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Extensive Pineapple Production Constraints and Land Suitability in the Centre Region of Cameroon

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Abstract

The low level of productivity observed in pineapple fields in Centre Cameroon must be sustainably reduced in order to increase producers' income while using the same resources. The identification and control of production constraints are key steps in optimizing the use of limited resources. To this end, the FAO land assessment methodology following the Fuzzy-MCDM protocol was used for the two pineapple production basins in the Centre, namely Awae and Bokito. It was found that the land in Awae Basin is moderately suitable S2sf with constraints imposed by texture, pH and base saturation. In the Bokito Basin, 25% of the land is suitable S1wf and 75% is moderately suitable S2wsf with constraints imposed by soil texture (27%), temporary soil water saturation (99%), pH, base saturation and exchangeable sodium. Constraint correction improves the land index (potential suitability) and remains limited by permanent constraints that cannot be corrected. Improvement of the technical itinerary through modification of plant densities, selection of improved cultivars and balanced fertilization must be undertaken to optimize pineapple production in Centre Cameroon.

Keywords

Land Suitability, Constraints, Pineapple, Centre Cameroon

1. Introduction

Pineapple production in Cameroon remains low with average yields of 39 t/ha, roughly half the yield of African countries such as Ghana, Benin and Côte d'Ivoire

[1]. However, pineapple is a highly prized plant with high economic value both for export and locally. Moreover, of the two production basins in the Centre Region, only the Awae Basin has an acceptable production, although pineapple cultivation has started in the Bokito Basin.

Crop yield is influenced by prevailing pedoclimatic conditions, socio-economic conditions, genotype and techniques used [2] [3]. Increasing crop yields starts with controlling the production constraints of the crop [3] [4] [5]. To this end, the work of [6] [7] provides a basic theoretical framework to identify pedoclimatic constraints. This theoretical framework called land assessment has been used by several authors to determine crop constraints in a given environment [8]-[17]. Various protocols have been developed around this theoretical framework with the aim of getting as close as possible to reality [18] [19] [20]. The land assessment assigns a crop limitation score to each land characteristic. Then, the characteristic scores are combined to give the final land limitation score for that crop [6]. This final limitation score (land suitability) allows decisions to be taken about the use of this land for the given crop, and even more so to guide the management of the crop in order to address the limitations.

However, constraints in this order are classified into three groups according to the level of limitation imposed on the crop and the possibility to address this limitation [5]. Factors that are possible, but expensive or impossible to control are grouped into characteristics or characterizing factors. These include temperature, CO_2, solar radiation, cultivar and texture. Factors that can be controlled, but have limitations on the crop that exceed 50%, are grouped as limiting factors, these being water and nutrients. Finally, the factors that can be controlled and the limitations imposed on the crop range from 16% to 34% are grouped into limiting factors, including diseases, weeds and pests [3] [21].

The objective of this work is to determine the constraints that make producers in Centre production basins, give more or less importance to pineapple cultivation, assess the suitability of the land for pineapple cultivation in the Centre region, and propose management approaches that would make it possible to address the production constraints in order to improve the yield and income of producers.

2. Data Bases

2.1. Location of Study Area

This study was conducted in the Centre Cameroon region, specifically in the production basins of Bokito and Awae. The Bokito Basin, located between latitudes 3.965 - 5.041 N and longitudes 10.466 - 11.771 E, belongs to the forest-savannah transition agro-ecological zone, which is characterized by bimodal rainfall, with an average annual precipitation of 1350 mm, an average annual temperature of 25˚C and an altitude ranging between 210 and 1212 m [22]. This basin is made up of four sub-divisions namely, Bokito, Bafia, Kiiki and Ombessa, with Bokito being the largest in terms of area. The Awae Basin is located between latitudes 3.618 - 4.106 N and longitudes 11.650 - 12.268 E, and includes the sub-divisions of Awae and Mengang. This basin belongs to the bimodal rainfall forest agroecological zone, with an average annual precipitation of 1500 mm, an average annual temperature of 24˚C and an altitude raging between 544 and 1168 m above sea level [23].

2.2. Climatic Data

Climate data were obtained from the Bafia weather station for the Bokito production basin, and online through the Climatic Research Unit gridded Time Series (CRUTS) platform for the Awae production basin [24]. The climate characteristics of interest were average annual precipitation, average annual temperature and average annual relative humidity, which enabled a climate assessment for pineapple [6] [7].

2.3. Pedological Data

Pedological data are based on previous studies conducted in the Bokito and Awae Basins. For this purpose, these data were extracted from dissertations, published articles [25] [26] [27] [28] [29]. Only those of the Awae Basin were obtained from the camsodat 0.1 database [30]. For the first 5 profiles in the Awae Basin, CEC was estimated by the Pedo-Transfer Function (PTF), Equation (1) for Ferraslsols [31]. The selected profiles were chosen on the basis of the topo sequence, after projecting onto a map and creating a topographic profile. This was done in order to take into account the diversity of soils and to avoid redundancy of the same soil type. The soil types found in the Awae Basin are deep A-Bo-C Ferrasols and those in the Bokito Basin are deep A-Bt-C Acrisols with Gleyic properties, variable depth A-Bt-C Nitisols and medium depth A-(Bw)-C Cambisols [29] [32] [33] [34].

3. Methodology

3.1. Data Processing

The processing of data related to the soil characteristics such as texture, Organic Carbon (OC), Cation Exchange Capacity (CEC), pH, Electrical Conductivity (EC) and Exchangeable Sodium Percentage (ESP) follows the procedure described by [35].

3.2. Land Assessment Procedures

The assessment of land suitability for pineapple cultivation of the three types of land use observed in the Centre region [36] was done according to the Fuzzy-AHP method. This method is described as more accurate than the FAO parametric method following Storie and/or square root modalities [11] [15] [37] [38] [39] [40] [41].

3.3. Quantification of Constraints Imposed by Land Characteristic

Based on the land characteristics for rainfed pineapple [7], the Sigmoid and trapezoidal Fuzzy functions (**Table 1**) were used to determine the constraint score of each land characteristic [11] [42]. This score is contained in the standard range of 0 to 1, with 0 representing extremely severe limitations and 1 no limitations for the characteristic of interest. For this interval, five categories, S1-0 suitable without any limitations, S1-1 suitable with low limitations, S2 moderately suitable with moderate limitations, S3 marginally suitable with severe limitations and N unsuitable with very severe limitations, were defined by FAO [6]. After recalculating the clay and silt contents along the profile, only the clay content value was used to determine the texture score [43].

3.4. Weighting of Criteria by Analytical Hierarchy Process (AHP)

Land assessment is a multi-criteria method requiring an understanding of the impact of each of these criteria in contributing to crop yield. As a matter of fact, each land characteristic is a criterion that influences crop yields. However, at different levels, the judicious choice of the weight of each of these criteria makes it possible to bring the estimate as close as possible to the observation. [44] defines a procedure to take into account the impact of each criterion by comparing

Table 1. Fuzzy functions used and threshold values of land characteristic.

Land characteristic	Characteristic boundary				Function
	a	b	c	d	
Base saturation	0	20	50	/	Sigmoid
OC	0	1.2	2.5	/	Sigmoid
CEC	0	16	26	/	Sigmoid
Coarse fragment	55	35	0	/	Sigmoid
Depth	0	40	76	/	Sigmoid
EC	4.2	3	0	/	Sigmoid
ESP	21	10	0	/	Sigmoid
pH	3	5.5	6	7.9	Trapezoidal
Precipitation	600	1200	1400	2000	Trapezoidal
RH%	30	60	80	100	Sigmoid
Texture	80	50	14	/	Sigmoid
Slope %	100	7.5	0	/	Sigmoid
Temperature	16	20	26	35	Trapezoidal

For the sigmoid function, a, b and c represent the lower bound with very severe limitation and a score of 0, severe limitation with a score of 0.5 and no limitation with a score of 1 respectively. For the trapezoidal function, a and d represent the lower and upper bound with very severe limitations and a score of 0, b and c are the interval for which there are no limitations with a score of 1.

them two by two, *i.e.* the importance of a criterion a versus b. This comparison is done using a quantitative grading scale (**Table 2**). The validity of this procedure lies in the Consistency Ratio (CR) which must be less than 10% to be accepted [44]. The consistency ratio is given by Equation (1). The closer the consistency ratio is to 0.000, the better the consistency of the weighting matrix. This step provides the weight for each of the characteristics.

$$RC = CI/RI \tag{1}$$

where CI = Consistency Index given by Equation (2); RI = Random consistency Index given by (**Table 3**).

Table 2. Scale for comparing alternatives, adapted from [44].

Intensity	Definition
1	Equal importance
2	Equal to moderate importance
3	Moderate importance
4	Moderate to high importance
5	High importance
6	High to very high importance
7	Very high importance
8	Very high to extremely high importance
9	Extremely high importance

Table 3. Random consistency index for matrices of different sizes, source [44].

Matrix size (n)	RI
1	0
2	0
3	0.52
4	0.89
5	1.11
6	1.25
7	1.35
8	1.40
9	1.45
10	1.49
11	1.51
12	1.52
13	1.56
14	1.57
15	1.58

$$\mathrm{CI} = (\lambda_{\max} - n)/(n-1) \tag{2}$$

where $\lambda_{\max}$ = maximum eigenvalue of the judgment matrix; n = order of the matrix or number of characteristics assessed.

3.5. Land Suitability Index

The final land suitability index is given by Equation (3), and is the result of additive linear combination models [12] [15].

$$\mathrm{IA} = \sum_{i=1}^{n} w_i \times A_i \tag{3}$$

where IA is the final suitability, W_i is the weight of factor i, which is calculated from the matrix AHP, A_i is the degree of contribution of each land characteristic with i ranging from **1** to **n** (**Table 4**). With the values of W_i and A_i both between **0** and **1**, the land index is therefore between **0** and **1,** with **0** indicating unsuitability and **1** perfect suitability. The final suitability is assessed on the basis of the intensity of the limitations (**Table 4**), which is similar to that of [45]. In this work, climate and soil are considered to have the same weight and there is no need to construct a two-dimensional matrix [44].

3.6. Yield Estimation

The yield was estimated according to the FAO yield table for rainfed agriculture [35]. For this purpose, each bound of the yield interval of the pineapple crop without any constraints was multiplied by the value of the land index to define the interval corresponding to the determined suitability.

Pineapple crop yield is strongly influenced by the seedling density. However, several authors argue that density does not influence the fruit mass [46] [47]. For these reasons, a second estimate was made to take into account the increase in density and its contribution to yields with the advanced research on pineapple production intensification Equation (4):

$$Y = NP_R \times (IT \times M_{FC}) \tag{4}$$

where

Y = yield in t/ha; NP_R: number of fruits harvested per unit area; M_{FC}: the average fruit mass for the given cultivar

Table 4. Suitability class and land index score adapted from [6] [45].

Suitability class	Intensity of limitation	Land indexe score
S1	None to light	1 - 0.85
S2	Moderate	0.85 - 0.60
S3	Severe	0.60 - 0.40
N1	Very severe	0.40 - 0.25
N2	Extremely severe	0.25 - 0.00

The fruit mass of the smooth Cayenne variety used in the two production basins of the Centre region is between 1.5 and 4.5 kg. Minor soma clonal variations have resulted in variants with average fruit masses of 1 to 2 kg and 2 to 4 kg for the smooth Cayenne. That is, an average range of 1.5 to 3 kg/fruit, which was considered in this work [48] [49]. The number of fruits harvested in the Awae Basin ranges from 25,180 to 36,628, and in the Bokito Basin from 230 to 1390 fruits, these limits were considered in the yield assessment [36].

4. Results

The comparison matrices and the weights of the criteria and sub-criteria determined for the land assessment (**Table 5**, **Table 6**) can be used with confidence, as they have a Consistency Ratio (CR) closed to zero. In this assessment, climate is judged to be of equal importance with soil at a weight of 0.5. For the climate criterion, precipitations are considered more important than temperature and relative humidity. Soil texture, soil humidity, CEC, O.C, soil depth, slope and pH are the most important characteristics for the soil criterion (**Table 5**, **Table 6**).

Table 5. Weight of climatic criteria generated by the AHP.

	Precipitation	Temperature	Humidity	Weight
Precipitation	**1**	2	4	**0.57**
Temperature	1/2	**1**	2	**0.29**
Humidity	1/4	1/2	**1**	**0.14**
CR = 0.0000				

Table 6. Weight of soil criteria generated by the AHP.

	Text	CF	CEC	Depht	V%	pH	Slope	EC	ESP	OC	SW	Weight
Text	**1**	5	3	3	5	3	3	3	3	2	1	**0.169**
CF	1/5	**1**	1/5	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/5	**0.018**
CEC	1/3	5	**1**	3	5	3	4	4	5	1/5	1/5	**0.139**
Depht	1/3	4	1/3	**1**	4	3	1	4	4	1/3	1/3	**0.091**
V%	1/5	4	1/5	1/4	**1**	1/3	1/3	3	3	1/4	1/4	**0.047**
pH	1/3	4	1/3	1/3	3	**1**	1/3	3	3	1/4	1/4	**0.061**
Slope	1/3	4	1/4	1	3	3	**1**	1	3	3	1/2	**0.099**
EC	1/3	4	1/4	1/4	1/3	1/3	1/2	**1**	1	1/2	1/3	**0.038**
ESP	1/3	4	1/5	1/4	1/3	1/3	1/3	1	**1**	1/2	1/3	**0.036**
OC	1/2	4	5	3	4	4	1/3	2	2	**1**	1	**0.136**
SW	1	5	5	3	4	4	2	3	3	1	**1**	**0.168**
CR = 0.0007												

CF: Coarse Fragment; **CEC:** Cation Exchange Capacity; **V%**: Base Saturation; **OC:** Organic Carbon; **EC:** Electrical Conductivity; **ESP:** Exchangeable Sodium Percentage; **SW:** Soil Water Saturation; **Text:** Texture.

4.1. Limitation Imposed by Land Characteristics

The climate limitations imposed on the 6 land units in the Awae production basin are due to the annual precipitations ranging from 1546 to 1577 mm, which is moderate. The Bokito production basin has no climate constraints to pineapple production (**Table 7**). The base saturation rate V% has very severe limitations for all identified land units. This is because the sum of exchangeable bases is low, there is imbalance in the cation balance and the CEC is high. These soils can handle large amounts of fertilizer because of their low reservoir. The high clay content in these soils gives very severe limitations for pineapple quality for all identified land units; however, its Ferralsols structure improves infiltration and does not lead to temporary waterlogging situations. The limitations imposed by pH are severe, for land units from 2 to 6, phosphorus fixation by aluminum starts for pH ≤ 5.5 and increases for even lower values, the pH values for these units are in the range of 4.2 to 4.8 (**Table 8**). Temporary waterlogging imposes extremely severe constraints to pineapple cultivation on 99% of the land units in the Bokito production basin. Despite having 62.5% of favorable textures, these soils are dominated by micropores that reduce water infiltration and lead to this temporary saturation condition of 24 to 120 hours. 37.5% of these soils have very severe permanent limitations imposed by the (clay) texture. 50% of the soils have very severe limitations imposed by the organic carbon content (≤0.8%) and 25%

Table 7. Limitation score imposed by climate characteristic on the pineapple crop.

Land Unit	Climatic characteristic		
	Precipitation	Relative humidity	Temperature
AW1	0.80	1.0	1.0
AW2	0.80	1.0	1.0
AW3	0.70	1.0	1.0
AW4	0.70	1.0	1.0
AW5	0.70	1.0	1.0
AW6	0.70	1.0	1.0
BK1	1.0	1.0	1.0
BK2	1.0	1.0	1.0
BK3	1.0	1.0	1.0
BK4	1.0	1.0	1.0
BK5	1.0	1.0	1.0
BK6	1.0	1.0	1.0
BK7	1.0	1.0	1.0
BK8	1.0	1.0	1.0

AW: for the Awae production basin; **BK:** for the Bokito production basin; indices 1 to 8 each represent a soil unit in each of the production basins.

Table 8. Limitation score imposed by soil characteristic on pineapple cultivation in Awae and Bokito Basins.

Land unit	Soil characteristic										
	V%	O.C	CEC	CF	Depth	EC	ESP	pH	Slope	Text	SW
AW1	0.11	1.00	1.00	1.00	1.00	0.99	0.98	1.00	0.92	0.42	1.00
AW2	0.00	1.00	0.98	1.00	1.00	0.99	0.84	0.52	0.92	0.11	1.00
AW3	0.05	1.00	0.98	1.00	1.00	0.99	0.96	0.76	0.92	0.28	1.00
AW4	0.14	1.00	0.99	1.00	1.00	0.99	0.99	0.68	0.92	0.42	1.00
AW5	0.05	1.00	1.00	1.00	1.00	0.99	0.97	0.68	0.92	0.28	1.00
AW6	0.09	1.00	0.72	1.00	1.00	1.00	0.87	0.48	0.92	0.22	1.00
BK1	0.84	0.19	0.32	0.99	0.99	0.99	0.56	0.89	1.00	0.28	1.00
BK2	1.00	0.03	0.05	1.00	1.00	0.99	0.57	0.94	1.00	0.26	0.00
BK3	1.00	0.14	1.00	1.00	1.00	0.98	0.58	0.92	1.00	0.31	0.00
BK4	0.41	0.88	1.00	1.00	1.00	1.00	0.86	0.73	0.92	0.88	0.00
BK5	1.00	0.68	0.20	0.99	1.00	1.00	0.77	0.21	0.92	0.97	0.00
BK6	0.96	0.12	0.73	0.73	1.00	1.00	0.78	0.89	0.92	0.97	0.00
BK7	1.00	0.74	0.21	1.00	1.00	1.00	0.95	1.00	0.73	0.99	0.00
BK8	0.97	1.00	0.56	1.00	1.00	1.00	0.97	0.96	0.92	0.98	0.00

AW: for the Awae production basin; **BK:** for the Bokito production basin; indices 1 to 8 each represent a soil unit in each of the production basins. **CF:** Coarse Fragment; **CEC**: Cation Exchange Capacity; **V%**: Base Saturation; **OC**: Organic Carbon; **EC:** Electrical Conductivity; **ESP:** Exchangeable Sodium Percentage; **SW:** Soil Water Saturation; **Text:** Texture.

have moderate limitations for the same characteristic. In addition, CEC imposes very severe limitations on 50% of the soils and moderate limitations on 25% of the soils. These soils are poor and cannot handle large amounts of fertilizer, the reservoirs are more than 50% full, only 1% of these soils have extremely severe limitations for base saturation. Also, 1% of these soils have moderate limitations due to the percentage of coarse fragments on the surface. This makes the soil preparation time increase as a result of the drudgery imposed by these coarse fragments (Table 8).

4.2. Land Suitability and Yield

Pineapple has a moderate suitability S2sf in the production basin. Constraints come from texture (physical fertility), base saturation rate and pH. Expected yields range from 32 to 38 t/ha. The soil in the Bokito Basin is suitable **S1wf** for 25% of the soils and moderately suitable **12.5% S2sf, 37.5% S2wf and 25% S2wsf** for 75% of the soils. Expected yields range from 34 to 43 t/ha (Table 9). Constraint correction (IT_{PO}) for base saturation, pH and exchangeable sodium percentage will improve the land index of all soils in the Awae Basin without changing the suitability class. The dominant constraint here is texture, which cannot

Table 9. Land suitability index for pineapple cultivation in the Awae and Bokito Basins.

Land unit	IC	IS	ITA	ITPO	RdtA t/ha	RdtPO t/ha	YA (1.5)	YPO (1.5)	YA (3.0)
AW1	0.89	0.68	0.79 S2sf	0.81 S2s	33 - 38	35 - 39	30 - 44	31 - 45	87
AW2	0.89	0.59	0.74 S2sf	0.78 S2s	32 - 36	34 - 37	28 - 41	30 - 43	82
AW3	0.83	0.64	0.74 S2sf	0.76 S2s	32 - 36	33 - 36	28 - 41	29 - 42	82
AW4	0.83	0.67	0.75 S2sf	0.78 S2s	32 - 36	34 - 37	28 - 41	30 - 43	83
AW5	0.83	0.64	0.74 S2sf	0.77 S2s	32 - 36	33 - 37	28 - 41	29 - 43	82
AW6	0.83	0.58	0.71 S2sf	0.74 S2s	32 - 36	32 - 36	28 - 39	28 - 41	78
BK1	1.00	0.64	0.82 S2sf	0.89 S1s	35 - 39	38 - 43	0.3 - 1.7	0.3 - 1.9	91
BK2	1.00	0.42	0.71 S2wsf	0.79 S2s	32 - 36	34 - 38	0.2 - 1.5	0.2 - 1.6	78
BK3	1.00	0.58	0.79 S2wsf	0.86 S1s	33 - 38	37 - 41	0.3 - 1.6	0.3 - 1.8	87
BK4	1.00	0.74	0.87 S1wf	0.90 S1	37 - 42	39 - 43	0.3 - 1.8	0.3 - 1.9	96
BK5	1.00	0.61	0.81 S2wf	0.85 S1	35 - 39	37 - 41	0.3 - 1.7	0.3 - 1.8	89
BK6	1.00	0.64	0.82 S2wf	0.89 S1	35 - 39	38 - 43	0.3 - 1.7	0.3 - 1.9	91
BK7	1.00	0.66	0.83 S2wf	0.85 S1	36 - 40	37 - 41	0.3 - 1.7	0.3 - 1.8	92
BK8	1.00	0.76	0.88 S1wf	0.88 S1	38 - 43	38 - 42	0.3 - 1.8	0.3 - 1.8	97

AW: for the Awae production basin; **BK:** for the Bokito production basin; indices 1 to 8 each represent a soil unit in each of the production basins. **UP:** Pedological Unit; **IC:** Climate Index; **SI**: Soil Index; **ITA:** Current Land Index; **ITPO:** Potential Land Index; **RdtA:** Current Expected Yield; **RdtPO:** Potential Expected Yield; **YA (1.5):** Current expected yield Equation (4) for a fruit mass of 1.5 kg; **YPO (1.5):** Potential expected yield Equation (4) for a fruit mass of 1.5 kg; **YA (3.0):** Potential expected yield Equation (4) for a fruit mass of 3.0 kg; (3.0): **a** - **b** in **YA (1.5)** and **YPO (1.5)** are calculated for the min and max numbers of harvested plants 25,180 - 36,828 found in the Awae Basin and 230 - 1390 in the Bokito Basin respectively.

be corrected. The correction of temporary water saturation, organic carbon, pH and exchangeable sodium will increase the land index and make 87.5% of the soil suitable for pineapple cultivation. These corrective measures are important; however, their influence on yield remains low. The use of high-yielding cultivars or more productive variants of the same cultivar will increase yields (Table 9). The two methods of estimating yields gave overlapping intervals, so it is possible to use this second method to determine yields with intensification-type farming practices.

5. Discussion

The production constraints to pineapple cultivation imposed by the soil in the Awae production basin are in line with the observations of [50] on Ferralsols/Oxisols. The low pH and base saturation rate indicate a high level of cation loss through leaching, highlighting a high macropore proportion leading to rapid infiltration [51]. Decreased nutrient availability at low pH levels limits the expression of the cultivar used [52]. Texture is another constraint to pineapple production for all soils in the Awae Basin. However, it is impossible to change texture, therefore it is a permanent constraint. In addition, [43] points out that soils with textures containing less than 35% of clay give better quality fruit, and this observation justifies the appreciation given to the fruit produced in the Bokito Basin. Correcting soil constraints by liming and balancing the cation balance (an expensive solution) does not have a significant impact on yield, and without combined organic amendments, soil deterioration continues [53] [54] [55]. Indeed, yield is also influenced by the characteristics of the genotype used [56] [57]. In fact, the nutrient use efficiency capacity differs from one cultivar to another and allows to reduce the amount of fertilizer or to maintain it while increasing the yield [58]. Because of its high nutrient use efficiency, MD2 can be recommended for pineapple production in any two production basin [58]. Pineapple production is improved by modifying the technical itinerary [4], *i.e.* increasing seeding rates and balancing fertilization [46] [47] [52]. To get close to the estimated YPO yields (**Table 9**), approximately 18 bags of urea, 3 bags of triple superphosphate and 19 bags of potassium chloride are required [52]. With the current high price of fertilizer in Cameroon, it is difficult to recommend such fertilization to low- and medium-resource producers; focusing on optimal seeding rates is the most effective way to increase yields [4] [46] [47]. Also, it is possible to increase yields by reducing the amount of fertilizer applied to the pineapple crop [59]. Is not only quantity of macronutrients that drive yield of the crops, a certain interaction exists among macronutrients, micronutrient and between the two. The imbalance between quantities of macronutrients/micronutrients and between their interactions brings out a diminishing of nutrient use efficiency and therefore reduction of yields through antagonism and augmentation of fertilizer expense [60]. Emphasis put on quantity of primary macronutrients (NPK) in low-income countries is not the solution; all deficient essential plant nutrients must be balanced understanding the requirement of crop. This approach guides reduction of macronutrient quantity applied to the crop, because it promotes synergism [60]. Expected and observed yields in the Awae and Bokito Basins are in accordance [36]. The low level of pineapple production observed in the Bokito Basin is not only the result of pedoclimatic constraints, but also of the availability of labor, knowledge of the appropriate technical itinerary and the lack of interest of men in this crop [4]. The major constraint of Bokito soils is temporary waterlogging. This constraint can be addressed by drainage; however, this is a costly approach that requires proven knowledge of water management [61]. Tillage and especially ridging is another method to increase infiltration and reduce water saturation in the rhizosphere. Nevertheless, the size of the ridges and the slope of the furrows (water drainage area) are parameters to be determined, which influence the cost of the technique and the tools to be used [61]. This reduction in waterlogging needs to be combined with organic amendment and fertilization to overcome fertilization constraints and sustain pineapple production [54]. The low level of resources of pineapple producers in the Bokito Basin prevents them from addressing all production constraints. Nevertheless, the latter are implementing types of ridging to reduce the waterlogging of production plots; but some years, these water control measures fail to cancel out the waterlogging.

6. Conclusion

The land in the Centre region is moderately suitable for pineapple cultivation no matter which basin is considered. Constraints to pineapple cultivation are soil-based and relate to soil texture, pH, base saturation and temporary water saturation. The correction of constraints improves the land index, but has no major influence on pineapple yields. Increasing yields require an improvement in the technical itinerary for pineapple production in the said region.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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