculture approach leads to high failure risks and low productivity, resulting in low farmer incomes. Intensive cropping requires attention to crop, soil, and climate conditions. Groundwater availability, which depends on rainfall, is crucial, and groundwater balance and regional land analysis are conducted using CropWat software. Crop water requirements are affected by evapotranspiration (ETo), which is widely analyzed by climate factors such as exposure time, wind speed, humidity, temperature (Penman-Monteith) [12], and crop coefficient (Kc). To determine and analyze crop water requirements and groundwater balance will certainly help dry land farming in analyzing suitable cropping patterns and schedules. In addition, it is hoped that production will be increased to boost farmers' income.

2.2. Method of Dry Land Development

Dry land development in Bali, covering areas from Gilimanuk to Sanur, was conducted from October 2018 to July 2019 through field experiments, observations, and interviews. The farming systems used by farmers were identified via interviews and observations, while dry land-based agricultural water balance patterns were developed through field trials. The study locations were chosen after consultation with relevant agencies. Preparations included a literature review on dry land cropping patterns and moisture balance conducted at Udayana University Central Library, Central Mahasaraswati University Library, and other related institutions. Crop water demand, estimated yield reduction, and reference evapotranspiration were analyzed using CropWat for Windows.

3. Results and Discussion

3.1. Vegetation in Dry Land Development

Dry land development supports the growth of various crops such as teak, turi, srikaya, mangoes, papayas, oranges, waluh, cassava, peanuts, and maize, which are often cultivated together in vegetable beds. However, direct field observations revealed that vegetable growth is infertile, uneven, and sparse during the dry season, with flourishing weeds during the rainy season due to limited water availability. Cultivated plants are mainly annual, including beans, maize, and cassava, with turi, teak, orange, mango, and coconut as annual crops, and papaya and banana as semiannual crops. Despite being dry lands with only rainwater as a water source, local farmers typically cultivate once a year. Monoculture cropping with minimum tillage is common, leaving potential land overgrown with weeds. Some areas have hard limestone soil, making cropping impossible. Additionally, significant agricultural land has been converted for tourism facilities like villas and sand. Tables 1 and 2 outline farmer incomes per hectare and cropping pattern area, respectively.

3.2. Regional Water Balance Method by Thornthwaite-Mather

A surplus month from January to April is presented in Tables 1 and 2; however, a deficit month is presented from May to November. The annual evapotranspiration and rainfall were 1,833.7 mm and 1,723.9 mm. High rainfall has occurred in the last 5 months.

Table 1 Farmer income per ha for each series cropping pattern (Developed by the authors)

Plant	**Varieties**	**Period-growing crops**	**Yield (t per-ha)**	**Farmer Income (Rp)**
Cropping pattern 1: Monoculture				
Cassava	Adira-1	22 Oct-21 Jun	24.19	2,833 million
Cropping pattern 2: Intercropping of corn cassava				
Cassava	Adira-1	22 Oct-21 Jun	22.19	11,1905 million
Corn-3	Pertiwi	22 Oct-26 Jan	5.44	
Cropping pattern 3: intercropping: Cassava + Maize-Peanut				
Cassava	Adira-1	22 Oct-21 Jun	22.54	11,3855 million
Corn-3	Pertiwi	22 Oct-26 Jan	5.44	
Peanut	hare	3 Feb-5 May	0.17	

Table 2 Farmer income per year per cropping pattern area (Developed by the authors)

No.	**Cropping pattern planting**	**Area (Ha)**	**Period (Day)**	**Farmer Income (Rp.)**
1	Cassava	38	242	107,654,000
2	Cassava + corn	38	242	425,239,000
3	Cassava + Corn - K. Land	38	242	432,649,000

3.3. Water Balance Simulation by CropWat

3.3.1. CropWat for Windows

The simulation was performed using the CropWat model for Windows according to the FAO model proposed by Smith [4]. The data were taken from climatology data from 2010 to 2017 from the Meteorology Center for Climatology and Geophysics Region III Ngurah Rai station.

3.4. Analysis of Planting Patterns

3.4.1. Economic Value

Intercropping cassava with peanut corn yields the highest economic value, generating Rp. 11,385.00 million per hectare, followed by cassava + corn intercropping with Rp. 11,905 million per hectare. The cassava monoculture has the lowest income at Rp. 2,833,000 per hectare. The third planting pattern of cassava + corn-peanuts yielded the highest profit at Rp. 432,649,000, followed by the second planting pattern at Rp. 425,239,000. The cassava monoculture has the lowest profit at Rp. 107,654,000. Daily profit analysis for the third planting pattern was Rp. 299,038 for a 38-hectare cropping area, while the cassava monoculture and the second planting pattern yielded Rp. 1,201,802 and Rp. 1,181,219 respectively. Hence, the second and third intercropping patterns offer greater benefits compared to monoculture. Local farmers in Pecatu village currently practice monoculture cropping once a year during the rainy season, leaving the remaining land overgrown with weeds. Establishing demonstration plots in the field for socialization is necessary to encourage farmer participation in intercropping and cultivation techniques, thereby promoting food security and increasing yield.

3.4.2. Cropping Schedule

Trials of the cropping schedule were carried out in dry land fields to assess the effects of the cropping schedule on yield and growth. The analysis result of the simulation indicates that cassava can only be grown during October 22-29 as presented in Table 3, and it is obtained the estimation of the linear regression formulation as follows: y = 0.093 x + 0.289 with R^2 is 0.99. Based on this formulation, the obtained crops were cropped on October 22, and the evapotranspiration of actual crop (ETc) was 1,070.00; however, the maximum evapotranspiration is 1,133.5 mm, and water shortage = 63.5 mm to meet the demand of maximum ETc; thus, the reduction in yield was 6.2%.

Table 3 Groundwater balance and yield reduction during the rainy season by reversing planting time (Developed by the authors)

Pattern	Crop into 1	Planted	Effective rain (mm)	ET0 (mm)	ET0/ETM (%)	SMD end (mm)	Reduction result (%)
UK + (J-KT)	Cassava	22/10	1,022.30	1,070	94.4	47.7	6.2
		29/10	990	1,047.40	91.7	57.5	9.1
		11/5	955.2	1,019.30	88.5	64	12.7
		11/12	919.5	987.5	85	67.9	16.5
	Corn	22/10	337.7	348.5	100	10.8	0
		29/10	340	342.7	100	2.7	0
		11/5	331	339.7	100	8.7	0
		11/12	324.7	340.1	100	15.4	0
JG + (KT-KT)	Corn	29/10	309.8	320.1	100	10.3	0
		29/10	312.5	315.1	100	2.6	0
		11/5	304.5	312.8	100	8.3	0
		11/12	299	313.7	100	14.7	0
		19/11	311.8	317.5	100	5.8	0
		26/11	311.8	323.9	100	12.1	0
	K Land	22/10	290.6	300.9	100	10.3	0
		11/12	279.2	294.3	100	15.1	0
		19/11	292	298	100	5.7	0
		26/11	291.7	304.1	100	12.4	0
UJ + (J-KT)	Sweet potato	22/10	495.2	504.5	100	9.3	2
		9/10	503	510	100	11.6	0
		19/11	510.3	514.6	100	4.4	0
		26/11	511.6	520.6	100	9	0
	Corn	22/10	301.1	309.1	100	8	0
		29/10	301.6	303.5	100	2	0
		11/5	294	300.4	100	2	0
		11/12	288.7	300.2	100	11.5	0
		19/11	298.7	303.1	100	4.4	0
		26/11	299.1	308.5	100	9.4	0
JG + (KT - J)	Corn	22/10	309.8	320.1	100	10.3	0
		29/10	312.5	315.1	100	2.6	0
		11/5	304.5	312.8	100	8.3	0
		11/12	299	313.7	100	14.7	1
	K Land	22/10	290.6	300.9	100	10.3	0
		29/10	293.2	295.7	100	2.5	0
		11/5	285	293.3	100	8.3	0
		11/12	279.2	294.3	100	15.1	0
		19/11	292	298	100	5.7	0
		26/11	291.7	304.1	100	12.4	0

If the cropping schedule is delayed to October 29, the ETc and ETm of the actual crop decrease to 1,047.4 and 1,142.2 mm, respectively, and the water lack is 94.8 mm that meets the ETm; therefore, there is a 9.1% reduction. If the cropping schedule is delayed again until November 5, then the ETc of the actual crop is 1,019.3 mm and the ETm is 1,151.8 mm; then, the water shortage is 132.5 mm, and a 12.7% reduction that passes the threshold of 10%. The increasing groundwater level deficit in the root zone is affected by this condition, as shown by the low ETc/ETm ratio. However, groundwater availability is insufficient to meet plant water demand, which indicates a low ETc/ETm. The sweet potato crops are cropped in the rainy season from October 22 to November 12, by a 0% reduction yield, while in dry season I those cropped on 3rd – 17th February as presented in Table 4, and it is based on the linear regression formulation as follows: $y = 0.294x - 3.075$ with $R^2 = 0.98$. Crops planted on February 3 had actual plant ETc and ETm of 543.3 and 570.7 mm, respectively, due to lack of water was 27.4 mm and 5.3% yield reduction. If the cropping schedule is delayed until October 29, the actual ETc is 496.1 mm and ETm is 536.3 mm, and the water shortage is 40.2 mm by an 8.3% reduction. If the cropping schedule is delayed until 5th November, the actual ETc is 457.3 mm and ETm is 502.5 mm, the water shortage is reduced to 45.2 mm, and it meets the ETm and the 9.9% reduction. If the cropping schedule is delayed again until February 24, the actual ETc is 398.0 mm, the ETm is 451.2 mm, the water shortage is 53.2 mm, and the resulting reduction is 13%.

The peanuts can be grown in dry season I (MK I), which is from 3rd February to 17th March and it is obtained by the estimated regression formulation as follows: $y = 0.20x + 0.052$ with R^2 is 0.99. In addition, for dry season I, corn crops can also be cropped from February 3 to March 17, which is obtained by the estimated regression formulation as follows: $y = 0.283x - 0.019$ with R^2 is 0.99.

Table 4 Groundwater balance and yield reduction during the dry season (Developed by the authors)

Plants to 2	Planting	Effective rain (mm)	ETc (mm)	Etc-Etm (%)	Final SMD (mm)	Reduction in yield (%)
Peanuts	2/3	348.6	356.7	100	8.2	0
	2/10	336.6	350.8	100	14.2	0
	17/2	340.7	346.4	100	5.7	0
	24/2	299.3	311.2	100	12	0
	3/3	602.1	333.7	100	18.1	0
	3/10	564.7	329.7	97.9	36	1.5
	17/3	526	313.9	91.9	44.6	5.7
	24/3	445.9	293.1	84.3	46	11
Corn	2/3	408.1	417.3	100	9.2	0
	2/10	402.3	418.4	100	16.2	0
	17/10	413.2	419.6	100	6.4	0
	24/2	398.70	412	100	22.5	0
	3/3	385.9	423.90	100	38	0
	3/10	356.7	427.90	100	71.2	0
	17/3	325.3	423.4	97.6	98	2.9
	24/3	294.3	395.7	89.9	101.5	12.7
Sweet potato	2/3	483.1	543.3	95.2	60.3	5.3
	2/10	433.4	496.1	92.5	62.7	8.3
	17/2	391.2	457.3	91	66.1	9.9
	24/2	329.9	398	88.2	68	13

Crop plants on 3rd February had an actual ETc of 543.3 mm and ETm of 570.7 mm; the water shortage was 27.4 mm, resulting in a 5.3% yield reduction. If the cropping schedule is delayed until October 29, the actual ETc is 496.1 mm and the ETm is 536.3 mm, and the water shortage is 40.2 mm, resulting in an 8.3% yield reduction. If the cropping schedule is delayed until 5th November, the actual ETc will decrease to 457.3 mm and the ETm will decrease to 502.5 mm, the water shortage will be 45.2 mm and it will meet the ETm by 9.9%. If the cropping schedule is delayed again until 24th February, the actual ETc is decreased by 398.0 mm, ETm is decreased by 451.2 mm, and the water shortage is 53.2 mm, which results in a 13% reduction. According to Prijono [10], the cropping schedule is based on the possibility of a decline in the most secure results and the evaluation results of groundwater balance if the decision to cropping is taken is taken at a possible risk of soil moisture deficit, which will be increasingly threatened.

4. Discussion

Simulation results for crops planted in the rainy season show yield reductions below 10%, such as 7.3% for cassava monoculture, 8.3% for cassava + corn intercropping, and 8.8% for cassava + corn-peanut intercropping. However, during the first dry season (MK I), peanuts showed promising results. Planting peanuts in the second, third, and fourth weeks of February leads to yield reductions of 6.1%, 10.3%, and 15.2%, respectively. All treatments resulted in yield reductions above 10%, indicating unsuitability for sweet potato cultivation in the first dry season, with a significant 35.6% yield decrease when beginning cropping in February alone. Sweet potatoes are suitable for planting during the rainy season (MH). The CropWat for Windows model analyzes crop reference evapotranspiration, plant water requirements, and estimated yield decline due to water stress. The maximum threshold for yield reduction is set at 10%.

Groundwater storage in cassava crops under monoculture planting (UK) shows a total change in storage (S) of 821.20 mm, with rainfall of 2,416.50 mm and runoff of 507.96 mm during the growth period. The total evapotranspiration was 1,087.34 mm, highlighting the substantial water demand of cassava in monocultures. Cassava yields under monoculture planting (UK) were 24.19 tons per hectare, lower than the potential yield of Muara variety cassava (38.2 tons per hectare (Department of Agriculture, Food Crops, and Horticulture, Badung Regency, 2009).

In the intercropping pattern of cassava + corn (UKJ), the fresh cassava yield was 23.941 tons per hectare, slightly lower than the monoculture cropping pattern of cassava (UK), which yielded 24.19 tons per hectare. As observed in [13], intercropping cassava led to decreased biomass production compared with monoculture in Rio Cabuyal. However, according to [14], there is no influence on fresh cassava yield when intercropping hybrid maize with cassava in Indonesia. The dry weight of corn shells was consistent at 5.44 tons per hectare, lower than the average production of Arjuna varieties in Bali at 5.64 tons per hectare. Intercropping patterns can lead to the competitive use of light, nutrients, and water, affecting crop yield and growth. Water stress can significantly reduce corn production, particularly during the critical growth stages. Groundwater balance analysis of intercropping patterns like cassava + corn-peanut mirrors that of cassava + corn. The water requirement for peanuts exceeds that observed during the research, suggesting higher water demands than previously estimated. Overall, intercropping patterns increased plant water requirements compared to monoculture cropping patterns.

The fresh cassava yield in this planting pattern was 22.54 tons per hectare, lower than that of the other treatments. This reduction aligns with the findings of [15] that revealed decreased cassava tuber yields in intercropping patterns of cassava + peanuts in India. Intercropping notably affects cassava yield, consistent with results of [16], indicating that rotational planting enhances secondary plant growth like Cowpea but hinders primary plant growth. In Nigeria, similarly higher fresh tuber yields were found in [17] when cassava was intercropped with Cowpea, attributed to Cowpea’s nitrogen-fixing ability, which enhances soil nutrient availability. Intercropping, especially with legumes, can improve soil nutrient status. Dry shelled corn yields remain similar in intercropping patterns like cassava + corn-peanut compared to cassava-corn intercropping, supported by findings [18], suggesting insignificant differences in maize and cassava yields across various intercropping treatments. Productivity variations in intercropping systems stem from differences in plant growth characteristics and maturity phases. Despite this, dry bean yields are lower than average due to competition for groundwater, nutrients, and light in intercropping patterns. Peanut yields are heavily influenced by soil moisture, with a 15% reduction in yield if water stress occurs during the vegetative and pod-filling phases and a 41% decrease if water stress persists until planting end. The critical impact of pod filling and flowering phases on legume yield potential, with potential reductions ranging from 35-69% was underscored in [19].

The assessment of effective rainfall and water requirements using CropWat for Windows shows that the water needs in monoculture planting patterns for cassava (UK) are 1,041.20 mm; for intercropping of cassava + corn is 1,050.50 mm; and for intercropping of cassava + corn-groundnut water is 1,070.00 mm by the same effective rainfall of 1,076.65 mm. The assessment results of CropWat for Windows showed that water demands for crops during the field research period is smaller than during the experimental period, as analyzed using the Hartman method. The water needs for cassava crops (UK) using CropWat is 1,041.20 mm and using the Hartman method is 1,087.34 mm; the water needs for intercropping of cassava + corn using CropWat is 1,050.50 mm and using the Hartman method is 1,088.89 mm; for intercropping of cassava + corn using CropWat is 1,070.00 mm and using the Hartman method is 1,109.99 mm. The analysis showed the advantages of Hartman method probably because the percolation is disregarded.

The highest economic value is the intercropping of cassava + corn-peanut with an income in amount of Rp. 11,385,500 per-ha, followed by the intercropping of cassava-corn in Rp 11.190.500 per ha, and then monoculture of cassava in Rp 2,833,000 per-ha. Therefore, second and third intercropping planting patterns can be selected; it is due to the provision of larger profits than monoculture cropping patterns. This result is in line with the statement that the cassava legumes intercropping is more productive than monoculture cropping. However, intercropping with corn or sorghum did not influence cassava yield when cereals were simultaneously cropped or one or two weeks after cropping cassava.

The simulation results of the cropping schedule indicate that cassava can only be planted from October 22 to 29, based on a linear regression model ($y = 0.093x + 0.289$, R2 = 0.99). Planting on October 22 resulted in an actual evapotranspiration (ETc) of 1,070.0 mm and potential evapotranspiration (ETm) of 1,133.5 mm, with a water shortage of 63.5 mm leading to a 6.2% yield reduction. Delaying planting until October 29 decreased ETc to 1,047.4 mm and ETm to 1,142.2 mm, with a water shortage of 94.8 mm and a resulting yield reduction of 9.1%. Further delay to November 5 reduces ETc to 1,019.3 mm and ETm to 1,151.8 mm, with a water shortage of 132.5 mm, exceeding the 10% threshold for yield reduction of 12.7%. This phenomenon affects groundwater levels, as indicated by a low ETc/ETm ratio, which indicates insufficient groundwater availability for plant water demand.

The analysis results show that sweet potatoes are cropped in the rainy season that is from October 22 to November 12 by 0% reduction. If sweet potato crops are in the first dry season, they can only be cropped on February 3-17 based on the linear regression estimated formulation as follows: y = 0.294 x – 3.075 with R^2 is 0.98. The crops plant on February 3, so the actual plant evapotranspiration (ETc) is 543.3, the maximum evapotranspiration (RTm) was 570.7 mm, and the water lack was 27.4 mm, representing a 5.3% yield reduction. If the cropping schedule is delayed until October 29, then the actual ETc is 496.1 mm and the ETm is 536.3 mm, and the water shortage is 40.2 mm, resulting in an 8.3% yield reduction. If the cropping schedule is delayed until 5^{th} November, then the actual ETc is 457.3 mm and the ETm is 502.5 mm, and the water shortage is 45.2 mm, which meets ETm by 9.9%, resulting in a reduction. If the cropping schedule is delayed again until 24^{th} February, then the actual ETc is 398.0 mm and the ETm is 451.2 mm, the water shortage is reduced by 53.2 mm by 13%, resulting in a reduction that is above the 10% threshold.

The peanuts can be grown in the first dry season (MK I) that is from 3^{rd} February to 17^{th} March which is obtained by the estimated regression formulation as follows: y – 0.20 x +0.052 with the R^2 is 0.99. In the first dry season, the corn crop assessment of the simulation results shows that corn can also be cropped from 3^{rd} February to 17^{th} March, which is obtained by the estimated regression formulation as follows: y = 0.283 x – 0.019 with the R^2 is 0.99. The crops plant on 3^{rd} February, so the actual plant evapotranspiration (ETc) is 543.3, the maximum evapotranspiration (ETm) is 570.7 mm, and the water lack was 27.4 mm, resulting in a 5.3% yield reduction. If the cropping schedule is delayed until 29^{th} October 29, then the actual ETc is 496.1 mm, ETm is 536.3 mm, and the water shortage is 40.2 mm, resulting in an 8.3% yield reduction. If the cropping schedule is delayed until November 5, then the actual ETc is 457.3 mm and the ETm is 502.5 mm, and the water shortage is 45.2 mm, which meets ETm by 9.9%, resulting in a reduction. If the cropping schedule is delayed again until 24^{th} February, then the actual ETc is 398.0 mm and the ETm is 451.2 mm, the water shortage is reduced by 53.2 mm by 13%, resulting in a reduction that is above the 10% threshold.

In further research, the cropping pattern arrangement can be used. Preparing the planting pattern involves selecting possible planting patterns with the safest level of yield reduction to increase dry land usability. The most important crops are those that are resistant to high production, dryness, and a short lifespan.

5. Conclusions

The annual rainfall at the research site is approximately 1,723.9 mm, and the annual evapotranspiration is 1,833.7 mm. The rainfall in the last five months (December to April) is 1,394.5 mm), whereas there was a low rainfall from May to November (329.4 mm. Water supply is surplus from January to April and deficit from May to November. The plant water requirement in the cassava monoculture root zone was 1,087.34 mm, which is lower than the intercropping of cassava + maize (1,088.89 mm) and intercropping of cassava + maize-groundnut that is 1,109.99 mm.

The study locations were chosen after consultation with relevant agencies. Preparations included a literature review on dry land cropping patterns and moisture balance conducted at Udayana University Central Library, Central Mahasaraswati University Library, and other related institutions. Bali's' clayey soil and hilly terrain support crops like teak, sugar apple, orange, mango, coconut, papaya, banana, turi, beans, cassava, and corn, relying solely on rainfall due to low soil fertility. Water balance analysis using Thornthwaite and Mather's method revealed' a surplus from January to April and a deficit from May to November. Intercropping patterns like cassava + corn-peanut are recommended for Bali farmers. Further research is required to assess planting patterns with high production, short lifespan, and drought resistance.

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