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LAND SUITABILITY OF WANI FRUIT (*Mangifera caesia*) FOR FRUIT DEVELOPMENT IN MOUNT BATUR, KINTAMANI, BALI

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Abstract. *Bali Province is one of the local mango producers, namely Wani fruit. Wani fruit (Mangifera caesia) is a local Balinese fruit that has the potential to be developed. Wani fruit production in Bali has decreased due to fewer trees in community gardens. This study aims to determine the suitability of land for wani fruit plants on the slopes of Mount Batur Kintamani. Evaluation of land based on agroecological zones includes slope, drainage, humidity and temperature. Sampling used composite sampling based on agroecological zones and data analysis using descriptive and comparative methods. The results of research on the suitability of Wani fruit land in Kintamani show three classes, namely moderately suitable (CS), marginally suitable (SM), and not suitable (TS) with the main limiting factors being slope, texture, temperature, effective depth and rainfall. Based on the results of research on the Kintamani area, Mount Batur is suitable for the development of Wani Fruit in Bali. Primarily for Horticultural and Conservation purposes for the protection of local species. Based on agroecological zones, the land area in the Kintamani Bali area that can be developed for Wani fruit plants are zones I, II and III with an area of 21,476 Ha, which is 58.53% of the area of Kintamani. The distribution of agroecological zones suitable for the development of Wani fruit in zone I and II land units is predominantly spread in residential plain areas, and land units in zone III are spread in hilly areas.*
Keywords: *fruiticulture; land suitability; mangifera caesia; wani fruit*

1. Introduction

There were many fruits products from Bali including Wani Fruit (*Mangifera caesia)*. Production in 2021 was 55,166 tonnes with a productivity of 75 kg/tree, but in 2022 it decreased to 49,139 tonnes with a productivity of 35 kg/tree (Department of Agriculture, 2022). One of the factors causing the decline in Wani fruit production is the conversion of Wani plantation land to non-mango plantation land. The potential for land for planting mangoes in Bali is very high. Until now, the local government has not optimized the availability of land for the development of mango plants. The opportunity for extensification in mango cultivation is still very high. Land suitability evaluation was carried out to see specifically the extent of land suitability in Bali for the development of the Wani type of mango (Anderson, 2019; Mahmud *et al*., 2019).

Wani plantation land in Bali is evaluated for land suitability based on an assessment of environmental characteristics, namely climate, soil, topography, hydrology or drainage

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(Hardjowigeno, 2003; Luo, 2021; Worlanyo & Jiangfeng, 2021). Evaluation of land suitability according to agroecological zones and physical conditions in Bali found four agroecological zones with varying sub-zones. The sub-zones in the agroecological zone relate to land characteristics that influence mango planting and production. The land suitability evaluation system is used as an initial stage to identify and view areas to be developed by dividing the area into agroecological zones based on almost the same physical environmental conditions, where the parameters consist of slope, climate (temperature regime and humidity regime) and drainage (Crawford, 2020; Dias, 2019; Eben, 2022; Purba *et al*., 2020; Sharma *et al*., 2018). Therefore, it is important to carry out this research so that it can provide accurate information regarding evaluation of land suitability for Wani trees so that optimal land management can be implemented. This is important to increase the productivity of Wani fruit and to maintain the conservation of Wani fruit to remain sustainable.

Zone classification is based on slope as the main limiting factor which is divided into four classes, namely zones I, II, III and IV. There is also a sub-zone classification consisting of humidity, temperature and drainage. Humidity is divided into three classes, namely moist, slightly dry and dry. Temperature is divided into two classes, namely hot and cool. Drainage is divided into two classes, namely good and bad (Mahinroosta & Senevirathna, 2020; Sutono, 2008; Timberlake *et al*., 2019).

Mount Batur Kintamani is located at an altitude of 900 – 1700 m above sea level with an average temperature of 15^{o}C – 25^{o}C. Average rainfall is around 245 mm – 309 mm per year. Kintamani controls 366.92 km2 of 480.61 km. Kintamani District covers 366.92 m^2 of the 480.61 m^2 area of Bangli Regency. Geographically, Kintamani District is located at 9,097,357.50 m to 9,076,529.26 m South Latitude, and 305,346.84 m to 329,210.17 m East Longitude (Yuniti *et al*., 2022). This research area is at an altitude of 900 to 1,600 m above sea level, with sloping to hilly topographic conditions. The slope level of the land in the research area is flat to a slope of 60^{o}, and most of the Kintamani District is rural. Land use Kintamani has a wavy to hilly topography, with a land slope ranging from 0 to 0.60%. This area is located at an altitude of 900 to m above sea level. Most of the area is plantation land, namely 13,860.48 ha (37.6%), moorland 10,858.46 ha (29.5%), bush 3,862.99 ha (10.5%), and forest 2,884.36 (7,8%), as well as several other uses (Bangli Regency Government, 2022; Yuniti *et al*., 2020).

Identification of land suitability can be assessed based on land characteristics, including temperature, rainfall, root depth, texture, pH, C-organic, CEC and DHL. Mango plants can grow optimally in areas that have moderate to wet rainfall, relatively low plains (the slope is not too steep), hot temperatures with sufficient sunlight, winds that are not too strong, pH close to neutral, good drainage (not flooded with water), and the soil is clayey or slightly clayey (Pusat Penelitian

Tanah (Soil Research Center, 1983). This research aims to determine the distribution of potential agroecological zones for the development of the Wani (*Mangifera caesia)* fruit found in Kintamani Bali. This agroecological zone indication can be used to determine the area of land distribution that is suitable for developing the Wani fruit commodity in Kintamani Bali.

2. Methods

This research was carried out from February to July 2022. Field data collection was carried out in Kintamani, Bali province. The research location is located at an altitude of 900 – 1600 meters above sea level, with an area of 366.92 km² (Figure 1) (Bangli Regency Government, 2022). Laboratory analysis was carried out at the Soil Science Laboratory, Faculty of Agriculture, Udayana University, Bali. This research uses descriptive and comparative methods. The field survey was carried out using a physiographic approach with a systematic free method based on land map units prepared using the information on slope, temperature, air humidity and drainage.

The descriptive method is carried out using qualitative data analysis. The comparative method aims to compare the actual land use area with the land use area based on agroecological zones. Soil samples were taken using the composite sampling technique. Twenty two samples took from 25 land units based on land map units taking into account land use. The parameters determining land suitability are based on determining land suitability for Wani fruit according to the (Soil Research Center, 1983). The limiting factors observed in the suitability of Wani land include temperature (average every month), water availability (dry months and rainfall/year), rooting media (soil drainage, texture and effective depth), nutrient retention (soil CEC, pH soil and C-organics) and terrain/mechanization potential (slopes, surface rocks and rock outcrops). The results of the assessment of the parameters compared with the growing conditions for Wani plants. The assessment results showed the land suitability classes are very suitable (SS), suitable (S), marginally suitable (SM), not suitable (TS) and permanently not suitable (TSP).

Observations of general physical conditions were carried out through field surveys in each agroecological subzone. Observation include the observations of soil characteristics, land use, slope, drainage, vegetation, topography, type of conservation and altitude at the research location. Soil sampling was carried out in Kintamani Bali using the composite sampling method. Soil samples were taken at a depth of 0-60 cm which is soil sample in top soil (0-20 cm) and sub soil 20-60 cm. Soil fertility analysis was carried out through laboratory analysis, which includes determining the pH value, organic matter content, electrical conductivity (DHL) and cation exchange capacity (CEC). Observing the physical properties of soil includes texture analysis in the soil physics laboratory. The assessment criteria for soil analysis results refer to the Soil Chemical Properties Assessment Criteria from the Soil Research Center (Hardjowigeno, 2003).

Land suitability assessment was carried out by matching tables between the growing conditions for Wani plants and the results of soil data interpretation.

Sampling Strategy

While the methodology mentions soil sampling using the composite sampling technique, it does not provide specific details on the sampling strategy, such as the selection criteria for sampling locations or the distribution of samples across the study area. Providing this information would help ensure the representativeness of the soil samples collected.

Figure 1. Research Location Map, Mount Batur, Kintamani Bali

3. Results and Discussion

3.1. Agroecological Zone Analysis

The Kintamani Bali area is classified into 4 (four) agroecological zones, namely Zone I, Zone II, Zone III, and Zone IV. Most of the Kintamani area is included in Zone 1 (Table 1).

Table 1. Area and Percentage of the Kintamani Bali Agroecological Zone

Zone	Land Use	Area (Ha)	Slope Class	Percentage (%)
I	Settlement	13.715	< 8%	37.38
II	Ricefield	110	8-15%	0.30
III	Garden (Tegalan)	16.203	16-40%	44.16
III	Plantation	4.833	16-40%	13.17
IV	Community Forest	1.831	> 40%	4.99
	Total	36.692		100

Source: (BPS, 2023)

Kintamani District, which has an area of ha, is used as rice fields, dry fields/gardens, plantations, community forests and settlements. The largest use of agricultural land is used for moorlands/gardens and for plantations of. The natural potential in the agricultural sector makes most people earn their living as farmers. The use of land in Kintamani District, Bangli Regency can be seen in Table 1. In the cultivation process, Kintamani District is divided into three parts of agricultural cultivation areas, namely: 1) The lower area which grows rice and tuber food crops, vegetable horticulture, fisheries ponds, and wood, 2) The middle area which grows orange plantations and vegetable horticulture, 3) The upper area which grows coffee plantations and some oranges.

Access to transportation infrastructure on the main road is adequate and paved, but the narrow condition of the road makes it difficult for large vehicles such as tourist buses and trucks carrying agricultural products to pass each other. Access to transportation infrastructure on village roads is inadequate and damaged, thus becoming an obstacle to the mobility of village communities to market agricultural products. Road infrastructure needs to be improved to speed up travel times and facilitate the movement of goods and services so that the community's economy can grow. Appropriate government policies are needed to overcome this problem so that infrastructure improvements can be implemented as soon as possible. This repaired road will have a positive influence on helping to improve the economy and society. Based on zoning and slope level, infrastructure becomes important. Areas with steep topography will affect road infrastructure. Infrastructure indirectly influences farmer activities. The condition of the population according to livelihoods is used to determine the socio-economic level and character of the area by looking at the livelihoods chosen to meet living needs (AL-Taani, 2021; Gaur, 2020; Hazarika & Saikia, 2020). This shows that the agricultural sector has a quite important role for Kintamani District in terms of absorbing labor in the agricultural sector. Most of the population makes a living as farmers and farm laborers. (Oladele & Fatukasi, 2020; Fitmawati *et al*., 2017; Mulyanto *et al*., 2023).

The agroecological subzone consists of humidity, namely: humid (x), slightly dry (y) and dry (z); temperature, namely: hot (a) and cool (b); and drainage, namely: good (1) and bad (2) presented in Table 2.

The distribution of the Kintamani Bali agroecological zone, land units in zones I and II are predominantly spread in areas with residential plain topography, while land units in zone III are spread in hilly areas, and land units in zone IV are spread in highland or mountainous areas. The land use carried out by the Kintamani Bali community is generally rice fields and community gardens in zones I and II. Zones III and IV are generally used as mixed garden land and community forests. The land use carried out by the community takes into account the location and topography of the area.

The agroecological subzone consists of humidity, namely: humid (x), slightly dry (y) and dry (z); temperature, namely: hot (a) and cool (b); and drainage, namely: good (1) and bad (2) (Table 2).

Table 2. Distribution of Agroecological Sub Zones in Kintamani Bali

Zone	Slope	Temperature Humidity	Drainage	Symbol	Code	Area (Ha)	Zone
I	< 8%	humid (x)	cool (b)	good (1)	Ixb1	1	772.16
		humid (x)	cool (b)	good (1)	Ixb1	2	3125.40
		humid (x)	cool (b)	good (1)	Ixb1	3	4485.87
		slightly dry (y)	cool (b)	good (1)	Ixb1	4	3787.25
		slightly dry (y)	cool (b)	good (1)	Ixb1	5	1544.32
II	8 - 15 %	humid (x)	cool (b)	good (1)	IIxb1	6	29.50
		humid (x)	cool (b)	good (1)	IIxb1	7	65.70
		humid (x)	cool (b)	good (1)	IIxb1	8	14.80
III	16 - 40 %	slightly dry (y)	cool (b)	good (1)	IIIyb1	9	2524.32
		slightly dry (y)	cool (b)	good (1)	IIIyb1	10	631.08
		slightly dry (y)	cool (b)	good (1)	IIIyb1	11	2103.6
		slightly dry (y)	cool (b)	bad (2)	IIIyb2	12	841.44
		slightly dry (y)	hot (a)	bad (2)	IIIya2	13	3155.40
		slightly dry (y)	hot (a)	bad (2)	IIIya2	14	4627.92
		dry (z)	hot (a)	bad (2)	IIIza2	15	1893.24
		dry (z)	cool (b)	bad (2)	IIIzb2	16	631.08
		dry (z)	Panas	bad (2)	IIIza2	17	1682.88
		dry (z)	Panas	bad (2)	IIIza2	18	2945.04
IV	> 40 %	slightly dry (y)	cool (b)	good (1)	IVyb1	19	329.58
		dry (z)	hot (a)	bad (2)	IVza2	20	183.10
		dry (z)	hot (a)	bad (2)	IVza2	21	256.34
		dry (z)	hot (a)	bad (2)	IVza2	22	512.68
		dry (z)	hot (a)	bad (2)	IVza2	23	549.30

3.2. Actual Land Suitability

Mangifera caesia is grown in tropical climates. To grow Mangifera caesia on a commercial scale and profitably, temperature and rainfall must be within well-defined ranges. Besides altitude, temperature, rainfall and wind speed, land suitability also influences the growth and production of Mangifera caesia. Mangifera caesia thrives in both moist and dry conditions. Mangifera caesia requires good rainfall during its growing season which is June to October and dry weather without rain from November onwards. Rainy or cloudy weather during flowering favors the emergence of powdery mildew and planthopper diseases.

The assessment of actual land suitability for Wani plants in each land unit can be seen in Table 3. The toughest limiting factors found in the research area are rainfall (w), temperature (t), slope (s) and texture (r).

Based on Table 3, the actual land suitability in Kintamani Bali which is the largest is CS w(rainfall) t (temperature) with an area of 10,920.15 Ha (29.67%) of the area of Kintamani. The lowest area for actual land suitability is TS (slope) with an area of 1,501.2 Ha (9.90%). The results of research on the suitability of Wani fruit land in Kintamani are categorized into three classes, namely quite suitable (CS), marginally suitable (SM), and not suitable (TS) with the main limiting factors being slope, texture, temperature, effective depth and rainfall. Based on the results of research in the Kintamani area, Mount Batur, it shows that it is suitable for developing Wani Fruit in Bali, primarily for horticultural and conservation purposes to protect local species. Limiting factors that are difficult to overcome include rainfall, slope, temperature and texture.

Table 3. Actual land suitability at sub class level for Wani plants in Kintamani Bali

Zone	Land Units	Actual Land Suitability	Area (Ha)
I	1	SSwt	772.16
	2	SSwt	3125.40
	3	SSwt	4485.87
	4	CSwt	3787.25
	5	CSwt	1544.32
II	6	SSwt	29.50
	7	SSwt	65.70
	8	SSwt	14.80
III	9	CSwt	2524.32
	10	CSwt	631.08
	11	CSwt	2103.6
	12	CSt	841.44
	13	CSr	3155.40
	14	CSr	4627.92
	15	SMr	1893.24
	16	SMtr	631.08
	17	SMr	1682.88
	18	SMr	2945.04
IV	19	CSwt	329.58
	20	TSs	183.10
	21	TSs	256.34
	22	TSs	512.68
	23	TSs	549.30
		Total	**36,692.00**

Rainfall is a meteorological element that has high variations in space and time scales, making it the most difficult to predict (Manurung *et al.*, 2015). The percentage of rainfall each year naturally has a very important influence on the flowering process. The rainfall that can be tolerated for the growth and development of mangoes ranges from 700-2,500 mm/year (Lakitan, 2009). Rainfall and dry months will affect the temperature. The ideal average air temperature for Wani plant growth is 25-32^{o}C with 4 –7 dry months during the year (Sutono, 2008). Slope slope is an important parameter in determining land suitability. This cannot be separated from assessing the dangers of erosion and potential land degradation. Apart from the problems of erosion and land degradation, other constraints such as energy efficiency in the long term need to be considered. On steep land, the energy required for transportation and mechanization will be very high (Agricultural Research and Development Agency, 1999; Fitmawati *et al.*, 2022; Martinello, 2021; Pashkevich *et al.*, 2019).

The effective soil depth suitable for mango plants is > 75 cm (Pakasi *et al.*, 2023; Saha *et al.*, 2010). Effective depth can be obtained through field observations and estimation of soil type.

Based on observations and measurements in the field, the effective depth of the soil reaches more than 60 cm. Estimation of effective depth based on soil type is carried out at the soil order level analysis. The soil types in Kintamani can be divided into Inceptisol and Andisol with the great groups Dystrandepts, Eutropepts and Dystropepts. These soils include developed soil types (Hardjowigeno, 2003) so that the effective depth can reach more than 1 meter. Therefore, overall effective depth is not a major limiting factor.

The Kintamani Bali area has an area of land that can be developed for Wani fruit plants based on agroecological zones, namely zones I, II and III with an area of 21,476 Ha, which is 58.53% of the area of Kintamani. The most severe limiting factor is water availability which is determined naturally by rainfall. The distribution of the Kintamani Bali agroecological zone which is suitable for the development of Wani fruit in zone I and II land units is predominantly spread in areas with residential plain topography, and land units in zone III are spread in hilly areas. Land use by the community in general is rice fields and community gardens in zones I, II and zone III generally as mixed plantation land and community forests. The overall suitability of Kintamani Bali's potential land falls into CS to TS classes. The limiting factors w (rainfall) t (temperature) and s (slope) for Zones I, II and III are in the appropriate class (CS). Meanwhile, the slope limiting factor (s) in zone IV cannot be improved for farmer activities because it has a slope > 40% so the recommended land use is land and forest conservation.

The CEC value of soil is directly proportional to the number of grains. The higher the amount of clay in a type of soil, the greater the CEC will be. The finer the soil texture, the greater the amount of clay colloids and organic colloids, so that the CEC is also greater. CEC greatly influences the growth of Mangifera caesia plants. The lower the nutrient retention (CEC and C-organic), the availability of nutrients (N, P and K) and the more acidic the soil pH will affect mango plant production (Rayes, 2007). Soil organic matter is generally low and the low organic matter content in Indonesia is caused by high temperatures and fast decomposition rates (Subowo, 2010). The pH value determines whether or not nutrient ions are easily absorbed by plants. In general, nutrients will be easily absorbed by plants at a pH of 6-7 because at this pH most of the nutrients will easily dissolve in water. The pH value in the soil also indicates the presence of elements that are toxic to plants. If the soil is acidic, you will find a lot of aluminum (Al), which apart from poisoning plants, also binds phosphorus so that it cannot be absorbed by plants (Akhter *et al*., 2016; Barceló-Anguiano *et al*., 2021; Meina, 2012).

3.3. Potential Land Suitability

Actual land suitability on a land can be increased to potential land suitability by making efforts to improve the limiting factors that exist on each land unit. The suitability of potential land for mango plants can be seen in Table 4. Improvement efforts are made by providing input that suits the needs of the land. The area and percentage of the suitability of Kintamani Bali's potential land can be seen in Table 4. The suitability of Kintamani Bali's potential land falls into classes CS to TS. The slope limiting factor (s) in zone IV cannot be improved because it has a slope > 40% so the recommended land use is conservation.

Table 4. Suitability of Potential Land for Wani Fruit in Kintamani Bali

Zone	Land Units	Actual Land Suitability	Area (Ha)	Improvement Efforts	Improvement Rate
I	1	SSwt	772.16	-	-
	2	SSwt	3125.40	-	-
	3	SSwt	4485.87	-	-
	4	CSwt	3787.25	-	-
	5	CSwt	1544.32	-	-
II	6	SSwt	29.50	-	-
	7	SSwt	65.70	-	-
	8	SSwt	14.80	-	-
III	9	CSwt	2524.32	-	-
	10	CSwt	631.08	-	-
	11	CSwt	2103.6	-	-
	12	CSt	841.44	-	-
	13	CSr	3155.40	Providing fertilizer	Low
	14	CSr	4627.92	Providing fertilizer	Low
	15	SMr	1893.24	Terrace construction	Tall
	16	SMtr	631.08	Terrace construction	Tall
	17	SMr	1682.88	Terrace construction	Tall
	18	SMr	2945.04	Terrace construction	Tall
IV	19	CSwt	329.58	-	-
	20	TSs	183.10	Not recommended	-
	21	TSs	256.34	Not recommended	-
	22	TSs	512.68	Not recommended	-
	23	TSs	549.30	Not recommended	-
		Total	**36,692.00**		

4. Conclusion

The Kintamani Bali area has a land area that can be developed for Wani fruit plants based on agroecological zones, namely zones I, II and III with an area of 21,476 Ha, which is 58.53% of the area of Kintamani. The toughest limiting factor is water availability which is determined naturally by rainfall. The distribution of agroecological zones suitable for the development of Wani fruit in zone I and II land units is predominantly spread in residential plain areas, and land units in zone III are spread in hilly areas. The use of rice fields and community gardens in zones I, II and zone III is generally as mixed plantations and community forests. Potential land suitability falls into CS to TS classes. The limiting factors w (rainfall) t (temperature) and s (slope) for Zones I, II and III are included in the CS class. Meanwhile, the slope limiting factor (s) in zone IV cannot be recommended for farmer activities because it has a slope > 40%, so the recommended land use is land and forest conservation.

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