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Mobilizing Agricultural Natural Resources for Development and Reducing the Risk of Food Insecurity in Cameroon

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ABSTRACT: This article proposes a practical model for organic agriculture (OA) that can strengthen the volume and quality of organic crop production and better combat food insecurity (FI) in Cameroon during periods of persistent heatwaves. We therefore needed to construct pairs of crops and agroecological zones suitable for high-temperature conditions. This objective was achieved by applying the Gale and Shapley model (1962). The results show that, to benefit from OA and control the risk of FI, each OA crop should be grown in the agroecological zone most favorable to its productivity. However, the success of this practice depends on increased funding for projects by organic and technological developers in agriculture and on improving knowledge of local meteorology. Furthermore, it is necessary to facilitate public and private investment in each region for the creation of sustainable processing infrastructure by developing appropriate industrial zones for processing harvested products. Emphasizing the optimal use of renewable energy sources, essential for better orientation of national economic policy towards achieving the Sustainable Development Goals.

KEYWORDS: food insecurity, organic farming, agroecological zone, matching

INTRODUCTION

The 2026 global report on food crises confirms the global systemic failure : 266 million people are in acute FI situations (Leszczynski, 2026) while humanitarian aid continues to fall and the vulnerability of sectors of activity caused by climate change takes time to be resolved. Among the sectors of activity identified as vulnerable to climate change in Cameroon, agriculture ranks first with fishing and livestock. Their vulnerabilities inevitably increase the risk of food insecurity. From this observation, we would definitely agree with Kressmann who in 2021 was already saying that by switching to organic (which reduces crop yields by 10 to 50%), the thinkers of degrowth are preparing the famines of tomorrow.

Among the sectors identified as vulnerable to climate change in Cameroon, agriculture ranks first, along with fishing and livestock farming. Their vulnerabilities inevitably increase the risk of food insecurity. As these sectors are heavily dependent on small businesses, measures to protect these activities are needed at the political, strategic, and operational levels. According to the National Institute of Statistics (INS) (2025), agricultural growth accelerated in 2024, reaching 5.2% compared to 1.4% in 2023, out of an overall rate of 3.3% and 3.6% for the primary sector, whose contribution to GDP was 0.6 percentage points compared to 0.4 in 2023. This growth was driven by subsistence farming at 3.2% and industrial agriculture at 9.5%, compared to 1.3% and 1.6% respectively in 2023. The same report indicates that agriculture's share of GDP reached 32,316.2 billion CFA francs, representing 11.03%, one of the largest shares of the country's GDP. Despite all this, the agricultural sector still requires particular attention. Indeed, the shift in agro-ecological zones due to the intensifying effects of climate change on soil composition could lead to the abandonment of certain crops (dates, potatoes, white pepper, bambara groundnuts, etc.) in some regions. This could alter the dietary habits of populations in these areas. To avoid a significant disruption to food security and to better guarantee crop productivity, it may be necessary to prioritize certain agro-ecological zones over others.

Maintaining good health, access to education, and, above all, proper nutrition remain major concerns for the people of Cameroon. With a growing population estimated at 28,758,503 by 2024 (Ministry of Health, 2019), these three concerns risk worsening in the coming years if nothing is done. The persistent shortages and dependence on certain food products are detrimental to the country's economic image. Despite its abundant natural resources (diverse soils and climates, rich marine resources, etc.), the country has struggled for several decades to meet the food needs of its population. The increasingly numerous and detrimental effects of climate change on the living standards of certain populations are raising further concerns about their ability to feed themselves in the future. In a press release from march 2026, we can read the statement by Adesh Tripathee, head of the IFRC country cluster delegation in Yaounde, which presents Cameroon as a country facing a silent crisis of read hunger for millions of people.

In Cameroon, between 2018 and 2020, approximately 5.3% of the total population suffered from malnutrition (BMZ and GIZ, 2022). Even today, all age groups experience periods of difficulty accessing food at some point. This is a particularly challenging situation for households with relatively low incomes, who often have to cope with water shortages, droughts, and floods (Djacbou and Feukeng, 2023). To address this, it is essential to increase public [1]and private investment in sustainable food systems and supply chains. While Cameroon is open to importing many foodstuffs, it remains more focused on its agricultural policy, which represents the best way to reduce its dependence on imported food. Indeed, climate change does not only have negative influences on agricultural production if we recall Lavoisier's thinking at the end of the 18th century : " *nothing is lost, nothing is created, everything is transformed* ." It is for this reason that in December 2023, the President of the Republic prescribed the integrated three-year import-substitution plan.

With the effects of climate change gradually pushing states to phase out fossil fuels by 2050, the country's agricultural sector should begin considering policies to reassess production methods now. By better integrating the challenges of sustainable development (economic growth, social cohesion, and environmental protection), new paradigms of adaptation and anticipation must prioritize and embrace the opportunities offered by renewable energies for a stronger, more widespread, and more sustainable agriculture. Organic agriculture is identified in three types that could help define possible development pathways in Cameroon (De la Paix Bayiha, 2020; De la Paix Bayiha and al, 2019). It helps practitioners obtain higher prices and preserve food autonomy through self-production (Temple and al, 2024) even if, its practice among a large number of producers, is slow to bring the expected added value.

Its practice by some producers has yet to deliver the expected added value. However, taking into consideration geographical parameters such as soil health and the ecosystem of the areas, OA has often raised doubts about its ability to participate in a technological and institutional transformation in order to contribute to the fight against FI (Temple and al, 2022).

The agricultural sector plays a role in reducing food insecurity (FAO, ECA, and AUC, 2021). It employs a significant portion of the rural workforce in developing countries (Ali and al., 2016). However, income from agricultural activity does not always allow rural workers to improve their standard of living. The often-observed gap between the purchase price of the product after harvest and the price approved by international organizations is a real problem. This price difference generally discourages the intensification of farming. Yet, intensifying cultivation presents a significant opportunity for reducing food insecurity. Guibert and al. (2016) show that, provided a better price is consistently applied during the harvest period, intensifying maize cultivation represents an opportunity to improve food security in northern regions. According to Ouoba and al. (2018), abundant Bambara groundnut production [2]is beneficial to the resilience of populations to Asian pests (AP). However, according to Wang-Bara and al. (2021), cultivating Bambara groundnut in northern and western Cameroon results in reduced yields in soils with high humidity. Finally, Maïmouna and al. (2021) present a [3]desert date palm cultivation method better adapted to soils developed on granite bedrock inoculated with mycorrhizae. These results demonstrate that expanding specific crops in specific regions of Cameroon could indeed be a lever for combating AP. Therefore, two research questions arise: how can agricultural natural resources be mobilized for development? Can crop matching with regions improve organic farming yields and effectively combat AP in Cameroon?

To our knowledge, very few studies have addressed the second question to date. Consequently, there is very little existing literature on the subject. This work therefore contributes to the existing literature. It helps to provide new directions for revising the National Development Strategy (NDS) for 2030 or for developing any other operational measures in the sector.

To address this concern, a literature review is conducted first, followed by methodological elements, results are presented third, and we conclude.

1. LITERATURE REVIEW

As an oil producer and user of its derivatives in industrialized agricultural production, Cameroon can still benefit from these energy resources thanks to the COP 28 consensus. The resolutions adopted at this climate conference, held in Dubai in 2023, give Cameroon the opportunity, and perhaps even the restraint, to continue its exploitation, albeit on a more moderate scale. Indeed, the solutions proposed by the consensus for a transition away from fossil fuels rely heavily on technological advancements and the development of artificial intelligence. However, it remained less forthcoming regarding support measures for developing countries in implementing the measures to phase out oil, gas, and coal.

OA alone will never be able to feed the planet (Kressmann, 2021) but, the cessation of fossil fuel exploitation, called for and desired by all major international organizations, the most vulnerable states, and international NGOs (GCHA, 2017), appears, in light of the damage caused by climate change, to be the best solution for maintaining hope for a return to ecosystem balance and a better recovery in food production. However, the majority of industrial production mechanisms in countries around the world still depend on it (The Essentiel, 2025; AFG, 2021). This is particularly true in Cameroon, where the problem of food insecurity among the population remains a genuine social scourge. At least, this is what emerges from reading the MINADER communication sheet (2023), which shows that equitable access to food remains a real concern for social cohesion among different social strata.

Dietary diversity is not only a function of agricultural production or harvests but also of the capacity of households to have access to the market and to obtain a sufficient level of income gains (Temple and al, 2024). Nowadays, if food safety has become more complex (Touzard and Fournier, 2014), FI has become rather easy. According to the FAO, food insecurity occurs when a person lacks regular physical or economic access to sufficiently safe, nutritious, and appropriate food to support an active and healthy life. This leads us to consider food insecurity as the situation of

[1]Public investment is needed, among other things, to adapt or improve infrastructure, research and extension services, climate information, financial services, and market access in the context of climate change. The provision of basic healthcare, water, and sanitation services is a key element in contributing to food security and nutrition in the face of climate change (FAO, EU, 2018).

[2]A plant with a high calorie content, balanced in terms of vegetable protein, rich in vitamins and minerals.

[3]A tree of the Zygophyllaceae family that thrives in arid and semi-arid regions. It can be used for food, firewood, and medicine. However, it remains largely wild and requires domestication.

a population unable to have regular and sufficient access to healthy food for consumption due to low overall food production. It is therefore a consequence of an inadequacy or slowdown in the blue economy, but even more so in the green economy, which is more accessible to all populations in a country because it relies heavily on agriculture. Down compared to 2022, Cameroon exposed in2023, 10% of the population inan FI situation, or around 3,000,000 people (Djacbou and Feukeng, 2023). In Cameroon, approximately 44% of the population is employed in the agricultural sector (BMZ and GIZ, 2022). However, a press release from the IFRC (2026) presents an assessment by the Cameroonian Red Cross noting that more than 60% of households, to cultivate crops during the next agricultural season, are resorting to extreme adaptation strategies, namely the sale of livestock, tools and other necessary productive assets. A decrease compared to the previous year, Cameroon had 10% of its population experiencing food insecurity in 2023, representing approximately 3,000,000 people (Djacbou and Feukeng, 2023).

To better address current and future challenges, Cameroon promotes organic farming (AB), which is part of smart agriculture [4]. Indeed, the latter is capable of restoring soil fertility and, the more varied the agroecological practices, the greater the chances of diversifying the diet (Temple and al, 2024).,. Among the three types identified, natural organic farming, for developing countries with abundant natural resources like Cameroon, is likely the most appropriate for strengthening food and nutritional security, reflected in food availability, access to food, food utilization, and food stability. Cameroon benefits from average rainfall and a wide variety of agro-ecological zones, combined with significant climatic diversity and vegetation conducive to agricultural development (FAO, 2020). This statement by the FAO partly testifies to the agricultural production potential preserved by the country's ecosystem, despite the disruptive effects of climate change. It is this natural wealth, which is not lost but rather transformed, that allows Cameroon to remain the breadbasket of the CEMAC zone, with an agricultural share of over 52.3% (FAO, 2021).

A relatively recent term in use, organic farming in its initial typology (according to Temple et al.) has been applied in Cameroon since around the 1990s. Natural organic farming, on the other hand, has been practiced there for decades. This is the type of farming practiced by rural farmers who lack the financial resources to industrialize their operations. To move away from FI, the factors of which have evolved with the rise of the agro-industrial model (Touzard and Fournier, 2014). To overcome the challenges of industrialization, Cameroon needs to accelerate agricultural growth of all kinds. The best approach proposed by Awoutcha and Fotsing (2023) involves prioritizing the redistribution of uncultivated arable land to farmers, strengthening agricultural training programs within rural secondary education curricula, and enforcing laws protecting land ownership. This proposal, focusing solely on education, already presents limitations in its implementation. While intensive in rural areas, agricultural activity is also a significant concern for the larger urban population in Cameroon. Moreover, it is more of a female practice in these cities, as confirmed by the study of Madou and al (2018), which shows that 98% of voandzou producers are women.

Over time, the rural population has become more educated, which has reduced the constraints related to producer training and natural resource management. However, some organizational problems persist across the entire production system. These may explain why some studies indicate the lack of a favorable environment for organic farming in Cameroon (Temple and De Bon, 2020), despite the Ministry of Economy, Planning and Regional Development considering it an opportunity for economic development (MINEPAT, 2020). Indeed, the argument of an unfavorable environment for organic farming in Cameroon is debatable, as its organization remains a matter of political will linked to the level of participation of international partners, increased community involvement, and, above all, good governance by public authorities. In fact, these partners are interested in smart agriculture to varying degrees (FAO and MINADER, 2019).

Cameroon encompasses a variety of landscapes, geomorphological zones, and climatic zones that can be grouped into five (5) specific agro-ecological zones. Based on their extent and soil characteristics, [5]these zones are presented in the table opposite.

Table 1: Coverage of regions by different agro-ecological zones

Agroecological zones	Soil types	Types of crops
Monomodal forest of 45658 km2 with a hot/humid tropical climate of 25.1 to 25.3°C.(a_1)	Volcanic slope, sediments of rocky origin (b_2)	Cocoa , (c_1)ginger, coffee, plantain, banana, pepper, potato, etc.
forest of 165770 km2 with a hot/humid tropical climate of 25.3°C.(a_2)	Clayey, ferralitic, acidic(b_5)	Cocoa, coffee, cassava, corn, pineapple, palm oil, plantain, potato
High plateaus of 31192 km2 with a hot/humid tropical climate of 25.1°C.(a_3)	Fertile and enriched with volcanic materials (b_3)	Cocoa, coffee , (c_2)dried beans, corn, potato, bambara groundnut
High savannas of 123077 km2 with a hot/humid tropical climate of 26.7°C.(a_4)	Permeable with medium water retention capacity, rich in iron, hydromorphic(b_1)	Cotton, maize, millet-sorghum, potato , (c_6)yam, bambara groundnut, coffee
Sudano-Sahelian of 100353 km2 with a hot/humid tropical climate of 26.7°C and a hot/semi-arid tropical climate of 28.7°C.(a_5)	Hydromorphic, alluvial, ferruginous, leached, etc. (b_4)	Cotton ⋆ (c_4), millet-sorghum ⋆ (c_5), bambara groundnut ⋆ (c_3), sesame, onion, black-eyed pea

Source: Authors (adapted from IRAD and the Statistical Yearbook of Cameroon – 2000) where ⋆ indicates the area most suitable for growing starfruit. Temperatures and climates are taken from BMZ and GIZ (2022).

The diversity and rich cultural heritage that spans the expertise of tropical African populations in the North and equatorial African populations in the South offers Cameroon, in the heart of Africa, advantages in diversifying agricultural production and enriching the national diet. Access to

[4]An approach aimed at creating the political, financial and technical conditions to achieve sustainable agricultural development that promotes food security in the context of climate change (FAO, 2013).
[5]Which are among the most important for agricultural production.

major waterways allows Cameroon to export significant quantities of agricultural products such as cocoa and its derivatives (beans, paste, butter, and preparations), cotton fiber, coffee, rubber, palm oil, bananas, and white pepper.

With an area of 475,650 km², its southern, central, coastal, eastern, and southwestern regions are characterized by a hot and humid climate with abundant rainfall, dense vegetation, and a vast hydrographic network. The western and northwestern regions are high plateau areas characterized by their abundance of volcanic soils. The Adamawa, northern, and far northern regions lie within the northern Sudanian-Sahelian zone, characterized by a dry tropical climate in the north and far north, and a temperate climate in Adamawa. However, there is a risk of a shift in agro-ecological zones given projections of a likely increase in average temperature ranging from 1.6 to 1.9°C by 2030 and from 3.8°C by 2080 (BMZ and GIZ, 2022). Already in May, we are beginning to see losses in the production of certain crops in the North due to rising temperatures.

As mentioned above, climate change does not only have negative effects on agricultural production. Indeed, increased radiation, rainfall, temperature, and carbon dioxide (CO2) levels are favorable to certain cultivated plants. Increased heat availability can lead to faster or more successful plant development in a given area at a specific time because there is neither a loss nor a creation of the physical and chemical elements of the environment, but rather a transformation of these elements. The shift in agroecological zones will thus make it possible either to cultivate crops in areas that were previously uncultivated or to develop new species that are more resilient to the changing diversity of the climate. Climate change can therefore be beneficial to crop rotation if it is managed intelligently. Organic farming does not appear to be disadvantaged by climate change (Brisson and Levrault, 2010). To increase and stabilize organic crop production in the long term, it would be necessary to focus on the soil and climate constraints that can affect it (Brisson and Levrault, 2010). The challenge here is to ensure that each cultivated plant is grown in the right location, even when the temperature may seem too high.

2. METHODOLOGICAL ELEMENTS

The lack of readily available databases leads us, in this article, to the use of a simulation. Belonging to the broader family of modeling, simulation has developed significantly with the digital age. Generally simple, models can be sufficiently accurate to represent reality (Lave and March, 1993). Simulation is a valuable tool for theoretical advancements that helps in developing better opinions when survey responses are difficult to analyze or when data access is limited during the study period. It closely approximates experimental conditions. It is a valuable instrument for the development of social science research. Among the existing modeling families, we will use generic algorithms. These are particularly well-suited to studies involving the processes of evolution by natural selection and learning (Cartier and Forgues, 2006). This will allow us to search for or identify one or more optimal solutions to the problem at hand.

Addressing the issue of association, grouping, or matching necessarily calls upon Cooperative Game Theory as an analytical tool. This theory requires formulating logical assumptions that will inevitably influence the outcomes of the resulting game. In various situations where the robustness of assumptions about players' cognitive change is reduced beforehand, the Gale and Shapley algorithm (1962) consistently delivers remarkable results for the (stable) association problem. Its application to game situations where the subjects of study are not human seems less straightforward, even though the conditions of no utility transfer and no manipulation [6]could be met naturally. Since the stability condition is one of the stated objectives of the two authors, they rely on two minimal conditions: first, a match $\mu$is individually rational if each individual $v$who does not remain single actually prefers to be married to their partner, $(\mu(v) p_v v)$or $\mu(v) = v$Given that a matching function $\mu : W \cup M \rightarrow W \cup M$associates a partner $\mu(v)$with each individual $v$and satisfies the following three conditions: (1) for each individual $w \in W$, $\mu(v) \in M \cup \{w\}$; (2) for each individual $m \in M, \mu(m) \in W \cup \{m\}$; (3) for each individual $v \in W \cup M$, $\mu(\mu(v)) = v$, it remains to verify the optimality of the resulting matchings. Because the aim of our work is to establish pairs consisting of an agroecological zone (climate type + soil type(s)) and at least one cultivable plant species, the matching model seems to be the appropriate tool. Its ability to endogenize the characteristics of the different variables in order to construct an equilibrium is a significant advantage.

2.1. Theoretical framework of the Gale and Shapley algorithm (1962)

2.1.1. General principle

We define two [7]distinct sets with a finite number of elements [8]. From these two sets, we seek to form, using a matching mechanism, pairs composed of one element from each set. A matching is a possible configuration of pairs of elements from the overall population under consideration. A mechanism The matching method assigns a match to each element's preference profile. For any given preference profile, there is no a *priori* reason to find a match that simultaneously satisfies all elements. An element preferred above all others by one element may, in turn, prefer another. The overall population is a set formed by all the elements of the two finite sets. This configuration is an endomorphism. Indeed, the Gale and Shapley model (1962) is defined for marriage situations. This is why we are looking for pairs here, that is, subsets formed by at most two elements. However, it is possible that the subsets sought may be composed of more than two elements; this is the case presented in the article.

Note 1: Each pair formed is such that one element is respectively the best choice for the other. For an element of one set, the best choice is an element of the other set, ranked first according to its order of preference.

The challenge is therefore to obtain an agreement that satisfies "as best as possible" the preferences declared [9]by the agents of both groups.

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[6] A match is "non-manipulable" by one of the two types of individuals when all individuals of that type have an interest in revealing their true preference to the planner.

[7]Although it becomes more complex to implement, it is possible to base the mechanism on more than two sets. This is what we do in this work by defining three sets instead of two.

[8]Each element of a set is characterized by a strict, transitive, and complete preference relation. In other words: We accept that (i) each element of a set is capable of ordering the options presented to it from the one it prefers most to the one it prefers least (strict preference), indifference is not allowed; (ii) each agent is rational, in the sense that it will always choose the option that is ranked above all the others (transitivity); and (iii) that each element of a set is capable of ordering all the options presented to it (completeness).

[9]Note that in this article, the elements of the sets cannot make concrete statements. However, by analyzing production volumes in a given soil and climate, we can establish a preferential ranking of a plant in specific soils and climates.

Note 2: It is possible that the matching mechanism may leave some unpaired pairs. This occurs mainly when the cardinalities of the sets are disproportionate.

2.2. Application of the Gale and Shapley algorithm (1962) in the geographical space of Cameroon

During work, we will call:

CL : Finite set of climates; SO : Finite set of soils; PL : Finite set of plants;

$|CL|$, $|SO|$ and $|PL|$ Are the respective cardinalities of CL, $SO$and PL ;

a_i : An element of $CL$with $i = \{1,2,3\}$; b_j : A element of $SO$with $j = \{1,2,3,4\}$;

c_k : An element of $PL$with $k = \{1,2,3, \ldots, n\}$;

$SO \cup \{a_i\}$A set consisting of the 3 types of soil and the climatea_i

$PL \cup \{b_j\}$The whole formed by the $n$most the groundb_j

$PL \cup \{a_i\}$A group formed by the $n$most climatea_i

$\beta(c_k)$The climate corresponding to the plant $c_k$by the mechanismβ

$\beta'(c_k)$The soil corresponds to the plant $c_k$by mechanismβ

$\beta''(c_k)$The soil and climate correspond to the plant $c_k$through the mechanismβ

2.2.1. Model :

- $PL > SO > CL$and it is possible for several plants to be grown on the same soil in the same climate.
- For compliance purposes we admit that the algorithm is reversible; [10]it can therefore prioritize plants, soils or climates in turn.
- Each plant is characterized by a $c$strict, transitive , and complete [11]preference relation p_c that describes its ability to thrive in any given climate and soil type. Therefore, $b_4 p_c b_2 p_c c$(respectively $a_3 p_c a_2 p_c c$) means that $c$it prefers to be planted (sown) in [unspecified] $b_4$rather than in [unspecified b_2], planted (sown) in [unspecified] $b_2$rather than in any soil (respectively that $c$it prefers to be planted (sown) in [unspecified] $a_3$rather than in [unspecified a_2], planted (sown) in a_2[unspecified] rather than in an unstable climate). We can write $p_c = b_4 b_2 c$(respectively $p_c = a_3 a_2 c$).
- (respectively) transitive p_a preference relation p_b and a complete relation which describes the possibility for it to remain without a plant to grow.
- A soil (or climate) is considered if it is favorable to the development of at least one type of plant.
- Any definitive culture, created based on individual preference orders, increases the production of AB [12].

Consider βa possible configuration of the associations between at least one plant, a soil, and a climate of the population $PL \cup SO \cup CL$under consideration. βThis is an endomorphism which... $\beta: PL \cup SO \cup CL \ \rightarrow PL \cup SO \cup CL$
$c \rightarrow \beta(c)$.

For any two sets taken, this configuration satisfies the following conditions:

1) $\forall c \in PL, \beta(c) \in SO \cup \{c_k\}And\forall c \in PL, \beta(c) \in CL \cup \{c_k\}$
2) $\forall a \in CL, \beta(a) \in PLAnd\forall b \in CL, \beta(b) \in PL$
3) $\forall c \in PL, \beta\big(\beta(c)\big) = c$

The first condition guarantees that each plant has a region suitable or unsuitable for its cultivation . The second guarantees that each soil or climate is suitable for at least one crop [13]. The third condition ensures the consistency of the established pairings. This means that only a plant whose soil and climate are simultaneously favorable to it can be cultivated.

2.3. Algorithm:

The algorithm here favors plants. The deferred acceptance algorithm will be used as follows:

Step 1 , 2, ..., n: Each plant $c$requests to be planted in an area with its preferred soil $b$and climate a, according to the preference relation p_c. If $c$it is refused planting at a step, it will reapply for another soil and/or climate according to its order of preference, and so on until it finds a match. If, at step n, it is not simultaneously preferred by a soil and climate, then $c$it will not be planted. Therefore, it is not cultivated, and the game ends for it.

Each soil or climate selects its preferred plants from among all available options. This reduces the stress that can be observed with the presence of an additional plant whose soil and climate are not simultaneously favorable.

Illustration

In this somewhat simplified simulation, we have a total population of 16 individuals whose set representations are such that $|PL| = 6$(the number of plants selected by the planner), $|CL| = 5$(the number of climates), and $|SO| = 5$(the number of soils). The preferences (the favorable nature) between the elements constitute complete antisymmetric preorders (linear orders). For each type of crop, there is a maximum acceptable temperature level. Above this maximum level, the plant does not survive. Let us assume that with a constantly increasing temperature level, only plants whose climate has been most favorable under normal conditions would be able to develop strong resistance and continue to grow. This example is similar to the situation of university admissions, but in addition to taking into account the volume (in terms of the diversity of cultivable

[10] Indeed, this work does not consider the fact that climates and soils are generally specific to a geographical area. The same type of soil can therefore be found in two different climates at the same time.

[11]That is to say, if a soil $b_1 > b_2$and$b_2 > b_3 \Rightarrow b_1 > b_3$(respectively $a_1 > a_2$and $a_2 > a_3 \Rightarrow a_1 > a_3$)

[12]A preference order is established based on the principle of an individual's rationality. Matches are therefore established under the assumption of player rationality. Thus, a farmer is considered rational if a marriage they arrange helps minimize transaction costs.

[13]We are excluding here the critical case, that is, the possibility of soil becoming arid and the possibility of climate becoming unfavorable to all crops.

plants) of each agroecological zone, it also considers the degree of temperature necessary for plant survival. As in the work of Kojima and Pathak (2009), the population size plays an important role.

P_{c_1}	P_{c_2}	P_{c_3}	P_{c_4}	P_{c_5}	P_{c_6}	P_{a_1}	P_{a_2}	P_{a_3}	P_{a_4}	P_{a_5}	P_{b_1}	P_{b_2}	P_{b_3}	P_{b_4}	P_{b_5}
a_1	a_3	a_5	a_5	c_5	a_4	c_1	c_1	c_2	c_6	c_4	c_6	c_1	c_2	c_4	c_1
a_2	a_4	a_4	a_4	a_4	a_3	c_2	c_6	c_6	c_2	c_5	c_3	c_2	c_6	c_5	c_6
a_3	a_1	a_3	c_4	c_5	a_1	c_6	c_2	c_3	c_3	c_3	c_5	c_6	c_3	c_3	c_2
c_1	a_2	c_3	a_3	a_2	a_2	c_4	c_5	c_1	c_5	c_1	c_4	c_4	c_1	c_2	c_5
a_4	c_2	a_2	a_1	a_3	a_6	c_5	c_3	c_4	c_4	c_6	c_1	c_3	c_5	c_6	c_4
a_5	a_5	a_1	a_2	a_1	a_5	c_3	c_4	c_5	c_1	c_2	c_2	c_5	c_4	c_1	c_3
b_2	b_3	b_4	b_4	b_4	b_1										
b_2	b_1	b_1	b_1	b_1	b_3										
b_3	b_2	b_3	c_4	c_5	b_2										
c_1	b_5	c_3	b_3	b_5	b_5										
b_1	c_2	b_5	b_2	b_3	c_6										
b_4	b_4	b_2	b_5	b_2	b_4										

Source: Authors

The algorithm works as follows:

Step 1: $c_1$makes a proposal to a_1, $c_2$makes a proposal to a_3, $\{c_3, c_4, c_5\}$each makes a proposal to , $a_5$and $c_6$makes a proposal to a_4. c_1, $c_2$and $c_6$are temporarily linked respectively to a_1, $a_3$and $a_4$because they are the only ones to have made them a proposal. $a_5$being more favorable to c_4, it will be temporarily linked to the latter. $c_3$and $c_5$are rejected.

Step 2: c_3Having $c_5$been rejected in the first step, they make a proposal to their second choice a_1. These are rejected. If the $a_1$first option is more favorable to the $c_6$second, it remains temporarily linked to the second option.

Step 3: c_3Rejected in stage 2, she makes a proposal to her third choice $a_3$who rejects her and remains temporarily bound to her c_2. As for $c_5$the one who prefers herself, the game ends for her.

Step 4: c_3She prefers herself, the game ends for her.

Step 5: $c_1$makes a proposal to b_2, $c_2$makes a proposal to b_3, $\{c_3, c_4, c_5\}$each makes a proposal to , $b_4$and $c_6$makes a proposal to b_1. c_1, $c_2$and $c_6$are temporarily linked respectively to b_2, $b_3$and $b_1$because they are the only ones to have made them a proposal. $b_4$being more favorable to c_4, it will be temporarily linked to the latter. $c_3$and $c_5$are rejected.

Step 6: c_3Having $c_5$been rejected in the fifth step, they make a proposal to their second choice b_1. These are rejected. $b_1$is more favorable to c_6, it remains temporarily linked to the latter.

Step 7: c_3Rejected in step 6, makes a proposal to her third choice $b_3$who rejects her and remains temporarily bound to [the other character c_2]. As for [$c_5$the other character], who prefers herself, the game ends for her.

Step 8: c_3She prefers herself, the game ends for her.

3. RESULTS

When the privilege is given to plants, the results obtained are $\beta, \beta'$and β''. The matching, $\beta^{\star}$on the other hand, is obtained after the introduction of the additional conditions presented by Mbomeyo (2024a); Schouame and Mbomeyo (2023).

a. The pairings $\boldsymbol{\beta}, \boldsymbol{\beta}'and\boldsymbol{\beta}''$

$$\beta = \{(c_1, a_1)(c_2, a_3)(c_4, a_5)(c_6, a_4), c_3, c_5\}$$
$$\beta' = \{(c_1, b_2)(c_2, b_3), (c_4, b_4)(c_6, b_1), c_3, c_5\}$$
$$\beta'' = \{(c_1, a_1 b_2)(c_2, a_3 b_3), (c_4, a_5 b_4)(c_6, a_4 b_1), c_3, c_5\}$$

The hypothesis is validated. However, these pairings show that the plants $c_3$will $c_5$no longer have cultivated areas once the mechanism is discontinued. The country would thus lose cultural diversity at the end of the mechanism. No longer cultivating Bambara groundnut or millet-sorghum could exacerbate the artificial instability, especially in regions with high consumption of these foods. This situation is not favorable for the country. The loss of agricultural crop variety will inevitably have a negative impact on the value of macroeconomic indicators.

- The pairings $\beta, \beta'$are β''not stable because they do not satisfy condition 4 which would require that each plant left without a cultivation area has effectively been rejected by all climates and all soils due to their incompatibility.
- $\beta, \beta'$and $\beta''$are not optimal for the plants to be cultivated.

b. The matching$\boldsymbol{\beta}^{\star}$

$$\beta^{\star} = \{(c_1, a_1 b_2)(c_2, a_3 b_3), (c_4 c_5, a_5 b_4)(c_6 c_3, a_4 b_1)\}$$

The matching $\beta^{\star}$is that obtained by assuming that $c_3$and $c_5$which are without culture area in the matchings β''have the possibility in a later step after step 8 (before stopping the mechanism), to make their proposals again and successively respectively to $\{a_5, a_4, b_4, b_1\}$and to $\{a_5, b_4\}$.

This result partially validates the hypothesis. Cocoa, cotton, millet-sorghum, potatoes, and coffee all remained linked to their most favorable agroecological zone. Only bambara groundnut (Vanosa spp.) is linked to the high savannah zone, which is less suitable for it compared to the Sudanian-Sahelian zone. Nevertheless, its production level in this zone is not low but average. With better soil management in this zone, its production level could meet demand. $\beta^{\star}$Therefore, this represents a stable and optimal pairing for all populations simultaneously.

- Despite its stability and optimal nature across all sets, $\beta^{\star}$it remains, however, manipulable.

Specifically, the matching $\beta^{\star}$indicates that during periods of extreme heat, in order to maintain the likelihood of good crop yields, cocoa production could be primarily concentrated in the monomodal forest zone. Coffee production could be concentrated in the highlands, cotton production in the Sudanian-Sahelian zone, and Bambara groundnut and potato production could be primarily intensified in the high savannas.

With agriculture exacerbated by the negative impact of climate change on farming practices, and with agricultural projections that do not favor the population due to the shift in agro-ecological zones and considerable damage to the infrastructure sector, it has become necessary for the Cameroonian government to strengthen its national development strategy for 2030. This inevitably requires a reassessment of its agricultural resource management policy. Extrapolating from specific results suggests that staple crops such as maize and peanuts could primarily be consolidated in the South, West, or North, depending on the predominant variety. Cassava cultivation could be concentrated in forest areas, while sorghum cultivation could be concentrated in the Sudanian-Sahelian zone.

The model of matching agricultural crops to the most favorable agro-ecological zones could contribute, to some extent, to: reducing losses related to the use of raw materials, reducing the risk of massive crop losses, maintaining production volumes at a considerable level, and making intelligent use of soils and climates. However, this model could be disadvantageous to smallholder farmers who often lack sufficient material resources and whose access to financing is frequently difficult. Furthermore, it requires a better understanding of local meteorology, which is not a given, as the sector remains relatively unknown to the public and the level of investment is still low. Finally, it would be necessary to have some expertise in the acquisition and efficient use of clean energy sources, which does not appear to be the case in the country.

CONCLUSION

Our task in this work was to propose a practical model of organic agriculture that could strengthen the volume and quality of organic production of certain crops and effectively combat food insecurity in Cameroon. Due to the difficulty we encountered in accessing data, we used a simulation based on a tool from cooperative game theory: The Gale and Shapley matching algorithm (1962), which is well-suited for addressing problems of forming stable associations. The results obtained showed that, in the event of a widespread heatwave, matching agricultural crops to the regions most favorable to their development constitutes a lever for strengthening the mobilization and exploitation of agricultural resources and thus combating heatwaves. However, to achieve better efficiency in the crop and region matching process, it is necessary to facilitate access to funding for projects by biological and technological developers in agriculture and local meteorology, with an emphasis on the optimal use of renewable energy sources. Furthermore, in each region, by developing appropriate industrial zones and prioritizing the use of clean energy sources, public and private investments should be allocated and encouraged in the creation of sustainable processing infrastructure for the main harvested products. This will also have a positive effect on farmers' ability to control prices.

REFERENCES

1) AFG (2021). Guide on developing a fossil fuel strategy for portfolio management companies: excluding coal and including unconventional fossil fuels, Professional Guide, October,
2) Ali, D., Bowen, D., Deininger, K and Duponchel, M. (2016). Investigating the gender gap in agricultural productivity: Evidence from Uganda. World Development, n°87, p. 152-170.
3) Awoutcha Tchieuzing, R. F. and Fotsing Waffo, FU (2023). Analysis of the determinants of agricultural production in Cameroon. Douala. https://nbn-resolving.org/urn:nbn:de:0168-ssoar-87181-6
4) Bertrand, WB., David, A., Jacques, HD and Guiwa, M. G (2021). "Evaluation of the effects of mycorrhizal doses on the growth and production parameters of three varieties of Voandzou in the locality of Dschang, West Cameroon", *European Scientific Journal* , Vol 17, n°17, 213.
5) Brisson, N and Levrault, F (2010). The CLIMATOR project green book.
6) BMZ and GIZ (2022). Climate risk profile: Cameroon, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and KfW Development Bank, July.
7) Cartier, M and Forgues, B. (2006). "Interest of simulation for management sciences", *Revue Française de Gestion* , Vol 6, n°165, p. 125-137.
8) Bayiha, G. (2020). Development of organic agriculture in Cameroon: an analysis using the socio-technical transitions approach, Doctoral Thesis, Quantitative Economics and Finance, Montpellier SUPAGRO, University of Yaoundé II FSEG.
9) Bayiha, G., Temple, L., Mathe, S. and Nesme, T. (2019). "Typology and outlook for the development of organic agriculture in Cameroon", *EDP Science* , Vol. 28, No. 3, pp. 1-8
10) Djacbou, S and Feukeng, L (2023). Food insecurity in Cameroon: Greenpeace calls on the government to focus on the fight against climate change, Related Posts, Press Releases, May.
11) FAO (2021). Country Profile-Cameroon, FAO-AQUASTAT Annual Report, Subregional Office for Subregional Office for Central Africa.
12) FAO (2020). The State of Food Security and Nutrition in the World 2020. Annual Report.
13) FAO, ECA and AUC. (2021). Africa—Regional Overview of the State of Food Security and Nutrition 2021—Statistics and Trends. Accra, FAO. https://doi.org/10.4060/cb7496fr
14) FAO and MINADER (2019). Climate change and climate-smart agriculture (CSA) in Côte d'Ivoire.
15) FAO and EU (2018). Strengthening sector policies to improve food security and nutrition: climate change, Policy Brief, No. 5, pp. 1-44.
16) FAO (2013). Climate change and food security, Climate-smart agriculture, Learner's file, lesson 4.
17) Gale, D and Shapley, L.S (1962). College Admissions and the Stability of Marriage, *The American Mathematical Monthly* , Vol 69, No. 1, p. 9-15.
18) GCHA (2017). From office to grave: the health burden of fossil fuels and the imperative of a just transition, 2nd Edition .

19) Guibert, H., Kenne Kueteyim, P., Olina Bassala, JP and M'Biandoun, M (2016). "Intensifying maize cultivation to improve food security: is it in the interest of the producer in Northern Cameroon?", *EDP Science* , no. 25, p. 1-11.
20) Kressmann, G (2021). « L'agriculture biologique, levier caché de la décroissance ? », Paysans et Société (SOCIETE), n°385, p. 1-6
21) Kojima, F and Pathak, P.A (2009). " Incentives and stability in large two-sided matching markets ", *American Economic Review* , Vol 99, n°3, p. 608-627
22) IFRC (2026). La « crise silencieuse de l'insécurité alimentaire » au Cameroun s'aggrave alors que des millions de personnes peinent à trouver de quoi se nourrir. Communiqué de presse, Mars.
23) INS (2025). *National accounts in 2024* , Department of Economic Synthesis, Annual Publication, August.
24) Lave, C. A and March, J. G (1993). "An introduction to models in social sciences", 1st publication : 1975 *University Press of America* , Lanham , MD
25) Leszczynski, S (2026). En dix ans, la faim dans le monde a doublé. Vatican News
26) Madou, C., Watching Djakissam., Vatsou, J., Ardjoune, F., Ndjouenkeu, R., Goudoum, A., Ngassoum, M. B and Ngamo Tinkeu, S. L (2018). "Farmers' practices for the sustainable production of Bambara groundnut (Vigna Subterranea (L.) Verde) seeds for food security in northern Cameroon ", *European Scientific Journal* , Vol 14, No. 18, ISSN: 1857-7881 (Print) e-ISSN 1857-7431.
27) Maïmouna, A., Saidou, M., Nwaga, D and Megueni, C (2021). "Soil developed on granite rock inoculated with mycorrhizal fungi: suitable substrate for juvenile growth of Balanites aegyptiaca (Linn.) under Sudanian-Guinean climate of Adamawa-Cameroon", *Journal of Experimental and Applied Tropical Biology* , Vol 1, n°2, p. 1-12.
28) Mbomeyo, A. (2024a) Risk modeling by insurance companies and businesses: an analysis by additive decomposition, European University Editions.
29) MINADER (2023). Harmonised Framework Analysis of risk areas and identification of populations in food and nutritional insecurity (CH) in Cameroon, Yaoundé.
30) MINEPAT (2020). National Development Strategy 2020-2030, Cameroon, MINEPAT , 231 pages
31) MINSANTE (2019). National strategic plan for digital health 2020-2024, Yaoundé.
32) Ouoba, A., Nadembega, S., Konaté, MN, Nandkangré, H., Ouédraogo, M and Sawadogo, M (2018). "Variability of the co-collaboration of the seed coat of Voandzou grains cultivated in Burkina Faso and the associated local names", Vol 14, n°33, ISSN: 1857-7881 (Print) e-ISSN 1857-7431.
33) Schouame, E. SF and Mbomeyo, A. L (2023). Strengthening the group insurance subscription process: a GS algorithm approach, *French Journal of Economics and Management* , Vol. 4, No. 12, pp. 1-12
34) Temple, L., Malézieux, E., Gautier, D., Aubry, C., Pourias, J., Puente Asuero, R and De Bon, H (2024). « Innovation agroécologiques, sécurité alimentaire et nutritionnelle pour les petits agriculteurs : une mise en perspective Afrique-Europe », Quae (ed), Hal Id : hal-05181588. https://hal.science/hhhal-05181588v1.
35) Temple, L., De la Paix Bayiha, G., Nesme, T and Mathe, S (2022). "Technological and institutional breakthroughs of organic agriculture in food security in Cameroon", *African Journal of Environment and Agriculture* , Vol 5, n°2 , p. 41-50.
36) Temple, L, and De Bon, H (2020). "Organic agriculture: controversies and global development challenges in Africa", Cah . Agric , Vol. 29, No. 3, pp. 1-7
37) The Essentials (2025). *Fossil fuels* , Public Life, No. 13, April.
38) Touzard, J-M and Fournier, S (2014). « La complexité des systèmes alimentaires : un atout pour la sécurité alimentaire ? », *VertigO*, Vol 14, n°1, p. 1-16
39) Wang-Bara, B., Kaouvon, P., Djida Housseini,J., Alioum Sounou, P and Danra Djackba, D (2021). « Effects of fertilization based on Chicken manuresand Mycorrhiza on vegetative parameters and phenological Stages of Sorghum bicolor in Yagoua, Far-North Cameroon », *International Journal of Plant & Soil Science*, Vol 33, n°24, p. 375-383

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