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GIS approach and evaluation of lowland rice production potential in Cote d'Ivoire: Case of the Poro region

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Abstract

This study was conducted in the Poro region to describe the potential for rice production in the lowlands of the Poro region. To do so, the GIS approach and multicriteria analysis (MCA) were used as a method. This multidisciplinary method, which is a decision support tool, made it possible to assess the total area available for rice production and to deduce the production prospects. The results showed that the areas with optimal potential are found in the central, central-eastern, south-eastern and western Poro regions. Suitable areas are more present in the central-western and northern parts of the region. Areas with average production potential are found mainly in the northeast, center and south of the area studied. As for the difficult and constraining conditions that cover less space, they are more scattered in the region. The synthesis of the surface proportions of each of these potentialities reveals that 90.74% (2545724 ha) of the departmental territory offers favourable possibilities, of which 59.13% (1659035 ha) is optimal, 12.38% is suitable (347276 ha) and 19.23% (259791 ha) is moderately favorable. About 10% (or 259791 ha) of the territory has a difficult potentiality. The GIS approach shows that the rice potential of the Poro Region is still under-exploited. A better exploitation of these potentials would allow to fill the totality of the rice needs of the region from 12 to 19 times more and to contribute to food security in the surrounding regions.

Keywords: Côte d'Ivoire, poro region, rice potential, lowland, multicriteria analysis, GIS

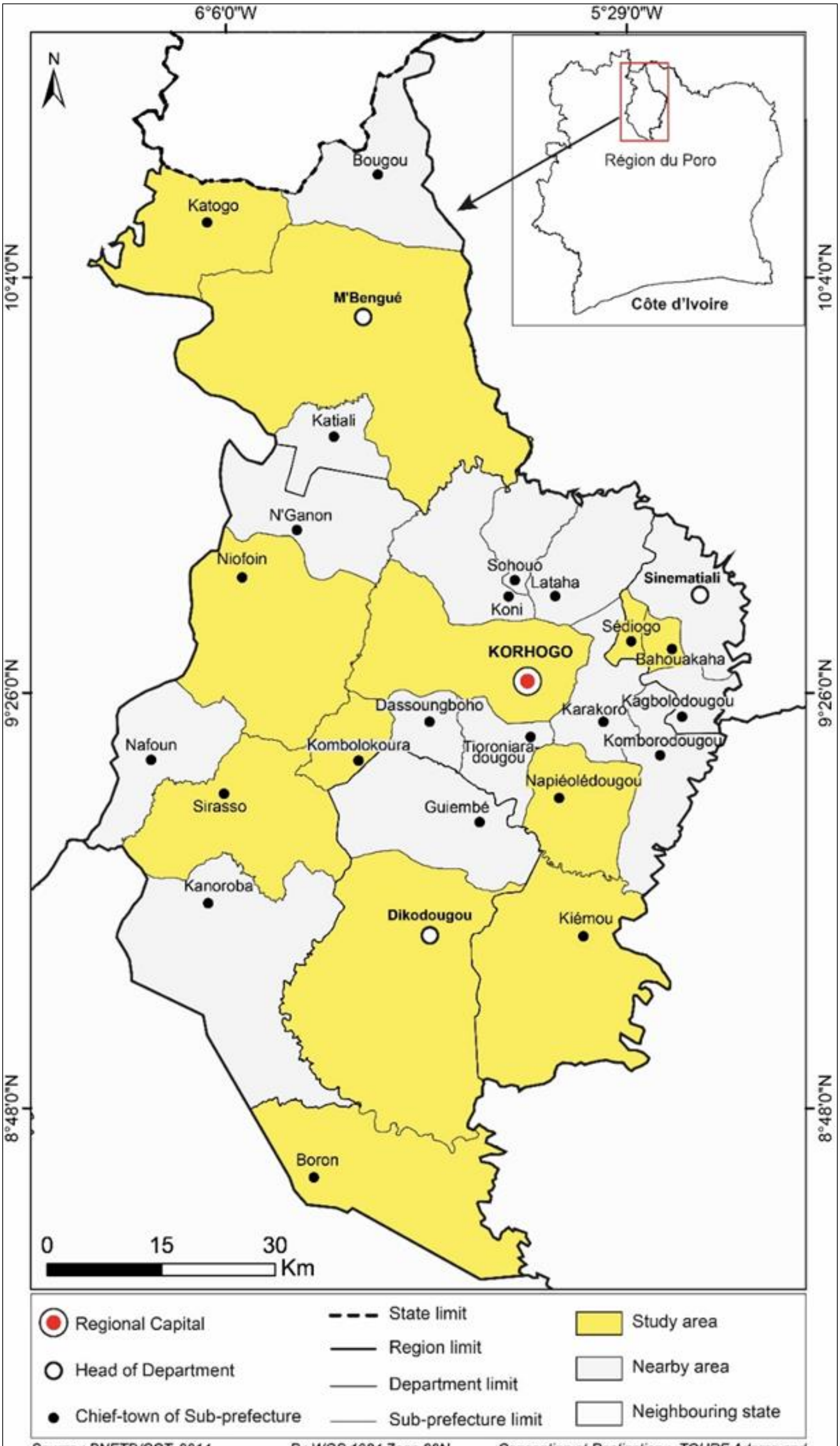
Introduction

In Côte d'Ivoire, rice has become the staple food for the vast majority of the population, changing eating habits in both urban centers and rural areas (FAO, 2009 p. 4). Its importance in the population's diet has gradually increased since independence in 1960 (FAO, 2021 pp. 1-2). However, Côte d'Ivoire is one of the countries that have deficits in rice production and depend on imports for its rice consumption (Ministry of Agriculture and Rural Development, 2020 p.1). Moreover, the rice deficit in Côte d'Ivoire appears to be a paradox, given the quality of the natural potential for the development of rice cultivation (ONDR, 2012 p. 4). For some authors, such as Depieu and *al* (2017 p. 80), rice self-sufficiency in Côte d'Ivoire can only be achieved through the development of lowland rice cultivation.

According to CIRAD (2002 p. 803), rice cultivation in floodplains represents 33% of the area worldwide. In Côte d'Ivoire, it represents about 36% of the cultivated area (Depieu and *al*., 2017 p. 80) [7]. In the Poro region rice is one of the main food crops (INS, 2001 p. 22). In contrast to its low importance in relation to cultivated areas, lowland rice is very important to the food security of those who cultivate it (Stessens, 2002 p. 130) [23]. In this region, which is dominated by drought- prone rainfed crops (Cecchi, 2007 p. 49), the hydrography offers opportunities for the extension of lowland crops that are less prone to water deficits. Indeed, the Poro region is fed by three major river basins (Silué, 2012 p. 84) [22]. These are the Niger, Bandama and Comoé basins, the presence of which has prompted hydro-agricultural development by the state in the region. According to Ndabalishye (1995, p. 202) [17], the Poro region is one of the regions with the most hydro-agricultural developments in Côte d'Ivoire. Despite these assets, rice production in the Poro region remains insufficient to meet demand (Touré, 2018 p. 37) [11]. This situation raises a question. Do the potentialities of the Poro region provide a favorable environment for sufficient rice production in the lowlands? To answer this question, it is necessary to conduct a study on the production potential in order to have information and make an evolutionary analysis of this potential in this region. This led us to formulate the term of the study as follows Evaluation of the production potential of lowland rice in the Poro region. The general objective of this work is to analyze the production potential of lowland rice in the Poro region. Specifically, the aim is to identify the criteria for lowland rice production, standardize the criteria, and identify the areas suitable for lowland rice production in the Poro region. This paper is organized into three parts: research methodology, results and discussion.

Material and Method

The study builds on previous work by Toure (2018 p.) [24] in the Poro region. The present study was conducted in the four (4) departments of the Poro region.



Source : BNETD/CCT, 2014 P : WGS 1984 Zone 30N Conception et Realization : TOURE Adama and SILUE Domin S, 2022

Fig 1: Location map of the study area

In total, 12 sub-prefectures were visited, including eight (6) in the largest department (Korhogo) and two (2) sub-prefectures in each of the other three departments (M'bengué, Sinématiali and Dikodougou). The study is based on a geographic information system and involves several steps.

1. GIS approach and multi-criteria analysis

In order to identify potential areas for rice development, this study uses Geographic Information Systems (GIS) and multi-criteria analysis (MCA) as tools. This multidisciplinary approach, which is an aid to decision-making, has made it possible to assess the total area available for rice production in the lowlands, and to deduce production prospects.

2. Analysis criteria and acquisition of data related to the selected criteria

The four categories of analysis criteria chosen are the ecological requirements of the plant, the nature of the soils, the demographic environment and the method of cultivation.

In terms of ecological requirements, two criteria were selected: precipitation and temperature. Temperature and precipitation affect the growth of the plant. The plant is sensitive to peaks in rainfall and temperature. The availability of water resources is one of the most important parameters for rice cultivation. Rainwater is necessary for vegetative growth of the plant. In terms of soil type, three criteria were also considered: pH, soil type and slope. Rice can withstand a pH of 4 to 8. The optimum ph is 6 to 7. Low desaturated soils are generally suitable. For aquatic cultivation, flood plains are suitable. In dry farming, rice requires rich, loose soil with good water retention capacity, as rice is a particularly drought-sensitive plant. In terms of the demographic environment, we used population density and labor force as criteria. In terms of cultivation methods, the reference was the use of plow-down cultivation.

Table 1: Analysis criteria retained for the evaluation of the potential for rice cultivation in the Poro Region

Category	Criteria used	Sources
Ecological requirements	Precipitation	Climate Research Unit
	Temperature	Climate Research Unit
Type of soil	PH	FAO-UNESCO PH Map of the World
	Slope	SRTM projet
	Soil type	FAO-UNESCO PH Map of the World
Demographic environment	Workforce	Literature and field surveys
	Population density	RGPH
Cultivation method	Animal traction	Literature and field survey

Source

This GIS is based on spatial data from various sources. Many of them are publicly available on the appropriate Internet addresses, in digital format at the FAO and the CRU (Climatic Research Unit). For each of the variables, qualifiers corresponding to thresholds, which determine optimal, suitable, average and difficult conditions were defined. We were also able to determine the constraints. They correspond on the whole to the large classified forests. Data on the climatic requirements of rice, in this case rainfall and temperature, were obtained from the Climatic Research Unit (CRU). This is an international organization that produces geographic data on a global scale. This global database contains climate data covering the period 1901-2014. Presented at the country level in the form of a map, it offers two possibilities of square grids, one of which is 10 km on a side and the other 5 km on a side. In our study, it is the database for the 5 km square grid that has been provided. Obtaining geographic data at the scale of the Poro Region required an overlay of the vector layer of the administrative boundary of the said region on the raster layers of temperature and precipitation. This step was followed by digitizing to frame the climate data. The results obtained were used in conjunction with the climatic requirements of the plant to determine the rice-growing potential of the region in terms of temperature and rainfall. In order for the plant to develop properly and ensure profitable production, average monthly rainfall must be between 100 mm and 300 mm. In addition, there must be a good distribution of rainfall during the cycle. The panicle initiation phase is particularly sensitive. Population density was estimated from the 2014 General Census of Population and Housing data (INS, 2014 p. 16). The option used is population density by department. Regarding labor availability, cultivation mode, and the order of importance of the criteria, the data collected in the field by questionnaire was reinforced by prior work in the literature. A survey form was used to acquire these data. The number of producers to be surveyed was based on the probabilistic rule of 10% of the parent population. The database used for the parent population was collected from the Programme d'Appui au Développement des Filières Agricoles (PADFA), which is a development program for the rice, vegetable and mango sectors in Côte d'Ivoire covering the period 2017-2025. This database was then updated and completed with the help of field visits in the localities. On this basis, the calculated sample size is 240 lowland rice producers. Producers were selected by random draw without discounting. The distribution of surveyed farmers is presented in Table 2.

Table 2: Distribution of producers by location

Departments	Sub-prefectures	Mother Population	Producers surveyed
Korhogo	Korhogo	321	32
	Sirasso	206	20
	Komborokoura	162	16
	Niofoin	68	7
	Kiemou	147	15
	Napié	224	22
Guiembé	M'Bengué	309	31
	Katogo	167	17
Dikodougou	Dikodougou	283	28
	Boron	407	41
Bahouakaha	Bahouakaha	160	16
	Sediego	151	15
Total		2605	260

3. Processing of data related to the selected criteria

Table 3 presents the analysis of the criteria for lowland rice in order of importance.

Table 3: Analysis of the criteria retained for lowland rice cultivation by order

Criteria	Optimal	Suitable	Medium	Difficult
Type of soil	Hydromorphic soil	Ferralitic soils low desaturated	Ferralitic soils low and medium desaturated	Highly desaturated ferralitic soils
Precipitation monthly	> 160 mm	130-160 mm	100- 130 mm	Less than 100mm
Slope	0 à 8 %	8% à 30%	-	-
Temparature	-	26-30	22-26	-
PH	> 7	5,5 à 7	4 à 5,5	Less than 4
Landuse	Lowland area	Body of water	Vegetation and rainfed crop areas	Cashew and orchard; habitat areas
Density of population	130-500	50-130	25-50	Less than 25
Workforce	Offer > demand	Offer = demand	Demand< offer	-
Harnessed cultivation	>75	75 à 50	<50	-

4. Implementation of multi-criteria analysis

The multi-criteria analysis we performed was invented by the mathematician Saaty (1977 pp.234-281). It is a hierarchical process analysis (HPA) that integrates several criteria and assists in the decision-making process of GIS data analysis. It proceeds by binary comparisons of each level of the hierarchy against the elements of the higher level. All the criteria are compared two by two with respect to the global objective of the study which generates the priority vector of these criteria. The hierarchical process analysis method is based on three concepts:

- the hierarchical structuring which is the decomposition of the problem into sub- problems;
- The structuring of priorities corresponds to the ranking of elements according to their relative importance;
- logical coherence, i.e., the elements are grouped and classified in a logical way. The hierarchical process analysis method has several notable interests and allows:
- to develop a compromise representative of the various opinions but not necessarily the consensus;
- to refine the definition of a problem by decomposition;
- prioritize;
- to take into account the interdependence of the elements;
- evaluate the logical consistency of the opinions used.

5. Standardization of factors

The determination of the relative importance of each criterion is defined by Prakash (2003 p.23) as the standardization of criteria. Several factors (qualitative and quantitative) were integrated and compared on a common scale. For this purpose, the Linear Weighted Combination (LWC) was used. The factors were standardized on a continuous scale of ability from 1 (least able) to 10 (most able).

6. Factor weighting

Before the different criteria were combined, they were weighted using the method developed by Saaty (1977 pp. 234-281). This is the method of pairwise comparisons (Hierarchical Analysis Process) which produces standardized weighting coefficients whose sum is equal to "1". The weights of the factors indicate their relative importance to all others. Factor weights are determined from a series of pairwise comparisons of these criteria, taking into account the relative importance of two criteria to suitability for lowland rice cultivation. Their importance is determined on a 9-level numerical scale (Table 4) and arranged in a decision matrix or pairwise comparison matrix.

Table 4: Saaty scale (1977 pp. 234-281) for the weighting of pairwise factors

Expression of one criterion in relation to another	Numerical scale
Same importance as	1
Moderately more important than	3
Significantly more important than	5
Very important than	7
Extremely more important than	9
Moderately less than	1/3
Significantly less important than	1/5
Much less important than	1/7
Extremely less important than	1/9

7. Aggregation of criteria

Once the assessment criteria have been weighted, they can be combined to arrive at a composite decision on the optimum suitability for lowland rice cultivation. This is a multi-criteria evaluation or aggregation of criteria, and allows for compensation between criteria. A factor with low suitability for a given area can be compensated for by another with high suitability; the importance of a factor being determined by the weight assigned to it. After the evaluation of the decision factors, a weighted linear combination was performed after assigning each decision factor a weighting coefficient (Table 5).

Table 5: Pairwise comparison matrix determining the weighting coefficient of suitability factors for lowland rice cultivation

	Type of soil	Precipitation	Slope	T	PH	Landuse	Populatio n density	Work force	Cultivatio n Mode
Type of soil	1	3	5	5	5	7	9	9	9
Precipitation	1/3	1	3	3	3	5	7	9	9
Slope	1/5	1/3	1	1	1	5	7	7	7
T	1/5	1/3	1	1	1	3	5	9	9
PH	1/5	1/3	1	1	1	3	5	9	9
Landuse	1/7	1/5	1/5	1/3	1/3	1	3	7	7
Density of Population	1/9	1/7	1/7	1/5	1/5	1/3	1	7	7
Workforce	1/9	1/9	1/7	1/9	1/9	1/7	1/7	1	9
Mode of Culture	1/9	1/9	1/7	1/9	1/7	1/7	1/7	1/7	1

The individual column comparison scores are then divided by their sum. For example, in the cell that intersects the precipitation-precipitation variables, 1 was divided by 2.405 and so on. The new scores obtained were summed in row and column. In the column, the sum is always 1 (Table 6).

Table 6: Comparison matrix of standardized variables in lowland rice production

	Soil type	Precipitation monthly	Slope	Temperature	PH	Landsue	Density of population	Workforce	Animal traction	Sum
Soil type	0,415	0,539	0,430	0,425	0,424	0,284	0,241	0,154	0,134	3,134
Precipitation monthly	0,138	0,179	0,258	0,255	0,254	0,203	0,188	0,154	0,134	1,763
Slope	0,083	0,059	0,086	0,085	0,085	0,203	0,188	0,120	0,104	1,013
Temperature	0,083	0,059	0,086	0,085	0,085	0,122	0,134	0,154	0,134	0,942
PH	0,083	0,059	0,086	0,085	0,085	0,122	0,134	0,154	0,134	0,942
Landsue	0,059	0,035	0,017	0,029	0,028	0,041	0,080	0,120	0,104	0,512
Density of population	0,046	0,026	0,012	0,017	0,017	0,013	0,027	0,120	0,104	0,274
Workforce	0,046	0,019	0,012	0,009	0,009	0,006	0,004	0,117	0,134	0,257
Animal traction	0,049	0,019	0,012	0,009	0,012	0,006	0,004	0,002	0,015	0,129
Sum	1	1	1	1	1	1	1	1	1	9

To calculate the weight of the different variables selected, it is enough to make the ratio between each "sum of the scores" obtained in line by the number of variables compared. For example, in the case of precipitation, 3.134 is divided by 9. The total sum of the weights is always equal to 1 (Table 7).

Table 7: Weight of the different variables retained for the multi-criteria analysis in lowland rice cultivation

Variables	Weight
Soil type	0,348
Precipitation monthly	0,195
Slope	0,112
Temperature	0,104
PH	0,104
Landsue	0,056
Density of population	0,030
Workforce	0,028
Animal traction	0,014
Sum	1

8. Consistency check

The notion of coherence in Saaty's pairwise comparison (1977 pp. 234-281) is based on the respect of the transitivity of our judgment. Thus, the coherence index expressed by the mathematical formula (1) measures the reliability of the comparison expressed to coherent judgments. The larger the coherence index becomes, the more inconsistent the judgments expressed in the comparison matrix would be and vice versa.

Equation 1. Consistency Index (CI)

$CI = (\lambda \max - K) / (K - 1)$ où $\lambda \max$ = sum of normalized scores/ number of variables

K = number of variables retained

Furthermore, the experiment established by Saaty (1977 pp. 234-281) defined the Coherence Ratio (CR) as the ratio of the coherence index calculated on the matrix corresponding to the actors' judgments and the Random Index (RI) of a matrix of the same dimension presented in Table III. The coherence ratio calculated by the mathematical formula below (2) measures the logical coherence of the experts' judgments. It allows to evaluate the consistency of the judgments by the pairwise comparison method. It provides information on the consistency in terms of the importance of the criteria to be compared. In general, when less than 9 elements are to be compared, a tolerance threshold of 10% is set for this coherence index. As a criterion rarely has more than 9 indicators, 10% is the most commonly used threshold in multicriteria analysis. Higher levels of inconsistency could be tolerated for comparisons involving more than 9 elements. The consistency ratio can therefore be interpreted as the probability that the matrix is randomly completed.

Equation 2. Consistency Ratio (CR)

$RC = CI / AI$ *in which* CI = Consistency Index

AI = Weight of a variable

The Consistency Index CI = 0; Consistency Ratio CR = 0 < 0.1. The Consistency Ratio being less than 0.1, which allows us to confirm that the assessment judgments of the criteria were consistent (Table 8).

Table 8: Matrix for calculating the coherence ratio in lowland rice cultivation

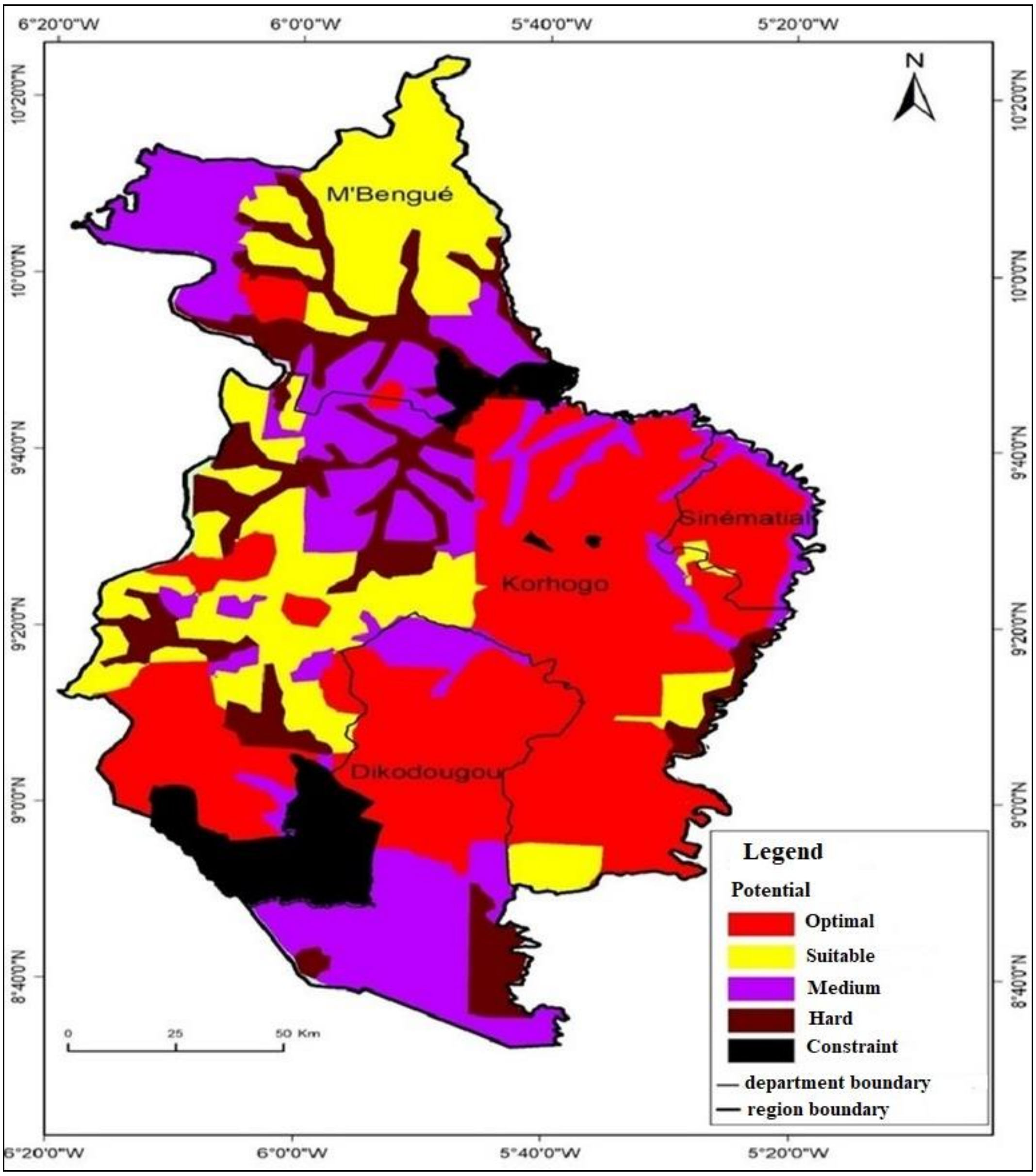
Variables	Weight	Score	Normalized score
Soil type	0,348	3,134	9
Precipitation monthly	0,195	1,763	9
Slope	0,112	1,013	9
Temperature	0,104	0,942	9
PH	0,104	0,942	9
Landsue	0,056	0,512	9
Density of population	0,030	0,274	9
Workforce	0,028	0,257	9
Cultivation method	0,014	0,129	9
Sum	1	9	81

Results

The results of the multi-criteria analysis are presented in map and table form. They show the spatial distribution of lowland rice growing capacities in the Poro region. The area covered by each capability was assessed at both the regional and departmental levels. In addition, the region's lowland rice production prospects were analyzed.

1. Lowland rice capacity is unevenly distributed in the region

The Poro Region has a different distribution of lowland rice potential, as shown in Figure 2.



Source: map processing result, 2022

Fig 2: Map showing the distribution of the potential of the Poro region in lowland rice cultivation

Analysis of Figure 2 shows that the potential of the Poro Region for lowland rice cultivation can be broken down into optimal, suitable, average, difficult and constrained areas. An unequal distribution of this rice-growing potential is observed throughout the region. The areas with optimal potential are mainly found in the central-eastern, south-eastern and south-western parts of the region. Suitable areas are distributed in the central-western and northern parts of the region. The average potential is concentrated mainly in the Northeast, Center and South of the territory. The areas with difficult and constraining potentialities are more in the South-West and North-Central parts of the region.

2. Significant spatial potential for lowland rice cultivation

The Poro region is favorable to lowland rice cultivation, as shown in Table 9, which summarizes the surface area proportions of each of the potentialities.

Table 9: Surface distribution of lowland rice potential in the Poro region by department

s	Area (%)				
	Korhogo	**Dikodougou**	**Sinématiali**	**M'bengue**	**Moyenne**
Optimal	48,43	60,66	94,30	53,38	59,13
Suitable	3,92	14,64	0,66	14,73	12,38
Medium	24,56	21,62	5,04	17,60	19,23
Total auspicious	86,91	92,92	100	85,71	90,74
Hard	13,09	3,08	00	14,29	9,26

Source: statistical processing result, 2022

Analysis of Table 9 shows that 90.74% (2545724 ha) of the region's territory offers favourable possibilities, of which 59.13% (1659035 ha) is optimal, 12.38% is suitable (347276 ha) and 19.23% (259791 ha) is moderately favourable. 9.26% (259791 ha) of the territory has difficult or even restrictive potential.

Analysis by department shows that land in the departments of Sinématiali (94.3%), Dikodougou (60.66%) and M'Bengué (53.38%) is dominated by optimal areas. In addition, the optimal areas are largest in the department of Korhogo (48.43%). In all four departments, optimal areas are seconded by medium potential areas, which are more important than so-called suitable areas. Difficult areas are found more in M'Bengué (14.29%) and Korhogo (13.09%).

3. Prospects for lowland rice production that can fill the local production gap

Assuming that for every hectare of suitable land, 0.01 ha is devoted to lowland rice, 56,336.66 ha could be used for lowland rice. These areas are by far comparable to the 229,622 ha devoted to all agriculture and the 135,148 ha allocated to food crops in the region in 1998 (INS, 2001 p.22). Some food crops are grown on larger areas in the region than those expected for fish farming. This is the case for yams, with 28,469.5 hectares of land in production.

Based on the potential yields for lowland rice in Côte d'Ivoire, which range from 4 to 6 tons per hectare (FAO, 2009, p. 5), and average yields in the region of about 3 t/ha, we estimated the following yields: optimal area, 4 t/ha; suitable area, 3 t/ha; and average area, 2 t/ha (Table 10).

Table 10: Potential rice production in the lowlands of the Poro region

Potential	**Area**	**Usable % (1%)**	**Average yield**	**Milled rice production (ton)**	**Per capita availability (kg/hbt./year)**
Optimal	1 659 035 ha	16 590,35	4 t/ha	43 134,91	69,75
Suitable	347 276 ha	3 472,76	3 t/ha	6 771,89	
Medium	259 791 ha	2 597,91	2 t/ha	3 377,28	
Total favorable	2 545 724 ha	25 457,24	-	53 284,08	

Source: statistical processing result, 2022

With these figures, the availability of milled rice per capita per year would be 69.75 kg. This is higher than the national average requirement, which varies from 58 to 63 kg/hbt./year (FAO, 2009 p. 5; ONDR, 2012 p. 13). In addition to allowing rice self-sufficiency in the Poro region, these lowland productions would participate in strengthening the food security of neighboring regions.

With improved yields and increased acreage, it is possible that the Poro region could actively and substantially participate in reducing the massive importation of rice nationwide in the coming years.

Discussion

Several studies in Côte d'Ivoire are based on the GIS approach for the evaluation of the production potential of agricultural activities. This is the case for the research of Assi *et al* (2019 pp. 49-68) on the assessment of pineapple production potential in the department of Grand- Bassam and that of Assi-Kaudjhis (2013 pp. 173-187) on the potential of peasant fish farming in the Centre-Est region. Rice cultivation has not been left out of studies that incorporate the GIS approach. In northwestern Côte d'Ivoire, an area close to the Poro region, this technological innovation has been used to identify areas suitable for rice cultivation (Konan-Waidhet *et al*., 2013 pp. 1-14) [13]. In the Poro region, a similar study was conducted by Touré (2018 pp. 350-366) [11].

The GIS approach carried out in this study shows that the Poro region has good potential to ensure its rice-growing needs and participate in the food security of neighboring regions. Indeed, it reveals that 90.74% of the region's territory is suitable for lowland rice cultivation. The results of this study confirm those obtained by Touré (2018 p. 377) [11] and Konan-Waidhet *et al* (2013 p. 11-12) [13] where 80.85% and 85.57% of the soils are suitable, respectively. However, there are a few differences to note. These discrepancies between our assessments and those of the previous studies are basically a result of the weighting criteria and the difference in the choice of threshold values. In Konan-Waidhet's (2013 p. 11-12) work the thresholds selected distinguish between three types of potentiality, namely very suitable, suitable and unsuitable. Moderately suitable areas were not considered by these authors. In addition, the number of evaluation criteria retained by them is five. These are slope, soil, population density, land use and rainfall. In addition to these five criteria, this study incorporates four additional criteria which are temperature, labor, cropping pattern and PH. Unlike Toure's (2018 p. 377) assessment which includes seven criteria in the same space, the analysis was strengthened by considering labor and cropping pattern. In addition, this study is distinguished by the evaluation and comparative analysis of departmental potential. This revealed that the region's potential for lowland rice cultivation is diversely distributed among the departments. In addition, there was a large difference in the size of the optimal area between the two studies. This increased from 24.94% in the first study to 59.13% in the second. In contrast to the increase in the optimal zone, the suitable zone decreased from 31.34% to 12.38%. The same is true for the moderately suitable and difficult zones, which have fallen from 24.57% to 19.23% and 19.15% to 9.26% respectively. This change in opposite directions is linked to the inclusion of labor and cultivation methods in the evaluation criteria. The use of the cattle team is an asset for rice- growing activities, in this case plowing in the lowlands. Plowing in the lowlands is a labor-intensive activity. The adoption of horse and cart by the majority of producers (Touré, 2018 pp.246-250) [11], following the spread of cotton cultivation in the region, appears to be a factor in alleviating and facilitating lowland production. Although a general labor shortage is reported in the area, the work of Touré (2019, pp. 371-375) reveals that rice cultivation, which coincides with the school vacations for most of the cycle, suffers less from labor unavailability. In general, only rice harvesting activities require the use of outside labor. In sum, the two integrated criteria are potential factors in the development of rice production in general, and lowland rice cultivation in particular, in the area studied.

This study highlighted the gap between the production potential and the level of rice production in the Poro region. Based on the writings of ANADER (2012 p. 36) and MINAGRI (2008 p.43) and Touré (2018 p. 37) [11], production is still well below the exploitable potential. In this region plagued by socio-environmental disturbances (BOKO *et al*., 2016 p. 40) [4], producers' perceptions of the natural assets of their production area are in contradiction (Touré, 2018 p. 137) [11] with the present assessment, which attests that 90.74% of the territory is suitable for lowland rice cultivation. Indeed, field observations and previous studies (Roose *et al*., 2008 p. 425; Boko *et al*., 2016 p. 40) [4] attest to a degradation of natural conditions unfavorable to production. This degradation is observed in other regions of Côte d'Ivoire, namely the Gbèkè region (Kanga *et al*., 2018 pp. 149-151) [11] and the northeast quarter of Côte d'Ivoire (Kanga, 2016 p. 288) [12]. The GIS approach applied in this study shows that despite the socio-environmental disruptions experienced in the study area, production potentials remain favorable for rice production in the lowlands. The contrast between this assessment and producers' perceptions raises the issue of disseminating research results to production units. Studies similar to this one should be encouraged and popularized in order to change the perceptions of producers and all links in the rice value chain. It opens up interesting perspectives for the elaboration of a more sustainable rice development policy.

Conclusion

In the end, the GIS approach combined with multi-criteria analysis made it possible to assess the potential for rice production in the lowlands of the Poro region. This method is used to guide stakeholders in the sector to potential rice-growing areas. In the Poro region, 90.74% of the land area offers favourable possibilities, of which 59.13% is optimal, 12.38% is suitable and 19.23% is moderately favourable. 9.26% of the land area has a difficult or even constraining potential. There is an uneven distribution of rice-growing potential across the region. The areas with optimal potential are found mainly in the central-eastern, south-eastern and south-western parts of the region. Suitable areas are distributed in the central-western and northern parts of the region. The average potential is concentrated mainly in the Northeast, Center and South of the territory. Areas with difficult and constrained potential are more in the southwest and north- central parts of the region. In the four departments of the region, the optimal zones, which are the most important, are followed by the zones of average potential, followed by the so-called suitable areas. Difficult areas are found more in M'Bengué (14.29%) and Korhogo (13.09%). Following this study, it would be interesting to organize investigations on the convergence between suitable areas and sites that actually host lowland rice cultivation in the Poro Region.

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