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Estimation of Planning and Agricultural Management in a Country in the Process of Development: Case of the Republic of Guinea

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Abstract

The rural population in developing countries depends on agriculture. However, in many of these countries, agricultural productivity remains low with episodes of famines in drought-prone areas. However, the Republic of Guinea, like other developing countries, has all the assets to plan and manage its agricultural domain which constitutes a basic key to emerge and determine itself less economically dependent. For this study, to determine the agricultural index; which allowed us to observe trends in normalization of agricultural activity in the Republic of Guinea. In short, this index can be used to estimate the overall production of consumable goods in a country in relation to the value of expenses linked to this production for all sectors of activity, and in particular for agricultural activity. In the rest of the work, we carried out the simulation after collecting the data relating to the variables of the problem. We can say from the model obtained that knowledge of the expenses allocated to production is essential, while the constraint equation characterizes the value of the product obtained.

Keywords

Planning, Agricultural Index, Modeling, Data, Model

1. Introduction

The agricultural sector remains a major concern in the basis of poverty reduction in a developing country. The rural poverty in developing countries largely depends on agriculture and about 70 percent of extreme poverty around the world is found in rural areas [1]. The agriculture requires to devise risk mitigating strategies [2]. Capacity development has moved to center stage on the agendas of development organizations [3]. Strengthening the capabilities of individuals, organizations, and institutions is essential to ensure that development efforts are sustainable and poverty is eradicated. The agricultural sector is at the heart of the economies of the least-developed countries (LDCs) [4]. It accounts for a large share of gross domestic product (GDP) (ranging from 30 to 60 percent in about two thirds of them), employs a large proportion of the labour force (from 40 percent to as much as 90 percent in most cases), represents a major source of foreign exchange (from 25 percent to as much as 95 percent in three quarters of the countries), supplies the bulk of basic food and provides subsistence and other income to more than half of the LDCs' population [4]. According to [5], the applications of farm management principles have been very difficult due to lack of data until last decade. However, in many of these countries, agricultural productivity remains low with episodes of famines in drought-prone areas [6].

More generally, production costs are increased for specific products in mass culture. But the difficulty is to determine how to take into account the joint inputs, that is, inputs used to produce several products. [7] calculated the cost of producing a commodity (wheat in the United States) on the basis the basis of accounting elements of farmers relating to the inputs purchased as well as data from farmers regarding the distribution of time of use of materials between the different activities. Although by using the declarations of the operators, we managed to determine agricultural costs. It exists other methods for allocating production costs spouses. [8] explained that land costs can be spread between the different activities according to the surfaces used by each of them, or again that we can first calculate the costs of inputs for exploitations specialized and then apply them to the activity considered of mixed farms. Another method consists of resorting to the econometrics based on the result of the following equation [9].

Whatever the method used, the influence of certain factors on productivity agricultural sector particularly deserves our attention regarding the costs of intraconsumption (particularly the foreman, equipment and land), which very often are not directly observable but nevertheless open to influence cost measurements of production.

Indeed, a solid food base is a crucial indicator for a country to move from an underdeveloped level to emergence; moreover, countries firmly established in an agricultural and food base are at the pedestal of a powerful economy in unprecedented growth such as the United States, France, England, China, Russia, Ukraine etc. In the Republic of Guinea, given climate change affecting the performance of agricultural activity, it is imperative that new methods of solving agricultural problems come into view.

The development of an environment favorable to sustainable agricultural production, in a context of poverty reduction, is at the heart of agricultural development projects of the AFD (Agency French of Development) [10]. This support has positively influenced economic issues, integration into markets, and the transformation of products, but in a sector, approach most often starting from production towards the markets.

However, rice and corn were chosen because these two products respond to the fertility of the cultivable soil, even if the second is less consumed in Guinea, which suggests that if a large proportion of the population consumes corn, the country will be able to cope with the food problem it suffers from. Even if other products like peanuts, cassava, millet, fonio, etc. remain very present in the Guinean diet, rice and corn occupy an important place. Agriculture in Guinea remains rudimentary despite often archaic means of production, which have nevertheless proven to be exceptionally profitable over the past decades. The forest zone remains particularly attached to the cultivation of rice and corn throughout the territory [11].

The objective of this study is to implement a mathematical model to establish the agricultural relationship between the results obtained and the resources used, by estimating a yield function to predict the production value and by promoting internal agricultural activity in order to increase the yield of these resources in agricultural areas.

2. Definition of Planning

We emphasize that a projection of agricultural yield in the future is necessarily a forecast that can be set, an objective to accomplish in order to satisfy the basic food need. It becomes planning, as soon as it is accompanied by a process decision-making, which aims to achieve the future situation. A general definition of planning can be formulated according to [12] as follows:

Given a system, which is described in terms of a number of variables and their interrelationships, and an administration, part of the system, which has the task of directing the system, planning is the decision-making, analytical and administrative process, which designates a coherent set of measures to take and means to implement to optimally achieve previously set objectives, taking into account predictable changes in variables, which the administration cannot control.

Examining the elements of this definition, he called the object to plan a “system”, capable of being described in terms of variables and their interrelationships. Unfortunately, he abdicates that this does not mean that we adhere to a mathematically formalized planning.

However, the related techniques are useful, and he goes so far as to say that ‘Even though we the existence of qualitative aspects, difficult to grasp, the object to be planned must nevertheless reveal a more or less predictable and therefore systematic behavior [12].

It is true that the field of study is reminiscent of written literature, but we can mathematically model an object or system. Our contribution will focus on the reality of what we think is purely a literary approach.

To estimate the relationship between the results obtained and the resources used to achieve the expected agricultural production, we will analyze the efficiency of agricultural activity.

3. Analysis of Agricultural Efficiency

Estimating agricultural efficiency is a fertile and diversified field of research that Tunisia, an African country, is exploring with interest to improve its agricultural management. The results in terms of fertility arise from the complexity of the organization and processes of agricultural production. As for its lasting extension, it refers to the methodologies developed in this field.

In its first section, the reference work [13] reviews the state of the art of efficiency, its origins, types and the main traditional approaches to evaluation. These approaches qualified as parametric (Parametric mathematical programming, Deterministic (econometric) frontier analysis, Stochastic frontier analysis) call on statistical tools with an econometric dominance and consider that the specification and construction of a production function are possible.

In its second approach, called non-parametric (Data envelopment analysis, Stochastic data envelopment analysis), is based on linear programming, we try to derive the production frontier from observed practices, and for which it is not necessary to specify a priori the functional form of the relationship that links inputs to outputs.

But it is very likely that the use of modeling tools will make it possible to obtain relevant quantitative results by integrating qualitative variables.

In short, the importance of scientific advances in the practice of efficiency measurement, and even the improvement of these quantitative models through the integration of quality variables, cannot be denied.

Even if for the moment no study has prescribed the indicators of quality the most relevant to adopt for optimal measurement of efficiency in production, this insufficiency deserves our interest in order to put to the point, the optimal combination of qualitative variables capable to improve the results of the efficiency measurement.

In the management of agricultural production, several indices are used to monitor the evolution of agricultural planning and resolve the problems which this management may face to.

It exists several indices characterizing economic activity linked to agriculture, for example the index of price to the consumer (IPC). It is a measure of overall level of price in an economy. IPC consists of a set of commonly purchased sets of goods and services. IPC measures the evolution of the purchasing power of a country's currency and the price level of a basket of goods and services. It expresses the variation in current prices of the basket of goods during a period compared to a reference period. IPC is usually calculated monthly or quarterly. It is based on a spending model representative of urban residents and includes people of all ages.

Most IPC index series use the period 1982-84 as a basis for comparison. The Bureau of Labor Statistics (BLS) of the United States has set the index level at 100 for this period. An index of 110 means that there has been a 10% increase in the price of consumer basket compared to the reference period. Likewise, an index of 90 indicates a drop of 10% of price of consumer basket compared to the reference period.

On the basis of the BLS survey, the IPC is evaluated by the ratio of Cost of consumption basket during a given year on the Cost of consumption basket during a reference year. This index measurement of prices is the basis of the digital quantities obtained to the daily; but to a more extensive extent of variables not necessarily quantitative, a formal modeling of distribution of the costs with parameters variables is possible.

4. Models of Distribution of the Costs with Variable Parameters

Often the lack of cooperation in production, as well as meager financing or almost none in agricultural communities can undoubtedly encourage producers the need of an indicator of agricultural production that we will call AGRICULTURAL INDEX. To define this index, we will proceed to the settings of production and consumption costs. Consider N inputs used by T firms producing K goods. Adopting a probabilistic framework, the model of distribution of the costs with variable parameters is formally written as follows [14] [15]:

$$x_{it} = \sum_{k=1}^{K} \beta_{ikt} y_{kt} + u_{it} \tag{1}$$

where x_{it} represents the expenses of a company t input i; y_{kt} is the total value of good k produced by company t; β_{ikt} is a variable parameter, specific to each firm, which is interpreted as the unobservable expense, incurred by firm t and relative to input i, necessary to produce a monetary unit of good k, and u_{it} is a term stochastic residual, also specific to each firm with zero expectation. We also assume that the residue u_{it} is distributed in a way identical, but independent between firms. The β_{ikt} coefficients must be positive or zero for any level positive production of good k. The fact to have variable β_{ikt} coefficients is essentially justified by the heterogeneity of firms [14] [15]. The above equation characterizes the value of the cost of agricultural production. But the estimation of this model admits a difficulty, because introduce all the total expense relative to an input between several products need to impose of constraints (equality and inequality) to the coefficients β_{ikt}. To resolve this difficulty, PEETERS, L. and SURRY will take into account the fact that all variables are in monetary units, of the accounting identity balancing total revenues and expenses which must be satisfied for each firm. This condition has the following consequences on the model (2) parameters established by [15].

1) $$\sum_{i} x_{it} = \sum_{i}\sum_{k=1}^{K} \beta_{ikt} y_{kt} + \sum_{i} u_{it} = \sum_{k=1}^{K}\left(\sum_{i} \beta_{ikt}\right) y_{kt} = \sum_{k=1}^{K} y_{kt} \tag{2}$$

2) the sum (in column) of the coefficients associated with the production of a good k for each company t must be equal to unity $\sum_i \beta_{ikt} = 1, \forall k, t$

3) $\sum_i u_{it} = 0, \forall t$ (3)

5. Measuring Profitability

It can be noted that profitability is linked not only to production costs but also to the revenues generated. It can be defined in several different ways, for example as the difference between revenues and costs (gross margin), or as the ratio between costs and revenues [14].

In some cases, one way to measure volume changes over time is to take the prices available at a given period (period $T = 0$) and multiply the volume of subsequent periods by these same prices. This actually involves re-evaluating current quantities at fixed prices over time [15].

Most index calculations do not take into account the influence of production constraints such as rainfall, temperature, greenhouse effect climate variation, we also find in this order the LASPEYRES index in the specialization:

$$I_{t/0} = \frac{\sum p_0 q_t}{\sum p_0 q_0} \tag{4}$$

However, since the accounts hardly provide the price of the base year (p_0), it is therefore possible to calculate the LASPEYRES index between successive periods.

$$I_{t/t-1} = \frac{\sum p_{t-1} q_t}{\sum p_{t-1} q_{t-1}} \tag{5}$$

where: q_t is the quantity of production in year t and p_{t-1} is the price in year $t - 1$. That is to say the value of the production of year t at the price of the previous year on the current value of the previous year [16].

The data is sometimes located spatially, sometimes using software such as GeoDa. We will focus on two types of products that are much more widely consumed in Guinea: rice and corn. Even if other products such as peanuts, cassava, millet, fonio, remain very productive, rice and corn remain in the food base in Guinea. Agriculture in Guinea remains rudimentary with often archaic means of production, yet exceptionally profitable in recent decades. In particular, the forest area remains attached to the cultivation of rice and corn throughout the territory.

6. Modeling of the Agricultural Index

6.1. Model Variables

The definition of integral variables is very useful for representing functions that are not strictly linear. A very common case that illustrates the importance of binary variables is fixed cost. Very often, the cost of production is broken down into a fixed cost independent of the quantity produced (manufacturing of inputs, maintenance of tools such as the machine, etc.) and a variable cost per unit produced. In this case some will use a continuous variable x which defines the quantity produced and a binary variable y which will be worth 0 if no production is launched and 1 if we decide to launch the machine to produce x units [17].

To determine the agricultural index, we will estimate the ratio of the production value of a consumer good b_k to the value of the expenditure for the production of this good for a given year.

Let us therefore consider by x_i the i^{th} value of the expenditure of a good i affected by coefficient ai and y_i the j^{th} value of production of a consumer good j affected by coefficient b_j.

6.2. The Model

Consider the Equation (2):

$$\sum_i x_{it} = \sum_i \sum_{k=1}^{K} \beta_{ikt} y_{kt} + \sum_i u_{it} = \sum_{k=1}^{K} \left(\sum_i \beta_{ikt} \right) y_{kt} = \sum_{k=1}^{K} y_{kt}$$

If the coefficient $\sum_i \beta_{ikt}$ is variable then it would be between 0 and 1. Let us denote by $I_a = \sum_i \beta_{ikt}$ the quantity which defines the ratio between the expenditure of an input on the production value of this good. The agricultural index is obtained over a well-defined period. This method therefore results in a production index which makes it possible to justify agricultural profitability.

$$\begin{cases} I_a = \dfrac{\sum_{i=1}^{n} a_i x_i}{\sum_{j=1}^{n} b_j y_j} \\ i, j = \overline{1, N} \end{cases} \tag{6}$$

where

$a_i = 1$ if good i is spent and 0 otherwise $i = \overline{1, N}$,

$b_i = 1$ if good i was produced and 0 otherwise $j = \overline{1, N}$.

6.3. The Constraints

The agricultural index is non-negative and the closer it gets to 0.5 the more we tend towards normalized agricultural activity in a country. The analysis of the plan of agricultural activities for the production of a consumable good and the action of the expenditure of this good must be called into question. If no production is recorded then, even if there is expenditure, the assessment of the agricultural index provides devastating details on the survival of the population.

6.3.1. Definition Domain of the Agricultural Index I_a

The analysis of the plan of agricultural activities for the production of a consumable good and the action of the expenditure of this good must be called into question. If no production is recorded then, even if there are expenses, the evaluation of the agricultural index provides devastating details on the survival of the population, that is to say if $I_a = +\infty$ or 0 then one of the causes must be considered (crises, wars, natural disasters). The more you produce, the more you consume without deficit. This is why the ratio of consumption value to production value indicates that consumption is a function of production.

If $I_a \in]0,1]$ a probable emergence in agricultural activity brings the day.

If $I_a \in]1,+\infty[$, extreme poverty is an explanation.

6.3.2. The Non-Negative of I_a

$$I_a \geq 0 \tag{7}$$

In short, this index can be used in estimating the overall production of consumable goods in a country in relation to the value of expenditure related to production for all sectors of activity, and in particular in agricultural activity.

7. Costs of Cereal Production

Knowledge of production costs is important in the face of inflation in the cost of agricultural raw materials; the evolution of the cost of consumption in relation to production defines a management tool which makes it possible to evaluate the economic efficiency of cultivation practices and can be integrated into the management of the agricultural operation. The production cost calculation method allows a cost to be compared to a selling price. However, the use of production cost must be done with caution. It is therefore important to be clearer in the definition of production costs and in the results obtained because an impact may be revealed on the analysis made by the farmer or the technician, especially in times of market crisis. The cost of production of a product includes all the costs necessary for its production, including the remuneration of production factors. It is divided into three main positions [18]:

- Input costs are directly applicable and consumed by the crop (seeds, fertilizers, pesticides, product taxes, crop insurance, irrigation costs).
- Structural costs arising from the means of production (mechanization, overheads, property and personal insurance, rent, buildings and equipment, financial costs, salaries).
- Additional charges correspond to the remuneration of family labor and its social security contributions as well as the remuneration of equity.

For each crop, the method allows us to calculate its production cost per tonne of product.

8. Cost Measures

8.1. Ratio of Cost in Domestic Resource

Let R_{ci} be this ratio, it compares the opportunity cost of domestic production to the added value that it generates. In other words, it compares the value of non-exportable domestic resources used to produce a unit of a given product to what that product would earn if it were exported.

For a product j, it is defined as follows:

$$R_{cij} = \frac{\sum_{i=k+1}^{n} a_{ji} P_i^D}{P_j^B - \sum_{i=k+1}^{k} a_{ji} P_i^B} \tag{8}$$

where a_{ji} is the quantity of the i^{th} traded input, if $i = 1$ up to k, or of a non-traded input, if $I = k + 1$ up to n, used to produce one unit of the j^{th} product (a_{ji} is sometimes called the technical coefficient); P_i^D is the domestic price of the i^{th} input; P_j^B is the border price of the j^{th} product; P_i^B is the border price of the i^{th} input. If $R_{cij} \in \left]0,1\right]$, this indicates that domestic production of the product considered is internationally competitive: the opportunity costs of domestic production (numerator) are lower than the value added of the product at world prices (denominator). It also indicates that the country should increase its exports of the product in question [14].

If $R_{cij} \in \left]-\infty,1\right[\bigcup \left]1,+\infty\right[$, (less than 0 when the denominator is negative) then a competitiveness deficit for the product considered is observed. R_{cij} ratios also allow countries to be compared with each other.

Less the higher the R_{cij} for a country, the more competitive it is. This indicator has often been used in studies on agricultural competitiveness, particularly concerning farm-level data.

8.2. Ratio of Social Costs to Benefits

According to Masters and Winter-Nelson (1995), since the R_{cij} ratio is based on the cost of non-exportable inputs, it understates the competitiveness of activities that primarily use these domestic factors compared to those that rely more heavily on exportable inputs. To overcome this shortcoming, the authors propose the social cost-benefit ratio (CAS). Based on the same data as the R_{cij} ratio, but used in a different relationship, the CAS ratio corresponds to the ratio of the sum of the costs of domestic inputs (non-exportable) and exportable inputs to the price of the product considered, it has the same set of definitions as the I_a index but different interpretations and admits the same variables as those of the R_{cij}.

$$CAS_j = \frac{\sum_{i=k+1}^{n} a_{ji} P_i^D + \sum_{i=k+1}^{k} a_{ji} P_i^B}{P_j^B} \tag{9}$$

8.3. Domain of Definition

$$CAS_j \in \left]0,+\infty\right[$$

Domestic production is competitive when the CAS ratio is less than 1, *i.e.* if $CAS_j \in \left]0,1\right]$, since this result shows that the total cost of inputs is less than the income generated by the product considered. The converse is true for a $CAS \in \left]1,+\infty\right[$ (a CAS less than 0 cannot exist) [14].

8.4. The Calculation Method in Summary

The method for calculating production costs in large-scale crops uses accounting elements with technical reasoning which integrates fallow land and equipment management and eliminates tax artefacts. For each crop, the cultural interventions grouped by position are indicated in number and in areas concerned: Soil work, Ploughing, Sowing, Spreading fertilizer, organic amendment, Spraying, Mechanical weeding, Harvesting, Haymaking, Forage harvest, Transport.

These activities require a lot of effort and economy; by considering the products much more cultivated in Guinea, such as rice and corn, we can define the ratio of the value of production to the cost of production, which calls into question in our study the definition of the agricultural index [11] (see **Table 1**). We can also explore an analysis of cultivable soils for the period 2017-2020 (see **Table 2**).

Table 1. Periodization of the average agricultural production cycle according to the cost of execution in thousands of Guinean francs.

Activity	Production value	Production cost	Period
Soil work	-	2000	1 Month
Plowing	-	1500	1 Month
Fertilizer spreading	-	1000	1 Week
Spray	-	700	2 Weeks
Mechanical weeding	-	1000	1 Week
Harvest	-	700	1 Month
Haymaking	-	500	1 Week
transportation	-	500	Less than a week

Table 2. Exploration of surface areas by agricultural products per year.

Year	2017	2018	2019	2020
Total area	2.725	2.725	2.725	2.725
Non-agricultural and semi-agricultural area	405	405	405	405
Useful agricultural area	2.32	2.32	2.32	2.32
Course	520	520	520	520
Cultivated agricultural area	1.8	1.8	1.8	1.8
Cereals	796	778	854	878
Industrial crops	6	10	12	12
Fodder	140	187	142	211
Legumes	94	76	98	91
Fallow	488	471	424	353
Total large-scale rotational crops	1.524	1.522	1.53	1.545
market gardening	48	50	54	99
Arboriculture	299	299	299	299
Intercropping	71	71	83	95

Figure 1 shows the analysis of cultivable soils. The annual variation between the surface area of arable land in relation to crops can justify the nature of the profitability of the seed of the good to be produced, while that of a type of soil over an annual period justifies the off-season adapted to the crop [19].

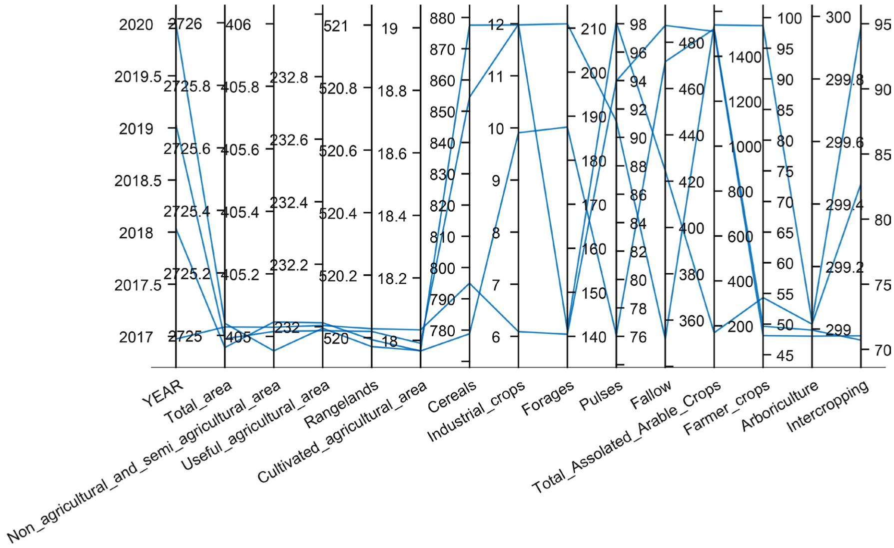

Figure1. Analysis of cultivable soils.

9. Problem Parameters: Rice, Corn and Cassava

According to the National Agricultural Statistics Service (SNSA), the quantities defined in the following tables indicate the need for good exploitation and management of soils and products (see **Tables 3-5**).

Table 3. Cultivated areas and yields (t/h).

	Rice		Corn		Cassava	
Region	**Production**	**Yield**	**Production**	**Yield**	**Production**	**Yield**
Boke	107,417	1.44	5129	0.79	4609	3.98
Faranah	87,843	1.83	20,119	1.24	6455	1.55
Kankan	137,769	1.00	33,890	0.81	34,451	1.54
Kindia	101,451	1.37	736	1.40	18,020	3.1
Labe	18,791	1.34	75,115	2.39	2355	2.76
Mamou	32,858	1.88	35,318	1.16	2247	4.25
N'Zérékoré	257,049	1.34	7749	1.36	16,461	4.35
Total	743,178	1.46	178,056	1.31	84,598	3.08

Table 4. Distribution of annual crop production by region (in tonnes).

Food	Quantity (kg)	Price (D/kg)	Value (D)
Cereals	204	0.050	10.2
Legumes	13	0.070	0.9
Vegetables	88	0.100	8.8
Fruits	65	0.100	6.5
Meat and poultry	12	1.000	12.0

Continued

Fish	2	1.000	2.0
Oil	18	0.400	7.20
Milk	46	0.080	3.7
Egg	33	0.025	0.8
Sugar	14	0.230	3.2

Table 5. Quantity and value of food consumed per person per year in rural areas.

	Rice		Corn		Cassava	
Region	Production	Yield	Production	Yield	Production	Yield
Boke	180,799	1.42	7167	0.79	79,040	3.98
Faranah	205,854	1.83	82,798	1.24	52,129	1.55
Kankan	254,745	1	145,707	0.81	352,892	1.54
Kindia	264,205	1.37	62,970	1.40	158,731	3.1
Labe	45,903	1.34	188,728	2.39	209,867	2.76
Mamou	51,659	1.88	72,856	1.16	177,206	4.25
N'Zérékoré	462,507	1.34	88,268	1.36	207,831	4.35
Total	1,465,672	1.46	648,493	1.31	1,237,695	3.08

10. Usefulness of the Agricultural Index

By using the Agricultural Index, the farmer will be able to observe the annual evolution of production and the stability of prices and goods consumed according to the expenditure of the production of these goods. And therefore, to adapt a good consumption of these different goods and services to have a better control on our expenses and our purchasing power.

11. Variational Study of the Soil Humidity Index of Guinea from 1990 to 2020

It exists several mathematical formulas to assess and identify agricultural areas based on the amount of precipitation and humidity. It can be calculated to assess favorable conditions for crop growth. Let us consider some approaches used:

11.1. Definition

The Humidity Index (IH) is an indicator of the humidity load imposed by the climate in a given region on soils and buildings.

11.2. Method of Calculation

IH is calculated based on two factors: the wetting index (IM) and the drying index (IA). Based on the regional annual precipitation amount, the IM takes into account factors such as rainfall, wind speed and direction, adjacent buildings, vegetation, topography and other factors present that can have a significant influence.

For its part, the AI takes into account the temperature and relative humidity of each locality in order to define the drying capacity of the ambient air.

11.3. The Soil Moisture Index, Interpreted in the Technical Sense

When the soil moisture index is close to 1, the soil is considered wet (greater than 1, it indicates that the soil is tending towards saturation). Conversely, when it tends towards 0, the soil is in a state of water stress (less than 0, it indicates that the soil is very dry).

12. Index of Humidity by the Normalized Difference

Index of Humidity by the Normalized Difference (NDMI) detects humidity levels in vegetation. It is a reliable indicator of crop water stress [20]. Severe drought conditions affect crops, but can also destroy the entire yield. NDMI can detect water stress at an early stage, before the problem gets out of control. Additionally, using NDMI to monitor irrigation, especially in areas where crops require more water than nature can provide, helps to significantly improve crop growth. All of this makes NDMI an excellent agricultural tool. And since dry conditions in vulnerable areas increase the risk of combustion, NDMI has yet another application: monitoring high-risk fire areas.

12.1. Interpretation of NDMI Values

Like most indices, NDMI can only have values between −1 and 1, making it very easy to interpret. Water stress would be signaled by negative values close to −1, while +1 could indicate waterlogging. Therefore, each intermediate value will correspond to a slightly different agronomic situation.

- −1 - −0.8 Bare soil,
- −0.8 - 0 high water stress or canopy cover is low or low at times,
- 0 - 1 low, high, very high, or no water stress.

12.2. Field of Application

Index of humidity by the normalized difference can be applied for:

- Regularly monitor crop water content,
- Determine areas of fields/farms with water stress,
- Improve logistical planning of tree felling,
- Determine combustibility levels in areas vulnerable to fire [18].

12.3. Visualization of NDMI

The two common ways to visualize NDMI values are the maps and the graphs. The map clearly shows the spatial distribution of water stress across the field(s), while a graph shows its evolution over time. It is therefore possible to detect waterlogged areas in a field using NDMI, to solve the problem and to prevent it in the future.

In Guinea, the socio-political factors and uncontrolled land use have led to a decline in the productivity of agricultural areas. The periods from November to December and from January to April are marked by high water stress, leading to inter-seasonal periods during which farmers turn to market gardening. The absence of water stress, which corresponds to the fertile period of the agricultural season, is clearly observed during the interval of months from April to October. A general overview of the specific humidity index over a long period, from 1990 to 2020, can provide us with information on periods of constant water stress favorable to agriculture.

12.4. Location of Seasonal Water Period of Specific Humidity Index

Figure 2 shows the inter-annual anomalies of the humidity index over 30 years. Compared to the threshold (level 0) of the humidity level, we note that in 1991, the humidity index by normalized difference had broken the record and since that year, a peak of high-water stress has been observed in Guinea, which can lead to a drop in agricultural production. Water stress, present from 1999 to 2002, is linked to the abusive use of agricultural land by refugees. In 2010, a peak in the absence of water stress was observed, and until 2020, a disturbance in the agricultural index draws our attention to the worrying rise in the effects of global warming.

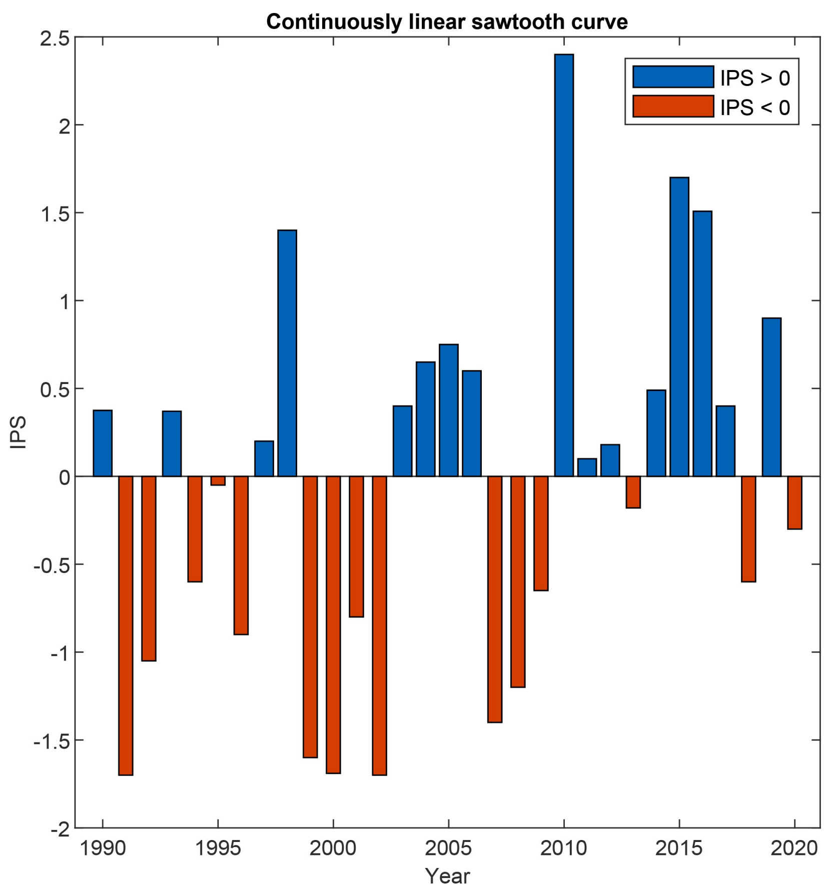

Figure 2. Inter-annual anomalies of the humidity index over 30 years.

12.5. Line of Linear Regression of Index of Specific Humidity

Figure 3 shows the inter-annual analysis of the 30-year regression line. By comparing the evolution of the water stress curve in regression, we observe a positive trend towards a period of constant and balanced fertility on Guinean soil, between 1997 and 1998, then between 2003 and 2006, and finally between 2010 and 2020. This trend can be explained by the fact that critical points are located further and further to the right. In 1991, the critical point is the furthest from the line and results in the highest water stress threshold over the study period.

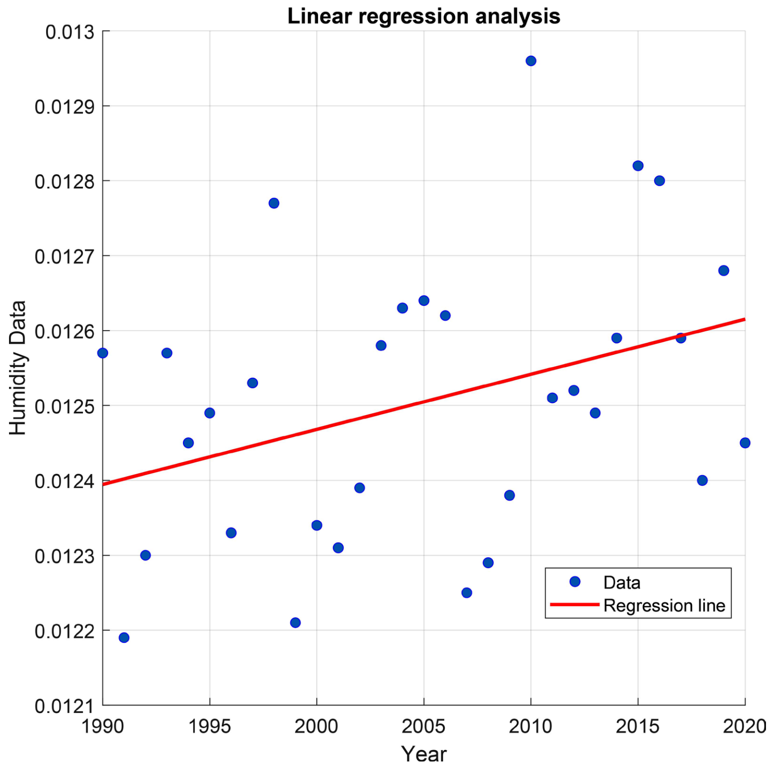

Figure 3. Inter-annual analysis of the 30-year regression line.

Unlike the period from 2000 to 2003, marked by the effects of rebel aggression, we observe a concentration of critical points in a band of agricultural fertility above the right.

12.6. Continuity Curve of Critical Humidity Index Points

Figure 4 shows the analysis of humidity index maxima and minima over 30 years. The continuity curve supports the results of fertility periods due to climate change, which are the cause of water stress disturbances. The vertices represent critical points, corresponding to maxima and minima. From 1990 to 2020, the curve shows a global minimum in 1991 and a global maximum in 2010. This observation suggests that, over 30 years, Guinea is less exposed to the presence of bare soil or the total absence of water stress. We can therefore conclude that Guinean soil is conducive to agricultural activity, especially for cereal crops such as rice and maize.

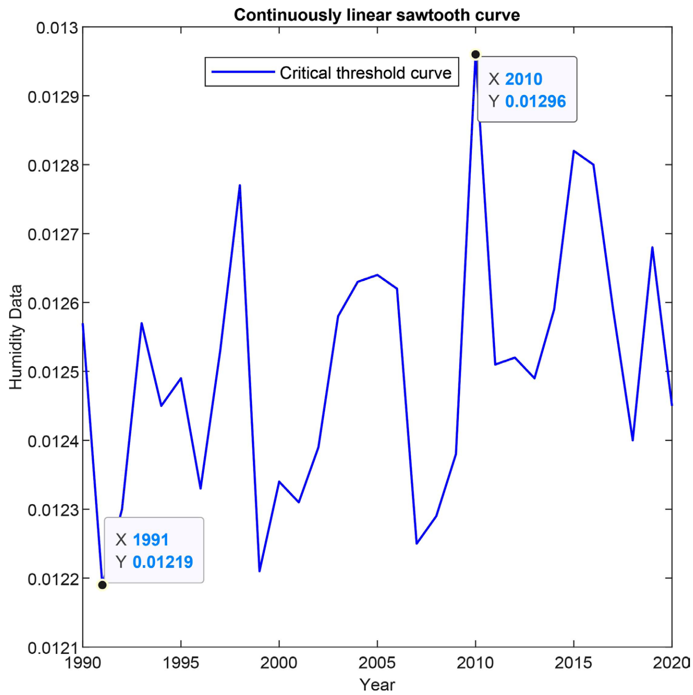

Figure 4. Analysis of humidity index maxima and minima over 30 years.

12.7. Spatial Location of Seasonal Specific Humidity Index Zones

Figure 5 shows the spatial variability of the humidity index over 30 years. The blue area indicates the area with more or less low or almost no water stress and the further we move towards the north of the country, the more the humidity varies downwards. However, according to the production quantities recorded in Guinea, the forest zone is more favorable for rice cultivation while that of middle and upper Guinea is for market gardening.

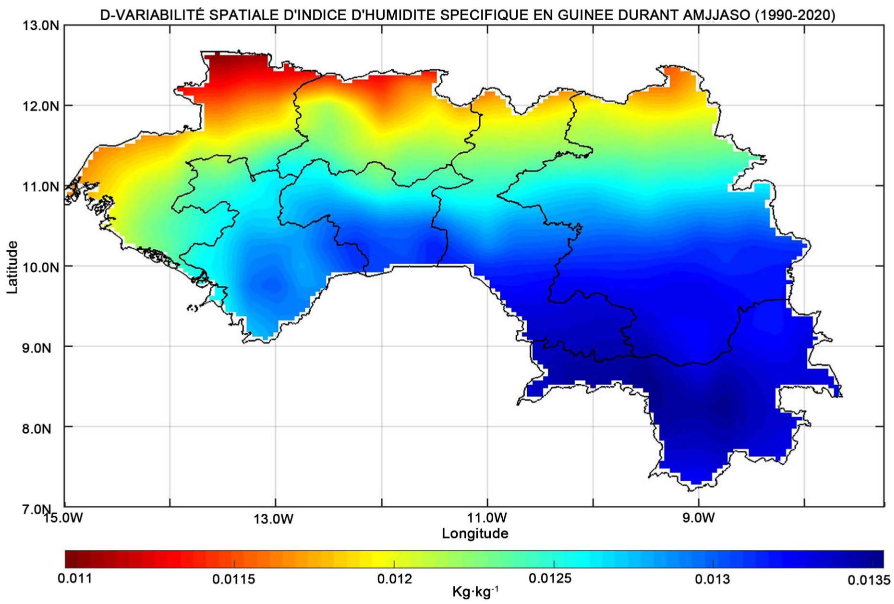

Figure 5. Spatial variability of the humidity index over 30 years.

13. Method for Solving the Index Calculation Problem

13.1. Non-Negative Factorization

A rational function is a quotient of two polynomials:

$$r(t) = \frac{P(t)}{q(t)} \tag{10}$$

Any non-negative rational fraction $r(t)$ on an interval $I = [-1,1]$ can be stated without loss of generality by a non-negative numerator on I and a strictly positive denominator on I [21].

13.2. Rational Programming

Let us use rational function programming by introducing our problem on the space of measures and show its equivalence with the general problem [22].

The principle of this approach removes the denominators q_i by introducing them into new measures m_i. To understand this method, we will treat the case where $N = 1$ and consider the problem

$$r^* \triangleq \min_{x \in K} \frac{P(x)}{q(x)} \tag{11}$$

The problem in the measurement space is written:

$$r' \triangleq \min_{\mu \in p(K)} \int_K \frac{P(x)}{q(x)} \mathrm{d}\mu \tag{12}$$

As $q(x) > 0$ then $\forall x \in K$ we set

$$\Lambda \triangleq q^{-1}\mu \tag{13}$$

It is to say that

$$\Lambda(A) \triangleq \int_{K \cap A} q(x)^{-1} \mathrm{d}\mu(x), \ \forall A \subseteq B(R^n) \tag{14}$$

By construction we note that Supp(Λ) = K and we retain that μ is a probability measure on K, which requires that

$$\int_K \mathrm{d}\mu(x) = \int_K q\mathrm{d}\Lambda = 1 \tag{15}$$

We therefore obtain the formulation of the previous problem:

$$r' \triangleq \min_{\Lambda \in M_+(K)} \int_K p\mathrm{d}\Lambda \tag{16}$$

$$s.c.l \ \int_K q\mathrm{d}\Lambda = 1 \tag{17}$$

Consider for $N > 1$ and define the problem in the following measurement space:

$$r' \triangleq \min_{\Lambda \in M_+(K)} \sum_{i=1}^{N} \int_K p_i \mathrm{d}\Lambda_i \tag{18}$$

$$s.c.l \ \int_K q_i \mathrm{d}\Lambda_i = 1, \ i = \overrightarrow{1:N} \tag{19}$$

14. Generalization of the Model

In the case where $N > 1$, let us estimate the previous model for N activities. We admit the following problem:

$$J_a = \min_{x\in K} I_a \tag{20}$$

$$J_a = \min_{x\in K} \frac{\sum_{i=1}^{n} a_i x_i}{\sum_{j=1}^{n} a_j x_j} \tag{21}$$

where

$$p(x) = \sum_{i=1}^{n} a_i x_i \ \text{ et } \ q(x) = \sum_{i=1}^{n} a_j x_j \tag{22}$$

Using the space of measures, it comes:

$$J_a \triangleq \min_{\mu\in p(K)} \int_K \frac{\sum_{i=1}^{n} a_i x_i}{\sum_{j=1}^{n} a_j x_j} \mathrm{d}\mu \tag{23}$$

It is obvious that $\sum_{j=1}^{n} a_j x_j > 0$ then $\forall x_j \in K$ we set

$$\Lambda \triangleq \left(\sum_{j=1}^{n} a_j x_j\right)^{-1} \mu \tag{24}$$

$$\mathrm{d}\Lambda \triangleq \left(\sum_{j=1}^{n} a_j x_j\right)^{-1} \mathrm{d}\mu \tag{25}$$

$$\int_{K\cap A} \sum_{j=1}^{n} a_j x_j \mathrm{d}\Lambda \triangleq \int_K \mathrm{d}\mu = 1 \tag{26}$$

We obtain the generalized formulation of the problem:

$$J_a \triangleq \min_{\Lambda\in M_+(K)} \int_K \sum_{i=1}^{n} a_i x_i \mathrm{d}\Lambda \tag{27}$$

$$s.c.l \ \int_{K\cap A} \sum_{j=1}^{n} a_j x_j \mathrm{d}\Lambda = 1 \tag{28}$$

15. Conclusion

In this study, we implemented a mathematical model to establish the agricultural relationship between the results obtained and the resources used, by estimating a yield function to predict the production value and by promoting internal agricultural activity in order to increase the yield of these resources in agricultural areas. The agricultural index obtained in this work allowed us to observe the trends in normalization of agricultural activity in the Republic of Guinea. This index can be used to estimate the overall production of consumable goods in a country in relation to the value of expenses linked to this production for all sectors of activity, and in particular for agricultural activity. In the rest of the work, we carried out the simulation after collecting the data relating to the variables of the problem. We can say that from the model of Equations (27) and (28) obtained, knowledge of the expenses allocated to production is essential, while the constraint equation characterizes the value of the product obtained.

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Author Contributions

Conceptualization, data curation, formal analysis, investigation, methodology, software, writing original draft and writing review and editing preparations, M. Léno and J. Djossou; writing review and editing, J. Djossou, O. Toure, K. S. Diallo, B. Mansaré and B. M. Touré; supervision, J. Djossou. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

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

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