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SHEEP BREEDS IN NORTH AFRICAN STEPPES: CASE STUDY OF THE BORDER REGION OF NAAMA (WESTERN ALGERIA)[1]

Ahmed Toufik Youcefi[2], Abderrazak Marouf[3]

Abstract

Localized in the west of Algeria, the region of Naama is the best known for its pastoral areas forged by the specific climate and available soil conditions that have characterized the region from time immemorial. Sheep breeding is the main activity on which the local economy is based. The main goal of this paper is to study the distribution of sheep breeds in herds of the border area of Naama. Used methodological framework for performed study is based on a field survey of 133 breeders from the municipalities of Kasdir, Ain Ben Khelil, and Sfissifa. The results show that the Ouled-Djellal breed dominates the sheep population in the study area, while it represents more than 90%. It is followed by the Daraa breed with a rate of 3.77% in overall structure, while the two breeds Hamra and Srandi represent 2.54% and 2.44% respectively. The rate of the last breed Rembi is 0.52%. Study also reveals some correlations (positive or negative) between sheep breeds and other ruminant species (mainly cattle and goat), as well as with the lifestyles practiced by farmers, or age of breeders.

Key words: Hamra, Sardi, sheep breeds, western Algeria, north African steppes.

JEL[4]: Q1, Q2, R1

Introduction

The breeding of small ruminants is part of the most significant agricultural activities in the world (Ghassan, 2006). Its most indisputable role is to contribute the satisfaction

1 The authors are thankful to the Naama Forest Administration and its staff who helped them in carrying out the field surveys.

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of protein needs of human population. It contributes to food security by transforming spontaneous plants, agricultural and other residues into protein foods with a high nutrient content. Livestock farming contributes the fight against poverty among a large number of rural families by creating employment in the agricultural sector (FAO, 2016; FAO, 2018). It also contributes to the production of manure usable for soil improvement (Otte et al., 2012). North Africa is characterized by large territories of steppe land dominated by sheep farming, where the steppe was named "the world of sheep", while the traditional valuation of the steppes was based on pastoralism (Bourbouze, 2000; Dutilly Diane, 2007). Livestock is the driving force behind the development of the agricultural sector, reflecting the social, economic and environmental changes linked to food systems around the world. It is usually a starting point for understanding issues related to sustainable agricultural development (HPLE, 2016; Youcefi, 2024).

Limited between the average annual isohyets of 100 mm and 400 mm, the steppes of northern Africa designate vast area that exceed 60 million hectares, while characterized by low and dispersed vegetation (Le Houerou, 1995). These steppes are expanding to the Maghrebians countries: Morocco, Algeria, and Tunisia, then shrink as a coastal strip in Libya and Egypt (Aidoud et al., 2006). Spread on over 20 million hectares, the Algerian steppes (located between the Moroccan and Tunisian borders) represent a territory with pastoral vocation typically dedicated to livestock (Youcefi, Marouf, 2023). In Algeria, livestock production accounts for a significant part (50%) of overall gross domestic agricultural output, with more than 21 million sheep, nearly 4 million goats, and about 1.7 million cattle (ONS, 2009).

The sheep species is distributed throughout northern Algeria, with a remarkable concentration in the steppe regions and high plains that gathers about 80% of the total national population (Bekhouche Guendouz, 2011). Localized in the west of Algeria, the steppe rangelands in the Naama region have suffered continuous degradation in recent years, reducing biological potential by causing a disturbance of the ecological and socio-economic order (Youcefi et al., 2024). These disturbances also affected the diversity of sheep breeds, and their distribution, which causes a risk to crossing of some breeds by others, and losing some genetic traits that distinguish Algerian sheep breeds (Djaout et al., 2017). According to this, research tries to contribute in describing the numbers of sheep breeds and their status in a pastoral region known for its large livestock. More precisely, it is chosen the border zone of the Naama region localized in the extreme west of Algeria. Paper intends also to interpret any possible relationships between the sheep breeds and breeders in observed area, or performed techniques of breeding.

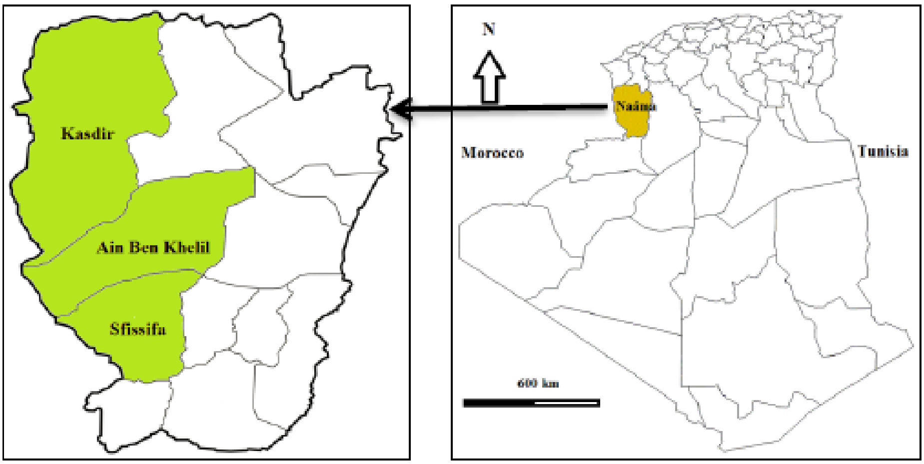
Materials and Methods

Field survey has been chosen as a method of work, while it is based on semi-directive single-pass interviews (Dockes, Kling Eveillard, 2007). Sample consists of 133 respondents, while defined population could be considered representative, since it covers the whole study area (municipalities of Kasdir, Ain Ben Khelil, and Sfissifa), while it assumes breeders randomly encountered in the observed area. Comparing the size of selected sample with overall size of population studied reveals an error margin of 7%. The survey has been lasted around seven months (from May to November 2021), while it represents a part of larger research towards agro-pastoralism that is carried out in the Naâma region. The information sought are herd size, species composition of ruminants, structure in ovine breeds, rates of sheep categories in possession, the lifestyle of farmers, and age of breeder. The calculations and statistical processing were carried out using the free software R (version 4.2.1), (R Core Team, 2022). Research was based on the structure and classification of herds by breed, as well as existing correlations between the breeds, breeders and breeding techniques.

Study area

The territory of Wilaya of Naama is located in the Algerian western steppes, (Figure 1.) covering a huge area of 29,819.30 km^2 (DPMD, 2021), while the steppe involves 74% of the overall area. Sheep rearing represents the main activity on which the local economy is based. Region is recognized for its agro-pastoral vocation (Youcefi, Marouf, 2024a).

Figure 1. Location of the study area



Source: Maps.com, 2024; Gifex.com, 2024.

The study area is composed of three border municipalities (Kasdir, Ain Ben Khelil, and Sfissifa) located at the extreme west of the region of Naama, more precisely on the Algerian-Moroccan border (Figure 1.). The data, describing the study area and number of sheep grown there are presented in detail in Table 1.

Table 1. Data from the study area

Municipalities	Surface area (in km^2)	Number of sheep
Kasdir	6,386.46	268,103
Ain Ben Khelil	3,800.03	254,227
Sfissifa	2,438.61	145,527
Total	**12,625.10**	**667,857**

Source: DPMD, 2021.

The total number of sheep in Algeria is estimated at 26 million in 2018. (Sahraoui et al., 2023), while the sheep population in the Naama region is represented by more than 1.6 million heads in 2021. (DPMD, 2021), while more than 40% are grown in the border area (municipalities of Kasdir, Ain Ben Khelil, and Sfissifa).

The climate in Naama region is semi-arid, characterized by dry summer season. The rainfall regime involves a long period of drought which extends from April to October (Guerine et al., 2020). The Algerian steppes are distinguished by their Mediterranean climate, marked by a dry and hot summer period, followed by a wet, cool or cold winter period (Nedjraoui, 2004; Nedjimi, Guit, 2012). Rainfalls in mentioned area are described as low, ranging from 100 to 450 mm annually, while average precipitation amounts 271 mm, while its irregular with usually significant spatial and temporal changes. The lowest average temperature in the coldest month is -0.5°C, while the highest average temperature in the warmest month is about 34.5°C. Meanwhile, pluviothermal coefficient ranges from 24.5 to 27.7 (Benabdeli, 2000).

The main sheep breeds in Algeria

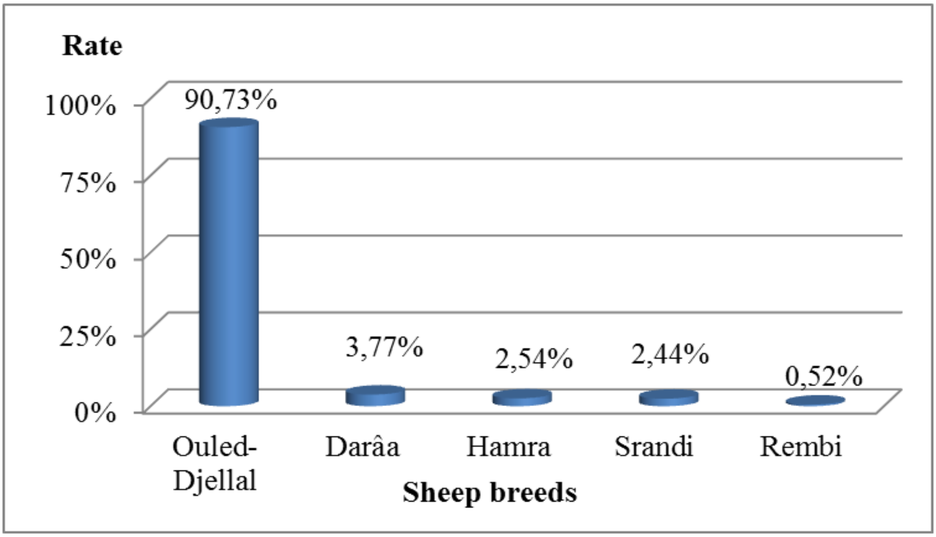
According to several studies on the richness of Algerian sheep breeds (Gaouar, 2009; Djaout et al., 2017; Belharfi et al., 2017; Ameur et al., 2018), as the main breeds are underlined Ouled-Djellal, Hamra, Rembi, Barbarine, Berbere, Taadmit, D'man, Sidaou, Daraa, Srandi, Ifilen, and Tazegzawt. Mentioned sheep breeds have been raised since ancient time in Algeria, mainly towards their characteristics compatible with arid and desert areas, or resistance to diseases, and achieving good production results.

Results and Discussions

Structure of sheep breeds

In order to study the rates of the breeds composing the livestock within the study area, there are drawn the histograms according to cumulative numbers of breeds held by surveyed breeders (Figure 2.). Thera re shown that Ouled-Djellal breed dominates in sheep population in the study area, as it represents more than 90% of overall population. As a second was ranked the breed Daraa with a rate of 3.77%, while it is followed by breeds Hamra and Srandi with more or less similar share, 2.54 and 2.44 respectively. The lowes share has breed Rembi, only 0.52%. In research the margin of error is set at around 7%.

Figure 2. Rate of sheep breeds in the study area



Source: according to Youcefi, Marouf, 2024b.

The study of the distribution of sheep breeds reveals that Ouled-Djellal has a high elasticity in the study area, as its morphological characteristics and its adaptation to the severe climate conditions are the main factors that encourage breeders to choose this breed. It is also well-known like the white breed Arab or Arbia. It is mostly bred in arid to semi-arid territories, while clearly preferred by breeders, thanks to its good reproduction quality and resilience to harsh production circumstances. Mentioned, primarily zootechnical characteristics contribute to the rapid increase in the number and size of herds, as well as in achievement of good results in meat production (Taherti et al., 2023).

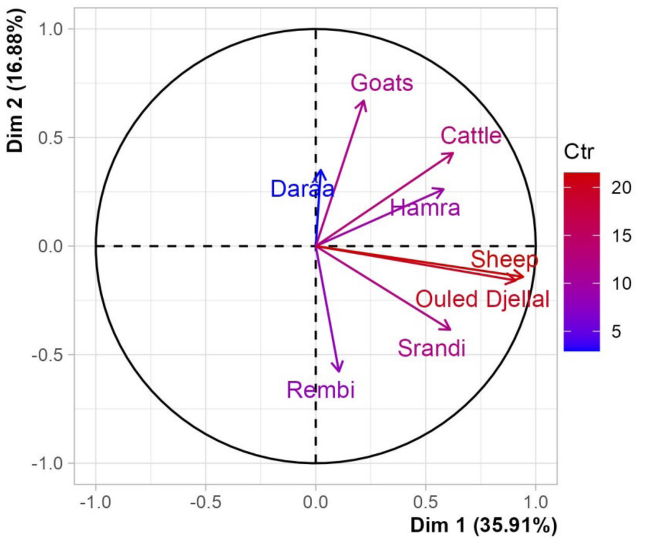
Principal component analysis

Principal Component Analysis (PCA) is the usually performed method of multivariate data analysis. It allows the study of a multidimensional data set with quantitative variables. Method is used in biostatistics and many other fields (Greenacre et al., 2022). In this part of research, there are opted for data analysis in main components by reducing 8 variables (5 breeds, as are Ouled-Djellal, Daraa, Srandi, Rembi, and Hamra, and 3 species, as are Sheep, Cattle, and Goats) in only two axes. The objective of this analysis is to interpret trends in breed numbers as a function of the numbers of species that form the herds.

The first two analysis dimensions represent 52.79% of the total inertia of the dataset (35.91 + 16.88), meaning that the plan explains 52.79% of the variability (Figure 3.). This share is relatively high, while the first plan well represents the data variability. The contribution of the variables is represented by colors. Red describes variable that contributes strongly to the analysis, and blue factor that contributes weakly. According to quality of their contributions, variables Ouled-Djellal and Sheep actively contribute to made study research. They are followed by the variables Cattle and Goats. At the end, variable Daraa has the lowest contribution. So, the variables Sheep and Ouled-Djellal have a perfect correlation, $0.98 \approx 1$, what seems logical because the Ouled-Djellal breed is the main component of the herds in the study area. According to the angles plotted by the vectors of the variables (Figure 3.), the correlation between the breed Daraa and the goats seems important, same remark could be for the correlation between the breed Hamra and cattle.

Analyzing the correlations between the sheep breeds grown in study area and other species that constitute the herds (goat and cattle, while all categories are combined) show existence of two more or less dominant associations. Small ruminant - Small ruminant association is composed of the Daraa breed and the goats, while the Small ruminant - Large ruminant is formed from the Hamra breed and cattle. The breed of Hamra is characterized by its small size, well recognized by high organoleptic qualities of meat, while it is distinguished from other breeds by color of its head and legs from dark-chestnut to red, or by its white wool with guard hair going from brown to russet-red (Gaouar et al., 2015). In addition to its small population, the Rembi breed has negative correlations with the other two species (goats and cattle), reflecting the poor adaptation of this breed to the general conditions occurred in livestock production in observed area. The Srandi (or Sardi) breed exists in Algeria with little herds, particularly in the Algerian - Moroccan borders' area. These measurements are close to Ouled-Djellal (size, color, and tail). Breed has white head without wool with black spots around the eyes, snout of ends of ears, paws and at the knees and hocks.

Figure 3. Graph of tested variables (sheep breeds/other species)



Source: according to Youcefi, Marouf, 2024b.

Correlation sheep breeds – age of breeders

After using statistical software R, in Table 2. are shown the different correlations between grown sheep breeds and age of breeders. Although these correlations are not really important, they give insight into the age trend of breeders related to grown sheep breeds. The Table 2. reveals the existence of three relatively distinct correlations. Moderately important correlation is varying from 0.33 and 0.29 respectively for the sheep breeds Ouled-Djellal, Daraa, and Srandi. Low correlation exists for Rembi breed, 0.12, while almost zero correlation occurs for the Hamra breed.

Table 2. Correlation between sheep breeds and age of breeders

Sheep breeds	Age correlation
Ouled-Djellal	0.33
Daraa	0.31
Srandi	0.29
Rembi	0.12
Hamra	0.05

Source: according to Youcefi, Marouf, 2024b.

The correlation between the ownership of sheep breeds and the age of breeders shows that for older breeders first opt is the Ouled-Djellal breed, then Daraa, and Srandi. Concerning the two remaining breeds, Rembi and Hamra, their detentions have no relation with the age trend of the breeders. Breeds Ouled-Djellal, then Daraa, and

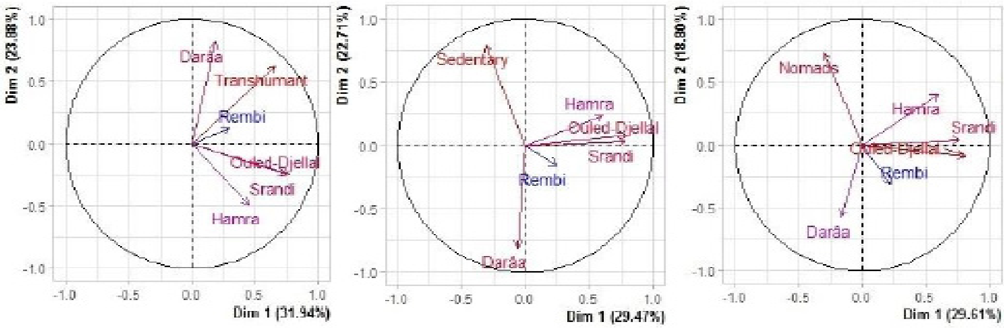
Srandi have large size and good weight growth compared to other observed breeds, meaning a production of significant amount of meat, or that older breeders are more experienced in obtaining the final product (meat).

Correlation sheep breeds - lifestyle

In order to perceive the relationships that could exist between sheep breeds and envisaged lifestyles, there have been also made correlation circles based on survey data (Figure 4.). In figure are shown that the best representation of the variables is at transhumant, with a rate of 55.82%. It is followed by the sedentary, with 52.18%, and at the end by the nomads, with only 48.41%. It could be noted that the variable Rembi represents the least contributing factor for three circles drawn.

The Hamra breed has no correlation with all lifestyles practiced in the study area (transhumance, sedentary, and nomadism). The breeds Rembi and Daraa have a strong negative correlation with the modes sedentary and nomadic, and a significantly positive correlation with transhumance. Ouled-Djellel breed correlates positively with transhumance, as the breeders belonging to this mode have the largest number of sheep herds.

Figure 4. Circles of correlation (sheep breeds - lifestyles)



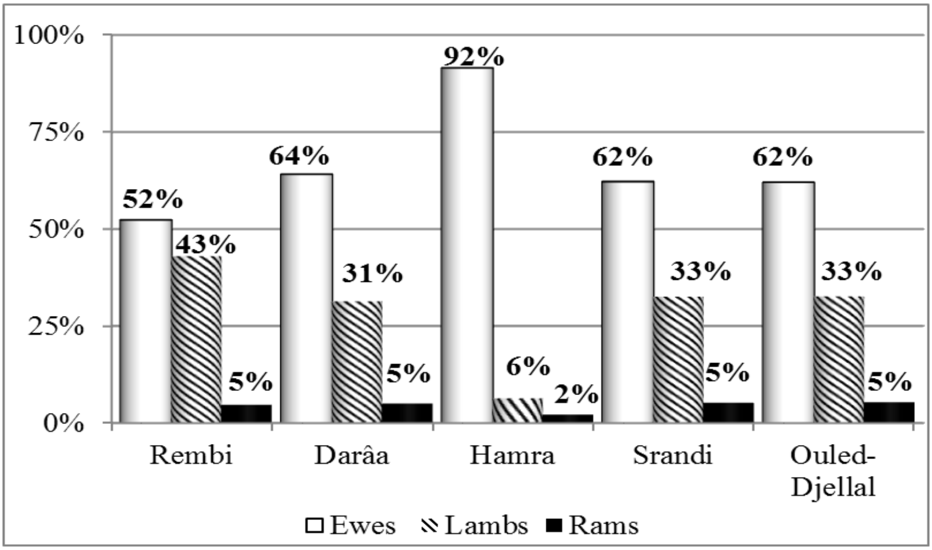
Source: according to Youcefi, Marouf, 2024b.

Possession of the Hamra breed in observed area is not based on technical parameters. Its presence does not meet any criteria, while is distributed randomly. Unlike, breeds Rembi and Daraa are much more present in transhumant, what can be justified by the favorable conditions offered by mentioned mode, especially the seasonal displacement to suitable areas in difficult conditions. Rembi breed is mostly grown in central territories between east of Algeria where Ouled-Djellal breed is grown and west of Algeria known for Hamra breed. Concerning the Daraa breed, it spreads all over the Algerian territory, but in little number of animals. Its head and limbs are totally black (there originate the name Daraa), covered by closed or semi-closed brown wool. The breed has medium long or long tail, while there are no horns at females, or they may exist at males (Mohammedi, 2023).

Herd structure by breed

As a part of performed research, suitable histogram is made, representing the different categories of sheep (ewes, lambs, and rams) that constitutes the structure of herds by certain breed (Figure 5.). For three breeds, Ouled-Djellal, Daraa, and Srandi, it is noticed certain similarity in distribution of categories. The rate of ewes varies between 62-64%, lambs 31-33%, while the rate of rams is up to 5% for all three breeds. For Rembi breed, the rams' share respects 5%, while the rate for lambs seems to be more important, 43%, or for ewes it relatively decreases to 52%. Hamra breed scores purely outliers compared to other breeds, for ewes is 92%, for lambs is 6%, while for rams is only 2%. Shown results may occurred due to fertility issues of this breed.

Figure 5. Structure of the herd (sheep breeds / categories)



Source: according to Youcefi, Marouf, 2024b.

The share by category imposes level of fertility of certain breeds and further sustainability of breeding. Hamra breed, typical for the region, seems less productive compared to other breeds (due to minimal share of rams of 2%), or due to low fertility of the females, as it may result from breeding practices knowing that the crossing between Hamra females and Ouled-Djellal gives birth to individuals with phenotypes close to those of the Daraa breed, which probably justifies the high rate of lambs of the Daraa breed.

Conclusion

The region of Naama represents an important part of Algerian territory used for the breeding of ruminants, particularly sheep. Derived study results showed that in border area of Naama there are generally five main sheep breeds grown, with dominance of the Ouled-Djellal breed, followed by Daraa, Hamra, Srandi, and Rembi breeds. Research shows existence of two more or less dominant associations (production systems) linked to animal growing, i.e. Small ruminant - Small ruminant association composed from Daraa breed and goats, and Small ruminant - Large ruminant, association formed from the Hamra breed and cattle. Observing the structure of sheep herds and lifestyle of producers, breeds Rembi and Daraa have a strong negative correlation with the modes sedentary and nomadic, while significantly positive correlation with transhumance. Ouled-Djellel breed correlates positively with transhumance, as breeders belonging to this mode of livestock production have the largest number of sheep herds. The share of heads of sheep by category within the singe herd impose questions on fertility of certain breeds and the performing of breeding activity. Hamra breed, typical for the region seems to be less productive compared to other sheep breeds. According to mentioned issue, it is necessary to try to repopulate the endemic species of the region (Hamra breed) by encouraging its breeding and improving its fertility either by organizing campaigns devoted to artificial insemination, or by distributing healthy rams to ensure successful fertilization.

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ASSESSMENT OF CALORIE INTAKE AND MICRONUTRIENT CONSUMPTION IN RURAL NORTH-CENTRAL NIGERIA

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Abstract

Due to rising food insecurity and prices, rural households in Nigeria are increasingly resorting to adverse coping mechanisms, such as replacing nutritious diets with larger quantities of less-nutritious and energy-dense foods. Therefore, this study investigated the relationship between calorie status and micronutrient foods intake of rural households in North-Central Nigeria. By employing a three-stage random sampling procedure, a total of 494 households were selected via a well-structured questionnaire. The finding showed that 42.7% of the households were calorie sufficient, while 57.3% of them were calorie deficient. Furthermore, households with sufficient calorie intake had a higher average micronutrient food intake score (52.12), compared to those with calorie deficiencies (38.38). The logistic regression analysis revealed that an increase in total vegetable intake, total protein intake, and dairy products intake signals a higher likelihood of household being calorie sufficient while increase in seafood and plant protein intake is linked to lower odds of the household being calorie sufficient ($p < 0.05$). The findings suggest that micronutrient food intake should be a central component of household food security policy in rural areas. Consequently, food security initiatives in these regions must include programs that are focused on dietary adequacy to promote productive and healthy living.

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Key words: Calorie intake, micronutrients, micronutrient foods, rural households, Nigerian food insecurity.

JEL[5]: Q18, I39

Introduction

Food security remained a critical policy consideration for successive Nigerian governments (Osabohien et al., 2020; Wudil et al., 2023). Country is currently faced with galloping inflation, particularly regarding the increase in prices of food products. This is coming at a period where the level of food insecurity already has alarming trend. About 21.4% Nigerians were estimated to be food insecure in 2020., and this is expected to increase in the next couple of years by 9.2% as a result of the Covid-19 pandemic and disruption of trade flows of both crops and livestock (FAO, 2021).

Also, the general reduction in farming activities arising from insurgency in the North-East, Banditry in the North-west and North-Central states has led to insecurity and displacement of large number of people, especially rural farming households and this continue to confound the food security situation in the country. About 43 million Nigerians are projected to be severely food insecure by 2030., representing the worst value among the West-African countries (Baquedano et al., 2020).

Amidst this situation, most studies focused on the relationship between households' food security status and coping strategies, with little or no attention on the quality of the diets. Food supplies the body with various nutrients, out of which, vitamins and minerals represent an essential aspect (Beal, Ortenzi, 2022). Vitamins and minerals are major micronutrients that are important for normal growth and development, though they are required in small quantity (Senbanjo et al., 2022). These nutrients cannot be synthesized within the body in sufficient quantity and are usually available through the consumption of micronutrient foods such as vegetables, fruits, dairy products, legumes, and animal source foods (Beal, Ortenzi, 2022).

Micronutrient malnutrition is more apparent in low and medium economy countries like Nigeria, where diets are majorly based on starchy staples, and deficient particularly in Fe, Zn, folates, vitamin A, Ca, and vitamin B12 (WHO, 2021; White et al., 2021). According to Stevens et al. (2022), deficiency in micronutrients is responsible for high rate of mortality in women and children, poor pregnancy outcome, high morbidity, retarded mental and physical development in children, and low productivity in adults. Out of the total death estimates in the 21st century, about 2.7 million can be linked to low diet in micronutrient foods such as fruits and

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vegetables (WHO, 2021). In Nigeria, micronutrient deficiencies remain a significant public health concern (Adams et al., 2024), and they have been linked with stunted physical growth, impaired cognitive function, weakened immunity, and an increased risk of degenerative and chronic diseases (Ibeanu et al., 2020). Nigeria is losing over 1.5 billion USD in GDP each year due to vitamin and mineral deficiencies (Senbanjo et al., 2022), with the most common deficiencies being in vitamin A, folate, Fe, I, and Zn (FGoN, IITA, 2024).

Thus, investigating the level of micronutrient foods intake especially among rural households requires urgent attention as they are particularly vulnerable to food insecurity and malnutrition due to limited access to diverse and nutrient-rich foods, lower income levels, and inadequate healthcare infrastructure (Ogunniyi et al., 2021). The relationship between food security and coping strategies has been extensive explored in Nigeria (Omotesho et al., 2008; Agada, Igbokwe, 2014; Adebo, Falowo, 2015; Salau et al., 2022). There are no studies that investigate the relation between calorie intake and households' micronutrient food consumption. Therefore, the present study aimed to identify the level of micronutrient foods intake among the rural households in North-Central Nigeria, and its linkage with calorie intake.

Material and Methods

Study area

This study was performed in North-Central Nigeria, a region situated within the Southern Guinea Savannah agro-ecological zone. The area involves six states: Benue, Kogi, Kwara, Nasarawa, Niger, Plateau, and the Nigeria's Federal Capital Territory (FCT). Region stretches across the whole width of country, from the border with Cameroon to that with Benin, covering an area of about 251,425 km^2. It is settled with a population of over 20 million inhabitants (NNBS, 2020). Subsistence agriculture is one of the main activities in the study area, while farms are usually small, based on the use of manual labor and primitive implements, such as hoes and machetes (Agada, Igbokwe, 2014). Even observed the rural areas as food production segment of country, the level of food insecurity in them is around 58%, compared to 18% in urban areas (Mekonnen et al., 2021).

Sampling procedures and data collection

Among the North-Central states, Kwara and Niger were purposively selected as the sampling frame adequate for samples obtaining. This selection is based on two considerations: 1) Niger state is the poorest state in North Central Nigeria (WB, 2022); and 2) Kwara state is one of the oldest states in Nigeria, so it has witnessed the influx and indigenization of several ethnics particularly of North-Central origins. Thus, this study involves all rural households in Kwara and Niger states in Nigeria.

This could potentially provide a limitation as food intake may differ with respondents in other states, however, gaining access to such a population size would prove difficult and beyond the budget constraint of this study. Notwithstanding, Kwara and Niger states are cosmopolitan states within North-Central Nigeria, making them strong representatives of the region. A three-stage random sampling technique was used to select respondents for the study. This is appropriate as both states have equal numbers of senatorial districts. Thus, to ensure proportionate representation in both states, the study adopted an existing cluster which is the senatorial districts in each of the states.

In the first stage, two Local Government Areas (LGA) were selected randomly in each senatorial district. In the second stage, two rural communities were selected randomly in each LGA. In the final stage, every fifth household was selected within each community. In total, 494 respondent households were selected for the study research. Data were collected directly from face-to-face interviews using a structured questionnaire. The questionnaire was used to solicit information on all food items consumed within the household in the last 24 hours (24-hour recall). Specifically, households were asked about all types and quantity of all food items consumed during the last day.

Household calorie intake

The calorie intake of households was investigated by the development of calorie intake index. Index was developed based on three major steps: 1) study participants were required to state the quantities of all food items consumed within the households in previous 24 hours; 2) the calorie content of the food items consumed was then calculated using the parameters that convert edible portions into calories (Fawole et al., 2016); 3) per capita calorie intake was estimated by dividing previously assessed overall household calorie intake by the number of adult equivalent (AE) in certain household (Dercon, Pramila, 1998). An estimated calorie intake in line of 2,800 kcal/person/day was adopted based on the average per capita calorie consumption in developing countries (FAO, 2023). Thus, households whose daily per capita calorie consumption, i.e. per AE (adult equivalence) was equal or greater than 2,800 kcal/person/day were assumed as calorie sufficient, with assigned value of 1. Other, that are experiencing calorie deficit were considered as calorie deficient, with assigned value of 0.

Households' micronutrient food intake

Micronutrient food intake was expressed in scores based on the dietary guidelines for Americans' recommendation as highlighted in the Healthy Eating Index 2015 (Bardos et al., 2022). The micronutrient food components under the HEI-15 are total fruits, whole fruits, total vegetables, greens and beans, dairy foods, total protein foods, seafood and plant protein food. As the fruit juice is rarely consumed at local level, whole fruit and total fruit were jointed into fruits. Thus, fruits, total vegetables, greens and beans, dairy products, total protein foods, and seafood and plant proteins were used to represent micronutrient food in the research study. Furthermore, the food items have been categorized into four groups: fruits, vegetables (total vegetable, and greens and beans groups), proteins (total protein food group, and seafood and plant protein groups), and dairy products, while to each group was awarded a maximum score of 25, according to intake of recommended amounts. Mentioned leads to overall maximum score of 100, where higher achieved scores reflect higher intakes that meet predefined standards.

In this research, the maximum and minimum intake were based on individual household's daily calorie requirement and score were assigned based on every 1,000 kcal consumed within the household as recommended in HEI-2015 (Krebs Smith et al., 2018). For fruits, the consumption of 0.4 cup equivalent or higher than 1,000 kcal assigns maximum score of 25, while no fruit consumption will amount to minimum score of zero. Total vegetables comprise all vegetables and legumes (beans and peas), while consumption of 1.1 cup equivalent or higher per 1,000 kcal will be underlined as maximum score of 12.5. Lack of vegetable consumption will be marked with minimum score of 0. Greens and beans component comprise legumes and dark-green leafy vegetables (i.e. spinach and jute leaves). The consumption of 0.2 cup equivalent or higher per 1,000 kcal will be expressed with maximum score of 12.5, while no consumption will amount to score of zero. The predefined score of 12.5 in both previous cases is because the group vegetable was divided into total vegetables, and greens and beans, what is in line to recommendation of HEI-15. The component dairy comprises to all dairy products, such are evaporated milk, yogurt, cheese, and soy beverages, whose consumption of 1.3 cup equivalent or higher per 1,000 kcal will be assigned the maximum score of 25, while lack of diary food intake will amount to 0. The total protein foods component pertains to all foods made from lean portion of meat, poultry, seafood, beans and peas, eggs, soy products, nuts, and seeds. Consumption of 2.5 cup equivalent or more per 1,000 kcal will attract a maximum score of 12.5, while no consumption of protein foods will amount 0. The seafood and plant proteins component consist of seafood, nuts, seeds, soy products (other than beverages), and legumes (beans and peas).

Table 1. Cup and ounce equivalence of common micronutrient foods

Micronutrient foods	g/ml	Equivalence in cup or ounce
Green leafy vegetables	200g	1 cup
Tomato	180g	1 cup
Pepper	150g	1 cup
Onion	160g	1 cup
Okro	100g	1 cup
Cabbage	89g	1 cup
Cucumber	102g	1 cup
Carrot	128g	1 cup
Potato	150g	1 cup
Corn	145g	1 cup
Mango	168g	1 cup
Orange	180g	1 cup
Pineapple	165g	1 cup
Pawpaw	230g	1 cup
Watermelon	154g	1 cup
Dates	147g	1 cup
Apple	125g	1 cup
Banana	136g	1 cup
Egg plant	82g	1 cup
Coconut	80g	1 cup
Guava	165g	1 cup
Cowpea	167g	1 cup/6 ounces
Peas	145g	1 cup/5 ounces
Soybeans	186g	1 cup/6 ounces
Eggs	50g	1.6 ounces
Fish	100g	3.5 ounces
Meat (mutton etc.)	100g	3.5 ounce
Chicken	100g	3.5 ounces
Soymilk	200ml	1 cup
Skimmed milk	200ml	1 cup
Full cream milk	300ml	1 cup
Powdered milk	124g	1 cup
Yogurt	125g	1 cup
Cheese	244g	1 cup

Source: According to author's computation.

The consumption of 0.8 cup equivalent or more per 1,000 kcal will amount to a maximum score of 12.5, while lack of their consumption will be marked as zero. Case of protein group is similar to group vegetable, as it was also divided into total protein foods, and seafood and plant protein food based on HEI-15 recommendation, where both of them could be maximally awarded with the score of 12.5 respectively. Finally, proportional scores were assigned to consumption between minimum and maximum standards. In Table 1. are displayed the cup and ounce equivalence of common micronutrient foods.

Statistical analysis

Collected data were analyzed using SPSS software (Statistical Package for Social Sciences, Statistical Software Program, Version 24.0, 2016, IBM Corp., Armonk, NY, USA), while statistical significance was set at 5%. Frequency and share were utilized to summarize the categorical data, while mean and standard deviation were utilized to summarize the continuous data. Independent sample T-test, and Chi-square test were utilized for numerical test comparisons between observed groups. A binary logistic regression analysis was applied to examine the relations between household calorie intake status and micronutrient foods intake. The logistic regression model has next formula:

$$z_i = \text{Log}\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 FT_i + \beta_2 GB_i + \beta_3 TV_i + \beta_4 SPP_i + \beta_5 TP_i + \beta_6 DP_i + \varepsilon_i$$

Where: z_i = calorie intake status of household i (Calorie sufficient = 1, otherwise = 0); P_i = the likelihood that household i will be calorie sufficient; $1 - P_i$ = the likelihood that household i will not be calorie sufficient; β_0 = coefficient of constant term; $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ and β_6 = slope coefficients; ε_i = error term; FT = fruit consumption score (count); GB = greens and beans consumption score (count); TV = total vegetable consumption score (count); SPP = seafood and plant proteins consumption score (count); TP = total protein consumption score (count); DP = dairy products consumption score (count).

Results

The sociodemographic characteristics of the households was examined based on their micronutrient foods consumption. In line to this, statistically significant difference was observed between the sociodemographic characteristics and intake of specified groups, i.e. greens and beans, total vegetable, total protein, seafood and plant protein, fruits, and dairy products. Micronutrient foods intake differs significantly due to household size, while these significant differences were observed in all foods considered except dairy products. Households with less than four members consumed more micronutrient foods except fruits. There was no statistically significant difference between off-farm employment and micronutrient foods consumption except for fruit intake (Table 2.).

Table 2. Sociodemographic characteristics based on micronutrient foods consumption (in g)

Element	n (%)	GB	TV	SPP	TP	FT	DP
Sex							
Male	443 (89.7)	106.87	111.53	107.28	181.62	29.66	5.32
Female	51 (10.3)	82.51	85.57	86.07	139.17	54.39	2.89
P-value		***0.129***	***0.004***	***0.121***	***0.004***	***0.001***	***0.520***
Age (years)							
20 – 45	185 (37.4)	133.09	137.68	134.46	210.24	34.32	4.76
46 – 65	293 (59.3)	85.28	89.67	85.82	156.07	31.89	5.53
65 – 75	14 (2.9)	133.39	139.18	128.51	197.83	9.13	-
> 75	2 (0.4)	34.88	36.37	37.62	65.33	10.20	-
P-value		***0.080***	***0.648***	***0.085***	***0.001***	***0.008***	***0.344***
Household size (members)							
< 4	99 (20.2)	194.06	201.07	195.43	291.69	35.24	10.15
5 – 8	306 (61.8)	87.19	91.24	87.52	156.87	35.75	3.27
9 – 12	78 (15.8)	54.61	57.91	55.55	112.26	16.79	5.70
> 12	11 (2.2)	138.43	141.35	126.07	168.79	15.03	4.56
P-value		***0.000***	***0.000***	***0.000***	***0.000***	***0.015***	***0.135***
Farm size (ha)							
< 4	409 (82.7)	106.35	110.67	107.88	180.12	36.05	2.73
4 -8	65 (13.2)	114.40	119.33	111.97	174.40	12.26	5.09
> 8	20 (4.1)	27.96	34.83	26.22	130.03	17.06	53.55
P-value		***0.000***	***0.009***	***0.000***	***0.116***	***0.000***	***0.021***
Farm income (NGN/year)							
150,000 – 1,000,000	291 (58.9)	110.49	115.81	113.14	183.97	41.62	2.08
1,000,001 –2,000,000	129 (26.1)	90.74	94.62	90.11	159.06	21.11	2.98
>2,000,000	74 (15.0)	104.15	124.11	100.21	184.50	14.06	20.46
P-value		***0.222***	***0.001***	***0.121***	0.***305***	***0.000***	***0.002***
Off-farm employment							
Yes	206 (41.2)	111.99	116.20	112.46	189.50	40.3001	4.3195
No	288 (58.8)	98.86	103.55	99.89	168.62	26.2093	5.6163
P-value		***0.170***	***0.120***	***0.188***	***0.068***	***0.004***	***0.577***
Educational Level							
No formal education	267 (54.3)	97.48	102.19	98.27	171.41	33.21	3.17
Primary education	140 (28.1)	98.28	102.26	99.47	161.52	12.45	8.61
Secondary education	59 (11.9)	139.41	143.96	140.26	218.95	71.59	4.86
Tertiary education	28 (5.7)	127.09	132.05	124.78	225.71	37.65	5.95
P-value		***0.030***	***0.087***	***0.035***	***0.001***	***0.000***	***0.269***
Access to credit							
Yes	49 (9.9)	162.04	169.31	160.82	241.26	33.92	0.23
No	445 (90.1)	98.19	102.39	99.09	170.40	31.96	5.60
P-value		***0.004***	***0.001***	***0.006***	***0.227***	***0.798***	***0.000***

Source: Abubakar et al., 2024.

Generally, the highest amount of total protein intake was noted among male headed households, particularly those within the age group of 20-45 years. Households with an annual farm income greater than 2 million NGN and those engaging in off-farm activities also showed higher total protein intake. Additionally, households with less than four members, those who had attained tertiary education, and those with access to credit for farming activities reported higher total protein consumption.

Similarly, The highest amount of total vegetable intake was observed among male-headed households, especially those within the age group of 65-75 years. Households with an annual farm income greater than 2 million NGN, those engaged in off-farm activities, and those with less than four household members also had higher total vegetable consumption. In addition, households with access to credit for farming operations demonstrated a higher total vegetable intake. Interestingly, fruit intake was significantly higher among female headed households. So, in previous table (Table 2.) was showed households' sociodemographic characteristics based on micronutrient foods consumption.

Out of the 494 households included in the study, 42.71% (211) of them were calorie sufficient, while 57.29% (283) were calorie deficient. In the group vegetable, average scores for greens and beans intake and total vegetable intake were higher among calorie sufficient than calorie deficient households. Similar results were obtained for all other micronutrient foods. Looking at total average score, the calorie sufficient households have total average score of 52.12 (out of 100), showing average consumption of micronutrient foods and diets that has to be improved. On the other hand, the calorie deficient households have a total average score of 38.38 (out of 100), what signifies poor micronutrient foods consumption, or diets that require significant improvement. In next table (Table 3.) is presented micronutrient food scores among the calorie sufficient and calorie deficient households.

Table 3. Calorie intake status and micronutrient food scores

Element	Calorie sufficient (n = 211)	Calorie deficient (n = 283)
Food Scores	Mean (SD)	Mean (SD)
Green and Beans	11.89 (1.30)	10.44 (2.52)
Total Vegetable	9.63 (1.05)	7.69 (1.61)
Total Protein Foods	9.46 (1.50)	5.82 (2.25)
Seafood and Plant Proteins	10.92 (2.01)	7.71 (3.91)
Fruit	10.05 (11.60)	6.64 (9.96)
Diary	0.18 (0.07)	0.08 (0.04)
Total	52.13	38.38

Source: Abubakar et al., 2024.

Furthermore, a statistically significant difference was observed between the groups based on greens and beans intake, total vegetable intake, seafood and plant protein intake, total protein intake, fruit intake and dairy products intake. In Table 4. is presented the independent sample t-test results.

Table 4. Differences between calorie sufficient and calorie deficient households based on micronutrient food scores

Variables	T	P	ETA squared	95% C.I. of the difference	
				Lower	Upper
GB	7.458	0.000	0.100	1.07264	1.84048
TV	16.198	0.000	0.345	1.70326	2.17353
TP	21.572	0.000	0.483	3.30640	3.96908
SPP	11.873	0.000	0.221	2.67380	3.73455
FT	3.458	0.000	0.023	1.47118	5.34572
DP	2.455	0.015	0.012	0.02133	0.19410

Source: Abubakar et al., 2024.

Examining relation between micronutrient foods consumption and households' calorie intake, statistically significant relationship was found between the dependent variable (household calorie intake status) and four out of the six independent variables (total vegetable intake, seafood and plant protein intake, total protein intake and dairy products intake). The result of the binary logistic regression (Table 5.) showed that total vegetable intake, total protein intake, and dairy products intake decreased households' odds of being calorie deficient by 162%, 528% and 702% respectively, while seafood and plant protein intake increased households' odds of being calorie deficient by 78% ($p < 0.05$). The intake of fruits, and greens and beans appeared insignificant.

Table 5. Relationship between Micronutrient foods Consumption and Households' calorie intake

Variable	B	S.E.	Wald	df	p-value	Exp(B)
GB	0.001	0.224	0.000	1	0.996	1.001
TV	0.964	0.192	25.202	1	0.000	2.621
SPP	-1.551	0.256	36.779	1	0.000	0.212
TP	1.838	0.241	57.996	1	0.000	6.283
FT	-0.006	0.026	0.058	1	0.810	0.994
DP	2.083	0.656	10.074	1	0.002	8.025
C	-31.058	4.257	53.234	1	0.000	0.000
Cox & Snell R^2	0.669					
Nagelkerke R^2	0.897					
-2 Log likelihood	132.281				0.000	
Hosmer and Lemeshow Test	2.456				0.864	

Source: Abubakar et al., 2024.

Discussion

The primary finding of this study is that calorie-sufficient households consume more micronutrient-rich foods than calorie-deficient households. Additionally, households that consume higher quantities of total vegetables, total proteins, and dairy products are less likely to be calorie deficient, while those consuming more seafood and plant proteins are less likely to be calorie sufficient. Furthermore, a large difference was observed between the two groups in terms of total vegetables, total proteins, and seafood and plant proteins intake. A moderate difference was found in greens and beans intake, while a minimal difference was observed in fruit and dairy products intake.

However, the micronutrient food consumption of both calorie-sufficient and calorie-deficient households remain below the recommended levels outlined in the HEI-2015. In particular, fruit and dairy products' consumption was notably low in both groups. This finding is consistent with the research of Otuneye et al. (2017), who reported infrequent intake of fruits as one of the poor dietary habits exhibited by adolescents in Abuja municipal area council. Litton and Beavers (2021) also noted that the intake of foods with healthy markers such as fruits and vegetables was lower among food insecure households compared to food secure one.

The consumption of micronutrient foods below the required standards, particularly among calorie-deficient households, may pose significant health risks. This is due to the fact that many of nutrients obtained from mentioned foods cannot be synthesized in sufficient quantities by the body, while they are essential for healthy development. The persistent increase in food prices continues to pose a significant threat to household food intake and, consequently, their food security status. This, in turn, may lead to considerable risks in their micronutrient food intake as households may resort to substitute quality diets with larger quantities of starchy foods, which can further exacerbate potential health issues.

The logistic regression results revealed that households that consumed more dairy products, total proteins and total vegetables were approximately 8, 6, and 2 times more likely to be calorie sufficient than those consuming lower amounts, respectively. Conversely, for every additional intake of seafood and plant proteins, households were 0.21 times less likely to be calorie sufficient. The basic understanding is that as households consume more calories, the more likely they will be calorie sufficient. While this current finding does not contradict that notion, it suggests that as households become more calorie deficient, they tend to consume more proteins from seafood and plant sources, or less from animal sources. Given the ready availability of plant proteins like beans, soybeans, or seafood like crab, especially in rural areas, calorie-deficient households may opt for these more affordable alternatives over more expensive eggs and different types of meat. Thus, consuming more plant-based protein foods, such as local delicacies like beske (a soybean byproduct), as substitutes for meat, cheese, and eggs can be an indicator of calorie deficiency and, by extension, food insecurity.

Essentially, the rate of consumption of seafood and plant proteins can be used to distinguish calorie sufficient from calorie deficient households. This is corroborated by finding of Amao (2013) who noticed that majority of households that could afford protein foods spend more on animal protein than plant protein sources. Abdulraheem et al. (2016) also found some statistical difference between food secure and insecure households based on their protein consumption.

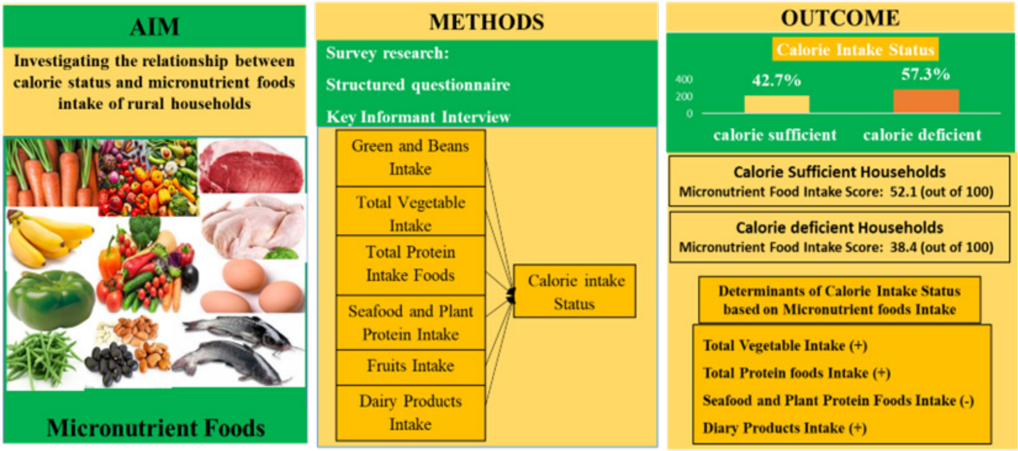
The consumption of fruits, greens and beans have appeared insignificant. Greens, such as jute leaf, spinach, and baobab leaf, were consumed daily by the majority of households, both calorie-sufficient and calorie-deficient, particularly combined with swallow foods like pounded yam, yam flour, and cassava flour, which are prevalent in the study area. Furthermore, bean consumption appeared to be insignificant, primarily due to the fact that households that cultivated more beans are consuming larger quantities than those cultivated less areas. Lastly, the insignificance of fruit consumption might be because fruit intake in rural areas is often habitual, with households consuming more or less based on seasonal availability rather than their overall calorie intake or food security status. That is, fruit consumption may not directly reflect a household's nutritional or caloric needs, but rather the accessibility of fruits during certain times of the year. This is consistent with Leung et al. (2014) who noted that there is no observable difference in consumption of fruits among food secure and food insecure adults in the USA. Diana et al. (2020) also noted that fruits that are highly available with low prices were consumed by all households in Madura Island (Indonesia) regardless to their food security status.

This research employed the 24 hours' recall method to collect information on households' micronutrient foods consumption. Thus, a longer recall instrument may provide more information on households' micronutrient foods intake.

Conclusions

Majority of the households in the study area are currently experiencing calorie deficiency and inadequate micronutrient food intake. Despite higher micronutrient consumption among calorie-sufficient households, overall intake remains below recommended levels. Notably, dairy products, total protein foods, and total vegetables intake are associated with increased calorie sufficiency, while seafood and plant proteins are linked to higher calorie deficiency. This suggests that households may prioritize seafood and plant proteins over vegetables and animal-source foods when facing calorie deficits. Brief presentation of performed research could be done in next graph (Graph 1.).

Graph 1. Structure and the flow of the performed research



Given the critical role of these foods in supporting the health and well-being of women, children, and adults, nutritional adequacy campaigns should be a cornerstone of any food security intervention in the rural areas. These campaigns should focus on educating households about the benefits and implications of mentioned foods. Moreover, food security programs must not only address the quantity of food consumed but also prioritize the quality of diets to promote productive and healthy living. Finally, conducting a comprehensive assessment of specific nutrient deficiencies (i.e. vitamins and minerals) in rural areas is necessary to identify key areas where dietary interventions are needed.

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INFLUENCE OF COVID-19 ON RICE FARMER'S INCOME IN KWARA STATE, NIGERIA

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Abstract

The COVID-19 pandemic has had a severe impact on agricultural productivity and the livelihood of farmers in developing countries. Observed research sought to evaluate the impact of the COVID-19 lockdown on the income of rice farmers in Kwara State, Nigeria. 120 respondents were selected for this study using a multistage sampling technique. Descriptive statistics, Average treatment effects, and Likert scale were used to address the main objectives. Results showed that the COVID-19 lockdown affected the income of the rice farmers during and after the lockdown, with a 6% decrease in the income of rice farmers during the lockdown as compared to before the lockdown and a 17.7% decrease after COVID-19 lockdown as compared to during COVID-19 lockdown. Furthermore, inadequate funds, flood, and high cost of labor were found to be the highest barriers to mitigating the influence of COVID-19 on rice production. Performed study recommends that a well-structured and carefully planned response strategy be developed for situations like the COVID-19 pandemic, including the establishment of alternative income sources for farmers in the event of a future recurrence or similar crisis. Additionally, policies should be implemented to ensure adequate access to credit for rice farmers, supporting increased production and improving their overall income.

Key words: COVID-19 pandemic, farmers' income, rice production, average treatment effects.

JEL[4]: Q12, Q18, I15

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Introduction

Rice belongs to essential staple grains that feeds about half of the global population and plays a major economic role (Fahad et al., 2019). Around 480 million metric tons of milled rice are produced worldwide each year, with India and China contributing to half of the world's rice cultivation and consumption (Mohammed et al., 2019). Rice is a significant source of carbohydrates, supplying 20% of the daily caloric intake for many people and animals (Ryan, 2011). Rice also plays an economic role by providing a means of revenue for several households around the globe. Many countries in Africa and Asia rely heavily on rice for revenue for the government through foreign exchange earnings. Rice production is expected to span over 160 million hectares worldwide, yielding approximately 500 million metric tons annually (Kirby et al., 2017). Rice demand has continuously grown over the years, and currently, it plays a significant part in many nations' strategic food security planning initiatives. Rice crop output has dropped significantly in recent years, failing to keep up with population expansion. This has led to shortages and rising prices, thus affecting smallholder rice farmers negatively (Denkyirah, 2015).

In compare to whole Africa, its west parts consume the most rice, with regional demand increasing at a rate of about 6% per year. In addition, yearly per capita consumption in West Africa has increased fivefold in the previous six decades and now is the most on the continent (Arouna et al., 2021). Nigeria's per capita rice consumption is estimated at 35 kg per year, resulting in a total annual consumption of 5.2 million metric tons (Gyima Brempong et al., 2012). Rice is widely cultivated in Nigeria in all agroecological zones through various production methods, such as deep water, swampy lowlands, mangroves, and rain-fed upland (Philip et al., 2018).

Despite Nigeria's substantial rice production capacity, the rice business has been unable to meet consumer demand. Local rice farmers meet around 70% of yearly rice consumption, while rice imports meet the remaining 30%. Nigeria has become Africa's largest rice importer and the world's second-largest (FAO, 2012). The increasing demand for rice is driven by higher income levels, expanding population, and the convenience of rice processing and storage (Esiobu et al., 2020). According to Osagie (2015), Nigeria spends approximately a billion Naira (NGN) each day buying rice, a phenomenon that helps farmers find jobs in trade partner nations such as Thailand, the United States, and India while throwing Nigerian farmers out of work. The Nigerian government issued a policy decision in 2015 to restrict rice imports, which went into force in 2019. Rice farming is being supported practically across Nigeria due to the current government's goal of diversifying the economy through agro-climatic conditions and varied production methods (Esiobu et al., 2020).

While rice farmers in Nigeria are still dealing with the detrimental effects of greenhouse gas (GHG) emissions and the changing climate, the COVID-19 pandemic introduced new hazards that jeopardized the most crucial worldwide staple food crop, “Rice”, and ultimately, farmers’ livelihoods (Ankrah et al., 2021). The first human cases of the disease caused by SARS-CoV-2, which led to the COVID-19 pandemic, were initially reported by officials in Wuhan City, Hubei Province in China, in December 2019. (WHO, 2020). The total count of confirmed COVID-19 cases in Africa as of March 2nd, 2022., was 11,549,076, accounting for approximately 2.62% of all global infections. In the same period, there had been over 440.8 million coronavirus infections worldwide, resulting in almost 6 million deaths, while about 392 million persons had recuperated from the disease (Kimeli et al., 2022). Nigeria’s first confirmed COVID-19 case was reported on 27th February 2020, after one Italian citizen was tested positive in Lagos (NCDC, 2020).

In April 2021, Nigeria’s Minister of Agriculture and Rural Development established a joint technical task force to address challenges posed by COVID-19. During the lockdown, this task force facilitated the unrestricted movement of farmers, agri-food products, livestock, and agricultural inputs throughout the country, aiming to prevent food shortages and mitigate the pandemic’s impact on the cropping season (Ogisi et al., 2021). In response to reports from transporters facing challenges with moving livestock, agricultural inputs, and food during the COVID-19 lockdown restrictions, the Federal Ministry of Agriculture and Rural Development of Nigeria established a task force to address these issues (Mukaila et al., 2024). The exemption granted for agriculture and food-related operations proved ineffective since acquiring the appropriate licenses was sometimes difficult due to office closures or limited working hours and a shortage of workers to process requests. This situation negatively affected agricultural activities during and after mentioned period (FAO, 2021).

Agricultural activities are also influenced by factors that include environmental, biological, financial, chemical, and human issues. These factors affect the timely execution of agricultural activities, and this determines to a great length the cost of production, the levels of outputs, and the profitability of the agricultural production process (Prager, Posthumus, 2010). The changing climatic conditions, coupled with other influencing factors, have become critical determinants in agricultural practices. As a result, farmers can no longer rely solely on their experience to make decisions, which affects the timely execution of agricultural activities. This delay in action often leads to increased production costs, ultimately resulting in reduced income for farmers (Gwiriri, 2012).

Rice, the most prevalent stable crop, is similarly affected, and its yield is heavily influenced by the factors described above. Every growing season, rice producers confront new challenges, such as price instability, limited rainfall, and ineffective government policies (Elbasiouny, Elbehiry, 2020). While attempting to regulate the issues influencing rice production, the novel COVID-19 pandemic posed additional obstacles to the rice value chain, which was already under severe pressure (San Juan, 2020). The COVID-19 pandemic highlighted the interconnectedness between health and food systems, including the linkage between local and global food systems. Lockdowns and border restrictions impacted local and national agricultural input, output, and food markets, leading to substantial losses in the global total economic output. These disruptions heightened the vulnerability of agri-food systems and rural livelihoods in impoverished nations (FAO, 2021).

The COVID-19 pandemic affected the operations and sales of rice, and this in turn affected the profitability of rice farmers, with most effects felt by the small-scale rice farmers in rural areas. The disruptions caused by the pandemic pose a significant danger to the livelihoods of rice farmers and the nation's food and nutritional security (Tansuchat et al., 2022). A few related studies have explored the impact of COVID-19 on rice farming (Esiobu, 2020; Hasanah et al., 2021; Schmidt et al., 2021). However, none of these studies have directly connected the perceived effects of the pandemic to a quantitative assessment of rice harvests. This study aims to address this gap. The primary objective is to examine the impact of the COVID-19 lockdown on the income of rice farmers in Kwara State, Nigeria. More specific, study describes the main sociodemographic features of rice farmers, identifies their information sources and the precautionary measures they adopted during the pandemic, evaluates the observed effects of COVID-19 on rice yields and market prices, and identifies the challenges faced in mitigating the pandemic's impact on rice farming.

Literature Review

Theoretical framework: Theory of income

Firms create the majority of the economy's production. They generate the whole number of final products and sell them on the goods market. The whole value of these final items equals the total revenue of the economy, which represents the inflow of money to the business sector. In agriculture, the farm produces agricultural commodities that are sold for income (Asimakopulos, 2012). "In the four-sector model, income flows between enterprises, households, the government, and the rest of the world, and these flows pass through the goods and capital (financial) markets, as well as occasionally from one sector directly to the other. The goods market is the market for final goods and services for consumption (excluding intermediate products but including investment goods)", (Ahern, 2013). Income is generated from the outputs of the production process. In agriculture, production is the process of combining resources such as land, labor, capital, and management to produce output (Kamaludin et al., 2021). Production can be represented as:

$$Q = f(X) \quad (1)$$

Where, Q = quantity of outputs, X = inputs (i.e. factors of production), and f = relationship between Q and X, while the total value of Q (produce) gives the total income in an economy.

Related empirical studies

Very few studies have been done to examine the impact of COVID-19 on rice production. Esiobu (2020) underlined that current dangers from the COVID-19 pandemic are posing additional obstacles to the rice value chain, which already had been under intense pressure. Farmers were urged to respond swiftly to the challenges posed by the pandemic by adopting yield-enhancing techniques. However, at the time of this study, no empirical data was available on the direct impact of the COVID-19 pandemic on rice output. Schmidt et al. (2021) investigated the effects of COVID-19-related income and rice price shocks on the welfare of households in Papua New Guinea. Their model simulations suggested that a 25% rise in global rice prices would result in a 14% decrease in overall rice consumption in the country, with a 15% reduction specifically among poorer households. Additionally, in the context of a projected 12% decline in household income due to the economic downturn caused by COVID-19, rice consumption among impoverished households decreased by 20% in urban areas and 17% in rural areas. Hasanah et al. (2021) investigated the influence of COVID-19 on rice farmers' household food security in Indonesia. The purchasing power of farmer families and the income exchange rate were used to calculate the degree of welfare of farmer households. They discovered that COVID-19 had a detrimental influence on farmers' revenue. The degree of food security of farmer households was also significantly impacted as the number of food-insecure households rose. Abdul (2020) discovered that the economy suffered more severe impacts as the number of lockdown days and restrictions on inter-state and cross-country movement increased. This subsequently led to situations such as increased postharvest loss, increased food prices, high transport costs, low purchasing power by households, hoardings by marketers, etc., all of which had an adverse effect on food security.

Materials and Method

Study area

Kwara State is situated in the West-Central region of Nigeria, within the area known as the Middle Belt. The state spans between longitudes 2°30’30 E and 6°25’ E and latitudes 7°45’ N and 9°30’ N, covering an area of approximately 32,825 square kilometers. Established in 1967, Kwara State consists of 16 Local Government Areas and has a population of around 2.37 million (NPC, 2006). It shares an international border with the Republic of Benin and is bordered by Oyo, Niger, Kogi, and Osun states within Nigeria. Agriculture is the primary occupation of its residents, with key crops such as rice, maize, beans, sweet potatoes, sorghum, and yam serving both as food staples and cash crops. The state experiences two distinct climate seasons (wet and dry) and features natural vegetation ranging from rainforests to wooded savannahs. The average temperature ranges from 30°C to 35°C, with annual rainfall levels between 1,000 mm and 1,500 mm.

Sampling techniques

The research was employed a three-stage sampling technique. During the first stage, two Local Government Areas (LGAs) out of the sixteen in Kwara State (Patigi and Edu) were purposively selected due to their prominence as the main rice-producing areas within the state. Next stage involved the purposive selection of six villages from each of these two LGAs. In the final stage, 10 rice farmers were randomly selected from each village for interviews, resulting in a total sample size of 120 respondents. The sample is representative of the study population as it purposively includes major rice-producing Local Government Areas (LGAs) in Kwara State. More precisely, it ensures that the selected 120 rice farmers reflect the average characteristics and experiences of those most impacted by the COVID-19 pandemic in this key agricultural region.

Data collection

Primary data was gathered using structured questionnaires, supplemented with interviews for respondents who were unable to read or write, conducted at suitable locations. The questionnaire was segregated into different sections and designed such that each objective was assigned a section to acquire information specifically on the intended objective.

Data analysis

Through the questionnaires collected data have been analyzed using the few methods.

Descriptive analysis

Descriptive statistics, including percentages, means, and frequencies, were utilized to describe the sociodemographic characteristics of the rice farmers, determine the source of information, and the precautionary measures farmers practiced during the COVID-19 pandemic.

Average treatment effect

The Average Treatment Effect (ATE) was used to estimate the difference in income levels of rice farmers before, during, and after the COVID-19 lockdown. To ensure accurate estimation and to account for potential biases, the study employed the Inverse Probability Weighted (IPW) regression adjustment of the treatment-effect model. This method adjusts for selection bias by assigning weights to individuals based on the inverse probability of receiving the treatment (e.g. being impacted by the lockdown). The IPW approach allows for a balanced comparison between treated (affected during the lockdown) and untreated (unaffected before lockdown) groups, thus providing a more reliable estimate of the impact of the COVID-19 lockdown on the rice farmers' income. ATE estimates derived through this approach help quantify the economic effects of the lockdown on rice production activities, capturing both immediate and residual impacts on farmers' livelihoods.

$$ATE\ (\Delta 1) = Yi1 - Yi0 \qquad (2)$$

Where, Yi1 denotes income during and after COVID-19, Yi0 denotes income before COVID-19

Likert - Scale

A five-point Likert Scale was used to identify the barriers to mitigating COVID-19 pandemic effects in production, while 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. Data collected using the Likert Scale were used to calculate the mean score.

Study limitations

The study's reliance on self-reported data from rice farmers may introduce recall bias, particularly regarding income and production levels during the COVID-19 lockdown. Additionally, the use of purposive sampling from only two rice-producing LGAs may limit the generalizability of the findings to all farmers in Kwara State. However, the insights gained are valuable for understanding localized challenges and guiding policymakers in developing resilient agricultural support systems for future crises.

Results and Discussion

Socioeconomic characteristics of respondents

Results show that almost all (96.67%) of the respondents were males (Table 1.). This finding probably indicates that rice farming activity is an energy-demanding work, with the females more involved in post-harvest operations like drying, threshing, cleaning, etc. This result is in consonant with the findings of Mafimisebi and Ikuerowo (2018), who noted that rice cultivation and marketing are predominantly carried out by males, likely due to the physically demanding nature of the work involved, which is suited to the more energetic nature of the male gender. Most (41.67%) of the rice farmers were up to 30 years old (mean age of the respondents was 36.66). This indicates that the farmers in the study area are young, energetic, and capable of utilizing their resources effectively. These findings are consistent with those of Matanmi et al. (2011), who observed that most individuals engaged in rice production belong to the middle age group, characterized by high energy and productivity. Additionally, most (75.83%) of the respondents were married, suggesting that a significant portion of them had access to family labor, which helped to offset the shortage of hired labor during the COVID-19 pandemic. This observation is in line with Esiobu (2020), who found that married farmers are more likely to adapt to the effects of the COVID-19 pandemic compared to their unmarried counterparts, due to their access to family labor.

Furthermore, a significant share of respondents (49.17%) had attained tertiary education, while nearly 15% had no formal education. Approximately 75% of the respondents had some level of education, which likely enhanced their understanding of the COVID-19 pandemic, its impact on rice production activities, and the various strategies for mitigating its effects on rice production.

Table 1. The Socio-demographic features of respondents (N = 120)

Variables	Frequency	Percent	Mean
Gender			
Female	4	3.33	
Male	116	96.67	
Age			
≤ 30	50	41.67	36.6
31 – 40	30	25.00	
41 – 50	29	24.17	
51 – 60	7	5.83	
Above 60	4	3.33	
Marital Status			
Single	24	20.00	
Married	91	75.83	

Variables	Frequency	Percent	Mean
Divorced	3	2.50	
Widowed	2	1.67	
Education Level			
No Formal Education	18	15.00	
Primary	18	15.00	
Secondary	25	20.83	
Tertiary	59	49.17	
Household Size (members)			
≤ 5	16	13.33	10
6 – 10	68	56.67	
Above 10	36	30.00	
Farming Experience			
≤ 5	7	5.83	18
6 – 15	58	48.33	
16 – 25	35	29.17	
26 – 35	12	10.00	
Above 35	8	6.67	
Land Ownership			
Owned	90	75.00	
Rent	24	20.00	
Borrowed	6	5.00	
Farm size (ha)			
≤ 5	88	73.33	4.36
6 – 10	28	23.33	
Above 10	4	3.33	
Access to Credit			
Yes	86	71.67	
No	34	28.33	
Farm Income			
≤ 50, 000	1	0.83	439,916
50, 000 – 100, 000	18	15.00	
101, 000 – 200, 000	23	19.17	
201, 000 – 300,000	19	15.83	
Above 300, 000	59	49.17	

Source: Belewu et al., 2021.

The majority of respondents (56.67%) had a household size of 6 to 10 members, with approximately 86.67% having more than 5 family members. The average household size was 10, indicating that many farms rely on a substantial number of family members, which contributes significantly to the overall labor capacity of the farms. This capacity is sufficient to offset any reduction in hired labor caused by the COVID-19 pandemic. These findings are consistent with those of Mafimisebi and Ikuerowo (2018), who reported that when the majority (62%) of households consist of 6 to 10 members, farmers are often able to involve their household members in rice production and marketing activities. Results further showed that 75% of respondents owned the farmland used in their farming.

Most of the respondents had farms in size of less than 5 ha, or in average farm size was 4.36 ha. This conforms with the findings of Matanmi et al. (2011), who reported that the majority of the respondents (approximately 72.7%) had farms in sizes of slightly less than 5 ha. Results also show that the most of farmers (48.33%) had a farming experience of 6-15 years, or on average 18 years, implying that farmers are well experienced, while had been in the farming business for a certain period before COVID-19. They could be experienced enough to control and manage risks and uncertainties in rice production.

Results further revealed that nearly half of respondents (49.17%) earned in average seasonal income of over than 300,000 NGN (around 380 USD), with the average annual farm income amounting to 439,916 NGN (approximately 558 USD). Besides, most of the respondents (68.33%) were primarily engaged in farming, so for most of them the major source of income is farming. This result is in consonant with the findings of Khattak and Hussain (2008), where the majority of respondents had farming as their major occupation. Also, the most of respondents did not have access to credit, possibly making it difficult to mitigate the effects of COVID-19 on rice farming due to a lack of available funds. Denkyirah et al. (2016) reported that the majority of rice farmers in Ghana had access to credit from family members and used the credits on non-agricultural activities.

Farmer's source of information and precautionary measures during COVID-19

The presented results show the main sources of information on the COVID-19 pandemic among rice farmers in the study area (Table 2.). It reveals that 31.67% of respondents used radio sets as the primary source of information, 30.38% used television as a source of information, 20% of respondents sourced information via SMS through mobile phones, and 16.67% of them sourced information through family and friends, and 0.83% of respondents obtained information through extension agents. Extension service, which should have kept farmers well informed about the impact of the COVID-19 pandemic, as well as various ways to mitigate the risks and curb its impacts, was lacking in the study area.

In terms of farmers' health precautionary measures during the COVID-19 pandemic, the result shows that 95.83% of the respondents used facemasks, 62.50% of the farmers practiced no handshaking, while 51.67% of them practiced social distancing, or 39.17% of respondents practiced healthy feeding in efforts to control the spread of the COVID-19.

Table 2. Farmer's source of information and precautionary measures during the COVID-19 pandemic.

Variables	Frequency (N = 120)	Share
Source of Information		
Extension agent	1	0.83
Friends and family	20	16.67
Radio set	38	31.67
Television	37	30.83
SMS	24	20.00
Farmers' Precautionary Measures		
Use of Facemask (Yes)	115	95.83
No Handshaking (Yes)	75	62.50
Social Distancing (Yes)	62	51.67
Healthy Feeding (Yes)	47	39.17

Source: Belewu et al., 2021.

Effects of COVID-19 on rice farmer's income during and after lockdown

The results presented in Table 3. explain the impact of the COVID-19 lockdown on the income level of farmers during and after the lockdown. Using the Inverse Probability Weighted (IPW) regression adjustment of the average treatment-effect model, the study addressed potential selection biases, particularly those arising from non-compliance, by adjusting for differences in observable characteristics between treated and untreated groups. The Average Treatment Effect (ATE) on the sub-population before lockdown was 6%. This implies that the respondents had a 6% increase in their income before lockdown than in the period of lockdown. This could translate to a significant impact of the lockdown on the income of the respondents during the COVID-19 outbreak. The ATE on the sub-population after lockdown was negative 17.7%. This implies that the respondents had a 17.7% decrease in their income after lockdown than in the period of lockdown. This suggests that the lockdown had a significant impact on the respondents' income, as well as on rice production activities after the lockdown. The disruption could be attributed to the residual effects of the various measures implemented to combat COVID-19. Additionally, the inability of farmers to quickly adjust to these challenges likely had a substantial impact on the subsequent rice production season.

The gained results (Table 3.) also showed that possible outcomes (PO) means for "0" before the lockdown is 0.276 (p-value < 0.01), indicating a highly significant mean outcome in the absence of treatment before the lockdown. This implies that the baseline conditions (without intervention or treatment) for rice producers were statistically robust and relatively favorable before the lockdown. After the lockdown, the PO means for "0" drops to 0.243 (p-value < 0.01) which is still statistically significant but indicating a decrease from the pre-lockdown baseline. This shift might be indicative of the broader economic or operational challenges that rice producers faced during the lockdown period, likely linked to restrictions on movement, supply chain disruptions, or reduced access to markets.

Table 3. Inverse Probability Weighted (IPW) regression adjustment of the ATE model estimation

Variables	Coefficient	Z	P > |Z|
Before Lockdown			
ATE			
1 vs 0	0.060*	1.63	0.103
PO means			
0	0.276***	5.62	0.000
After Lockdown			
ATE			
1 vs 0	-0.178*	-1.77	0.076
PO means			
0	0.243***	3.96	0.000

Source: Belewu et al., 2021.

Note: *** and *represents 1% and 10% significance levels respectively.

Barriers to mitigate the effects of COVID-19 pandemic on rice production

Results presented in Table 4. reveal the barriers faced by farmers in mitigating the impact of the COVID-19 pandemic on rice production using the Likert type scale. Inadequate fund was ranked as the first barrier with a mean score of 4.33. This was likely because it directly constrained farmers' ability to purchase inputs, invest in recovery strategies, and manage increased production costs during and after the pandemic. Flood (mean score 4.29) is being with the second highest score, suggesting that environmental factors exacerbated the challenges of the pandemic, possibly due to farmers' reduced capacity to cope with these events during a time of economic hardship.

Table 4. Barriers to mitigating the effect of COVID-19 pandemic on rice farmer's income

Variables	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree	Mean Score	Rank
	Freq (%)	Freq (%)	Freq (%)	Freq (%)	Freq (%)		
Inadequate Funds	58 (48.33)	50 (41,67)	6 (5.00)	6 (5.00)	0 (0.00)	4.33	1st
Flood	62 (51.67)	43 (35.83)	6 (5.00)	6 (5.00)	3 (2.50)	4.29	2nd
High Cost of Labor	58 (48.33)	39 (32.50)	16 (13.33)	6 (5.00)	1 (0.83)	4.23	3rd
Inadequate Information	54 (45.00)	49 (40.83)	4 (3.33)	12 (10.00)	1 (0.83)	4.19	4th
Poor Production	63 (52.50)	29 (24.17)	9 (7.50)	11 (9.17)	8 (6.67)	4.07	5th

Variables	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree	Mean Score	Rank
	Freq (%)	Freq (%)	Freq (%)	Freq (%)	Freq (%)		
Theft	47 (39.17)	45 (37.50)	13 (10.83)	11 (9.17)	4 (3.33)	4.00	6th
Poor Access to Credit	41 (34.17)	52 (43.33)	12 (10.00)	12 (10.00)	3 (2.50)	3.97	7th
Lack of Trust in Government	47 (39.17)	43 (35.83)	11 (9.17)	15 (12.50)	4 (3.33)	3.95	8th
Distance to Market	40 (33.33)	44 (36.67)	14 (11.67)	13 (10.83)	9 (7.50)	3.78	9th
Poor Extension Contact	35 (29.41)	32 (26.89)	21 (17.65)	24 (20.17)	8 (5.88)	3.52	10th
No Covid-19 Palliative	27 (22.50)	23 (19.17)	26 (21.67)	30 (25.00)	14 (11.67)	3.16	11th

Source: Belewu et al., 2021.

The high cost of labor (mean score 4.23) ranking as third, highlights the labor shortages and increased wage demands during the pandemic, likely due to restrictions on movement and the reduced availability of workers. Inadequate information had a mean score of 4.19, poor production had a mean score of 4.07, theft had a mean score of 4.00, poor access to credit had a mean score of 3.97, lack of trust in the government had a mean score of 3.95, distance to market had a mean score of 3.78, poor extension contacts had a mean score of 3.52, while no COVID-19 palliative had a mean score of 3.16. These constraints left the farmers unable to fully mitigate the effects of the COVID-19 pandemic on sustainable rice production in the study area. These rankings collectively suggest that financial and environmental constraints, compounded by increased operational costs, were perceived as the most significant obstacles to resilience and recovery among rice farmers in the study area.

Conclusion and Recommendation

According to performed study, it can be concluded that the major sources of information for farmers during COVID-19 were radio and television. There came a significant decrease in the income of rice farmers in the observed area during the COVID-19 lockdown, as well as a larger decrease in the following cropping season which could be attributed to the impact of COVID-19 on rice production and subsequent income of rice farmers. Several factors posed a barrier to mitigating the impact of COVID-19 on rice production, such are inadequate funds, flood, and high cost of labor, amongst others.

Based on the main findings, it is recommended that the government, agricultural agencies, NGOs, and certain financial institutions support farmers with easily accessible credit and input facilities at subsidized rates. This will largely improve rice production and, subsequently, the income of rice farmers since inadequate funds remain the largest barrier to mitigating the impact of COVID-19 in Kwara State. The government should implement adequate planning and establish effective response strategies to prepare for future pandemics or unexpected natural events that could significantly impact rice production and farmers' incomes. Additionally, farmers should receive training and education from extension agents on enhancing production, marketing, and sales of agricultural products to maximize income, as well as on strategies to respond effectively to unforeseen disruptions.

Future research could explore the long-term recovery trajectories of rice farmers and other crop producers post-COVID-19, focusing on the effectiveness of policy interventions and adaptive strategies in improving resilience and restoring income levels in rural agricultural communities.

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PRODUCTION AND ECONOMIC CHARACTERISTICS OF SOUR CHERRY CULTIVATION IN THE REPUBLIC OF SERBIA[1]

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Abstract

Fruit production is very important for the overall development of agriculture, where cherries, have become a very popular fruit species especially in recent years. For Serbia, cherries represent not only an important export product, but also a symbol of quality and a long production tradition.

The paper analyzes the production of sour cherries in the Republic of Serbia in the period 2014-2023. Research focuses annual changes in areas under sour cherries in Serbia by regions, different statistical indicators of sour cherries production, or achieved yields. Observing the average values for the examined period, it was shown that Serbia is ranked as the sixth worldwide, towards to level of sour cherry production (128,712 t), while participates in global production with 9.04% (period 2013-2022., in line to FAO data). In average, areas under sour cherry trees in Serbia for the observed period 2014-2023., amounted around 18,240 ha. The average production for the same period was 125,214 t, while the average yield was 6.8 t/ha (period 2014-2023., in line to SORS data). The key factors for the improvement of sour cherry production are state subsidies for plantations establishment, credit support to agricultural farms, as well as the readiness of agricultural producers to advance current production and introduce modern and innovative technologies into production.

Key words: Sour cherry, production, yield, economic indicators, Serbia.

JEL[5]: Q10, Q13, Q19

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Introduction

Fruit growing represents significant sector of agriculture in the Republic of Serbia, while the most significant fruit species are plums, apples, and sour cherries, both due to production area with native trees, or due to total production achieved (Milić et al., 2011; Kljajić et al., 2022; Kljajić et al., 2023; Korićanac et al., 2023; Sredojević et al., 2024).

Sour cherry (*Prunus cerasus L.*) originates from Europe (it was spreading out the territory between Caspian Sea and Istanbul), while it represents one of the most valued fruits among consumers (Vukoje et al., 2013; Casedas et al., 2016; Vasylyshyna, 2018). In practice, many calls it a sour the cherry (Wang et al., 2021). There is assumed that sour cherry was created by spontaneous, or natural hybridization between steppe cherry (*Prunus fruticosa L.*) and wild cherry (*Prunus avium L.*), (Radičević et al., 2012).

Sour cherry is characterized by simple cultivation. It is extremely resistant to low temperatures and can be successfully grown at higher altitudes, up to 1,500 m. Tillage and land cultivation is simple. Cherry trees come into fruit yielding very quickly, while pruning is not so complicated. Consequently, a large number of protective treatments with pesticides are not required during the production process. This is in favor to its resistance to many diseases and pests, where all previously mentioned give sour cherry a certain advantage compared to other fruits (Nenadović Mratinić et al., 2006; Milić et al., 2016).

The color of sour cherry fruit is red to dark red, juicy and sour. It is rich in carbohydrates, organic acids, while it also contains pectin, proteins, tannins and various vitamins, as well as other important nutrients. As a high-quality fruit, sour cherries have significant nutritional, dietary, medicinal and technological value (Janković et al., 2013; Savić et al, 2017). Sour cherries are mostly processed (as a raw material in the confectionery industry, in alcoholic beverages, such as brandy and liqueur, dairy products, such as fruit yogurt, etc., pharmaceuticals, energy generating, etc.), while rarely they are consumed as fresh (Radosavljević, 2008; Yaman, 2022). Sour cherry processing leaves certain volume of by-products (pomace and pits), for which there has been great interest in recent years. Sour cherry pomace has a high content of phenolic compounds, while the pit contains oil that has antioxidant, antimicrobial and anti-inflammatory properties, having the beneficial effect on human health (Yilmaz et al., 2019). Besides, sour cherry blossoming has a significant impact on honey production (Bukovics et al., 2003).

The most represented sour cherry varieties in Serbia are Oblačinska, with the highest share in overall number of sour cherry trees, and Cigančica, with a much smaller share. Oblačinska variety, dominantly grown in the southeastern part of Serbia, involves a mixture of numerous genotypes thanks to its cultivation in different agro-ecological circumstances, as well as the application of both vegetative and generative propagation methods (Radičević et al., 2012; Narandžić, Ljubojevic, 2022). Other existing sour cherry varieties in Serbia that belong to group of cherries with larger size of fruits are Heimanns Konservenveichsel, Rekelle, Šumadinka, and Schattenmorelle. The varieties Schattenmorelle and Heimanns Konservenveichsel have been also grown in several countries worldwide, as the highly valued varieties (Janković et al., 2013; Radičević et al., 2018; Blando, Oomah, 2019).

Sour cherries are represented in the following fruit-growing regions of Serbia: Subotica-Horgoš, Fruška gora, South Banat, Danube region, Timočka krajina, Šumadija, Rasina region, South Morava, and Kosovo and Metohija (Jeločnik et al., 2021). There are favorable agro-ecological conditions for the production of cherries in Serbia, but also good prospects for their export (Sredojević et al., 2011, Keserović et al, 2016).

The main goal of the paper is to analyze sour cherry production with its annual variations within the territory of the Republic of Serbia, further exposing the support tendencies and production advancement needed to better ranking of Serbian sour cherry at international market.

Material and Methods

The main research method used was desk-research method. Observed period was 2014-2023[6]. Databases of the Statistical Office of the Republic of Serbia (SORS) and the Food and Agriculture Organization of the United Nations (FAO) were used to obtain analyzed statistical data. Publications that are also served as data sources were Statistical yearbooks and bulletins for the observed years or certain months, as well as annual market reports of the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia (MAFWM) for cherries. Statistical indicators for sour cherry production in Serbia are given through the area under cherry plantations (in ha), total production (in t), and obtained yield (in t/ha). The research was also based on statistical and computational methods. Standard indicators of descriptive

6 Mentioned period does not refer to observation of sour cherry production worldwide, or to global ranking of Serbia as the sour cherry producers, where the observation period is 2013-2022., as there is lack of data at the time of research for 2023. Same period of research is also applied to observation of purchase prices of cherries.

statistics, such are average, standard deviation, or coefficient of variation, were used for the analysis of production, while the data interpretation is done through adequate tables and graphs. Extensive literature review included scientific and professional papers (domestic and foreign) that target similar or same topic as is the subject of performed research.

Research Results and Discussion

Sour cherry production in the world

Average world sour cherry production for the period 2013-2022. was 1,423,838 tons. The largest production was realized in Russian Federation, Ukraine, or Turkey. Serbia is ranked as the sixth on the list of world producers with an average annual production of 128,712 t, representing the 9.04% of the global cherry production (Table 1.).

Table 1. Average production, achieved yields and share of leading sour cherry producers worldwide (period 2013-2022., in t)

Production (t)		Participation in production (%)	Yield (t/ha)
World (total)	**1,423,838**	**100.00**	
Russian Federation	230,250	16.17	5.88
Ukraine	184,006	12.92	9.31
Turkey	183,625	12.90	8.68
Poland	166,900	11.72	5.87
Serbia	128,712	9.04	7.08
USA	115,197	8.09	8.11
Iran	99,178	6.97	4.90
Hungary	71,651	5.03	5.38
Other countries	244,319	17.16	-

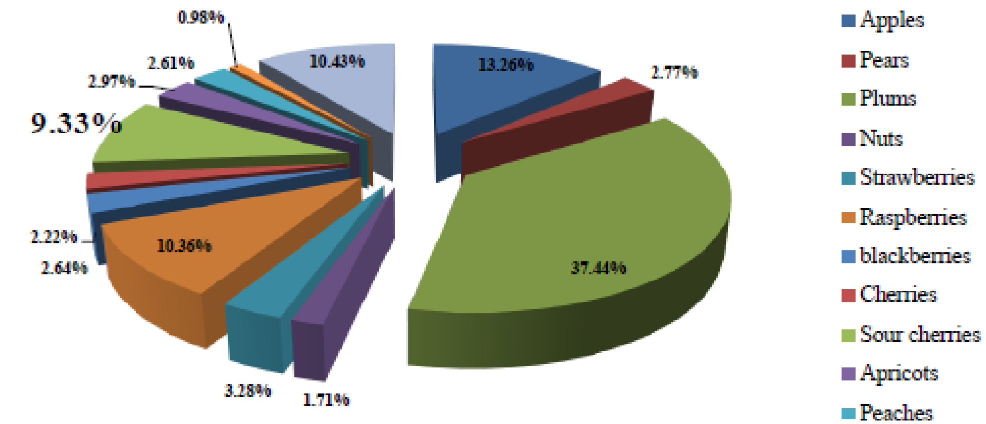
Source: Authors' calculations according to FAO, 2024.

The highest average yield is achieved in Ukraine (9.31 t/ha), followed by Turkey (8.68 t/ha), and USA (8.11 t/ha). The average yield of sour cherries in Serbia is 7.08 t/ha, what is far from the possible genetic potential of this fruit species (15 to 20 t/ha).

Sour cherry production in the Republic of Serbia

Out the twelve-fruit species whose production is monitored by SORS, sour cherries are ranked as the fifth in terms of volume of production. They participate with 9.33% in total fruit production in Serbia (Chart 1.).

Chart 1. Average prevalence of sour cherries and other fruits in Serbia (period 2014-2023., in %)



Source: Authors' calculation according to SORS, 2024.

Based on available SORS data for observed period, the average area under sour cherry plantations in Serbia was 18,240 ha. The largest area, 19,875 ha was harvested in 2022., while the lowest was harvested in 2014., 15,405 ha.

Table 2. Yearly changes in areas under sour cherries in Serbia by regions (period 2014-2023., in ha)

Year	Serbia North		Serbia South		Republic of Serbia (total)	Base index (2014=100)
	Belgrade region	Region of Vojvodina	Šumadija region and West Serbia	Region South and East Serbia		
2014.	744	1,319	2,993	10,349	15,405	100.00
2015.	794	1,385	3,142	10,713	16,034	104.08
2016.	881	1,486	3,273	11,157	16,797	109.04
2017.	986	1,629	3,426	11,525	17,566	114.03
2018.	1,104	2,049	3,637	12,051	18,841	122.30
2019.	1,170	2,034	3,683	12,227	19,114	124.08
2020.	1,204	2,079	3,815	12,503	19,601	127.24
2021.	1,194	2,019	3,804	12,534	19,551	126.91
2022.	1,233	2,112	3,865	12,665	19,875	129.02
2023.	1,245	2,042	3,806	12,521	19,614	127.32
Arithmetic mean	1,056	1,815	3,544	11,825	18,240	-
Standard deviation	180.22	304.55	298.88	794.76	1,571.54	
Coefficient of variation (%)	17.07	16.78	8.43	6.72	8.62	
Participation structure (%)	5.79	9.95	19.43	64.83	100.00	

Source: SORS, 2024. (Statistical yearbooks 2014-2023.).

Defining 2014. as the base for the trends in areas under sour cherry plantations, it can be seen that the areas have been slightly increased until 2022., while in 2023. there came to slight decrease. Observing the growing area by regions, the largest plantations under sour cherry are concentrated in South and Eastern Serbia regions, in average 11,825 ha, with share of 64.83%, while the smallest areas under cherry plantations are in Belgrade region, around 1,056 ha, with share of 5.79%. The coefficient of variation is the most pronounced in Belgrade region (17.07%), while it is the least pronounced in the South and Eastern Serbia region (6.72%), (Table 2.).

The average production of sour cherries in Serbia in researched period was 125,214 t. The highest production was achieved in 2020. (165,738 t), while the lowest was in 2017. (91,660 t). The largest production occurs in Southern and Eastern Serbia, with the share in total production of 67.71%, while the smallest production was realized in Belgrade region, with a participation of 6.14%. In same time, the region of Vojvodina participates with 8.69%, while the region of Šumadija and Western Serbia participate with 17.46% in overall cherry production. There are certain annual variations in overall production. The coefficient of variation ranges from 15.18% (for Belgrade region) to 29.06% (for region of Southern and Eastern Serbia), what could be seen in Table 3.

Table 3. Statistical indicators of sour cherries' production in Serbia by regions (period 2014-2023., in t)

Year	Serbia North		Serbia South		Republic of Serbia (total)	Base index (2014=100)
	Belgrade region	Region of Vojvodina	Šumadija region and West Serbia	Region South and East Serbia		
2014.	5,718	11,933	19,737	66,016	103,404	100.00
2015.	6,641	11,541	19,957	67,010	105,150	101.69
2016.	6,949	11,396	17,439	60,986	96,769	93.58
2017.	7,214	10,903	17,085	56,457	91,660	88.64
2018.	8,811	15,527	24,408	79,277	128,023	123.81
2019.	6,570	10,559	16,549	63,287	96,965	629.44
2020.	9,341	7,929	26,877	121,592	165,738	160.28
2021.	8,516	7,344	25,775	113,502	155,137	150.03
2022.	9,023	11,126	27,163	117,134	164,446	159.03
2023.	8,066	10,563	23,666	102,554	144,849	140.08
Arithmetic mean	7685	10882	21866	84782	125,214	-
Standard deviation	1,166.27	2,118.56	3,963.00	24,639.83	28,427.78	
Coefficient of variation (%)	15.18	19.47	18.12	29.06	22.70	
Participation structure (%)	6.14	8.69	17.46	67.71	100.00	

Source: SORS, 2024. (Statistical yearbooks, 2014-2023.).

The average yield of sour cherries in Serbia for the observed period was 6.8 t/ha. The highest yield was gained in 2020., 8.5 t/ha, while the lowest yield was gained in 2019., 5.1 t/ha. The coefficient of variation ranges from 10.53% to 28.68%, leading to conclusion that the variability of sour cherry yields is relatively weak (Table 4.).

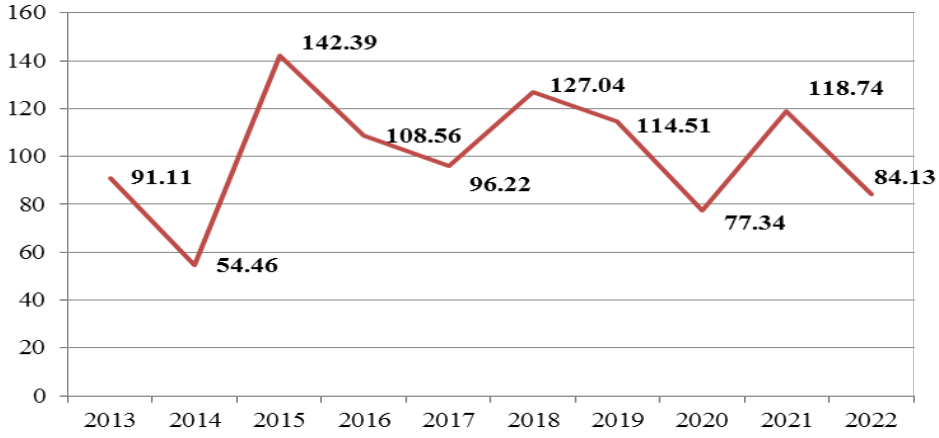
Table 4. Statistical indicators of sour cherries' yield in Serbia by region (period 2014-2023., in t/ha)

Year	Serbia North		Serbia South		Republic of Serbia (total)	Base index (2014=100)
	Belgrade region	Region of Vojvodina	Šumadija region and West Serbia	Region South and East Serbia		
2014.	7.7	9.0	6.6	6.4	6.7	100.00
2015.	8.4	8.3	6.4	6.3	6.6	98.51
2016.	7.9	7.7	5.3	5.5	5.8	86.57
2017.	7.3	6.7	5.0	4.9	5.2	77.61
2018.	8.0	7.6	6.7	6.6	6.8	101.49
2019.	5.6	5.2	4.5	5.2	5.1	76.12
2020.	7.8	3.8	7.0	9.7	8.5	126.87
2021.	7.1	3.6	6.8	9.1	7.9	117.91
2022.	7.3	5.3	7.0	9.2	8.3	123.88
2023.	6.5	5.2	6.2	8.2	7.4	110.45
Arithmetic mean	7.4	6.2	6.2	7.1	6.8	-
Standard deviation	0.77	1.79	0.85	1.70	1.15	
Coefficient of variation (%)	10.53	28.68	13.80	23.86	16.82	

Source: SORS, 2024. (Statistical yearbooks, 2014-2023.).

The purchase price of sour cherries is mainly determined by the unstable market of agricultural products at national level.

Chart 2. Purchase prices of sour cherries (period 2013-2022., in RSD/kg)



Source: MAFWM, 2024.

The largest quantities of purchased sour cherries are stored in cold storage, while later exported. Very small quantities are used fresh (for consumption, or sale at the markets). Purchase prices of sour cherries for the period 2013-2022. are shown in Chart 2. The average purchase price for the observed period is 100.00 RSD/kg, with the highest value achieved in 2018. (127.04 RSD/kg). In contrast, the lowest price was in 2014., only 54.46 RSD/kg.

Issues and measures towards improvement of sour cherry production in Serbia

As the main problems in the production of sour cherries, as well as in their marketing in Serbia, next could be singled out:

- fragmentation of plots under sour cherry plantations;
- extensive production;
- use of outdated machinery and technology;
- lack of irrigation system and anti-hail nets;
- rather high investments in the revitalization of old, than in raising new plantations;
- the lack of sufficient associations of sour cherry producers or agricultural cooperatives, leads to that producers act on the market independently and without connection with other producers;
- low and uncertainty in repurchase price and unregulated national market;
- only first-class fruits have guaranteed placement;
- lack of pickers (labor issues) during the pick of harvest season;
- the absence of a common strategy for the export of sour cherries to foreign markets, etc.

As the measure to improve sour cherry production, it is necessary to introduce new, modern technology into the production process in order to reduce costs. Producers must join together in order to provide mechanization for common picking, which would save the time and reduce the number of pickers. The associated producers would more easily provide irrigation systems, and further increase the yields. As was retained, producers can apply to the Ministry of Agriculture for funds intended for underdeveloped areas for the purchase of cold storages. This is important in order to decrease the impact of monopolists (certain wholesalers and processors).

The renewal of cooperatives is an opportunity for small scale producers to self-organize and establish control over the produced output. Joint performance after joining their production capacities is a chance to sustain the monopoly of large producers and extremely demanding market. Besides, it is so important to protect the Oblačinska sour cherry as the Serbian brand, which can be achieved by unifying the quality of produced sour cherries throughout Serbia.

Among the most important measures due to improvement sour cherry production within the national fruit production provided by the MAFWM, next could be underlined: incentives for establishment of new plantations through reimbursement of costs of purchased seedlings, support for chemical analysis of soil with recommendation how to fertilize, i.e. examination of the soil mechanical composition, as well as preparation and treatment of the soil, etc.

Conclusion

Sour cherry is one of the most significant fruit species in Serbia. It has great importance for population in rural areas, where the growing of sour cherries represents the main source of income for many families. Growth in production volume and exports can ensure a better living standard for many family farms engaged in mentioned production. On the other hand, given that Serbia is one of the main exporters of sour cherries to Europe, its production can significantly contribute to further strengthening of national agriculture and overall economy, as well as increasing the competitiveness of Serbian agriculture on the international market.

Serbia is ranked as the sixth among world producers of sour cherry, having a share in global production of 9.04%. At national level, sour cherries participate with 9.33% in total fruit production. The average production of 125,214 t is realized, in average on 18,240 ha under sour cherry plantations, while the realized production was being the highest in the Šumadija and Western Serbia region, or the lowest in the Belgrade region. On other hand, the highest yield was achieved in Belgrade region (7.4 t/ha). In average, the annual yield has been reaching around 6.8 t/ha, which is far below the yield that can be theoretically achieved. The coefficient of variation towards the production areas, volume of production and obtained yields is relatively small, meaning that production is currently stable, but needs to be improved and increased. In observed period, sour cherries were purchased at average price of 100.00 RSD/kg, reflecting the relatively lower prices, while describing the market generally uncertain and unstable.

The key factor for advancement of sour cherry production is its modernization in terms of introducing the new and innovative technologies, together with strong market focus. To fight for market position that is becoming increasingly demanding due to products' safety and quality, usually involves going in direction of modern trends in fruit growing development. Therefore, it is necessary to invest in modern technology with the application of EU standards. Besides, it is necessary to unite small scale producers with the provision of financial and institutional support, then to promote sour cherry products, as well as to enable joint exit to the (inter)national market.

State support, primarily through the Ministry of Agriculture plays a significant role towards previously mentioned activities. In line to above mentioned, further research steps will be focused to innovative technologies occurred in sour cherry production in those regions in Serbia where it is intensively grown.

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HUMAN CAPITAL DEVELOPMENT AND AGRICULTURAL PRODUCTION IN CAMEROON

Udeme Henrietta Ukpe[1]

Abstract

This study explores the influence of human capital development on agricultural production in Cameroon, while utilizing the data from 2000. to 2023. and analyzed them through quantile regression. The findings indicate that 78% of the variation in agricultural production is accounted for education expenditure, health expenditure, agricultural labor, and land use, which all exert a positive and significant influence on agricultural output. Conversely, fertilizers' use negatively and significantly affects production, likely due to inefficient or excessive application leading to soil degradation. The analysis further highlights that balanced investments in both education and health are essential for enhancing agricultural productivity, while imbalances in these expenditures can result in reduced output. The study underscores the importance of targeted investments in human capital development and sustainable farming practices to optimize agricultural production in Cameroon.

Key words: Human capital development, agricultural production, Cameroon, education, labor productivity.

JEL[2]**:** C53, Q18, O11

Introduction

Human capital development is an essential element of agricultural production, particularly in developing countries like Cameroon, where agriculture remains a significant part of the economy as a whole. It involves skills, knowledge, and experience of individuals, while it is essential in boosting productivity and advancing sustainable development within the agricultural sector. In Cameroon, where agriculture contributes around 23% to the GDP and employs nearly 70% of the labor force, the relationship between human capital development and agricultural productivity is particularly significant (WB, 2021).

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Human capital is regarded as a mix of knowledge, skills, habits, and precious experience possessed by individuals or groups, which contributes to the value of a country's organizations (Tasheva, Hillman, 2019; Gruzina et al., 2021). It has often been used worldwide as a key indicator of economic and social development (Kotsantonis, Serafeim, 2020; Gruzina et al., 2021). Throughout progress of civilization, several significant shifts and upheavals have totally transformed socio-economic relationships, shaping the concept of human capital. Mentioned changes have influenced the innovation and development of knowledge, and the formation of the global order (Hippe, 2020; Surya et al., 2020; Gruzina et al., 2021).

In addition to physical capital, human capital (including knowledge and technical expertise) is recognized as a key factor contributing to productivity growth. It is understood as the collective economic value of individuals functioning within economies, encompassing attributes as are knowledge, abilities, skills, habits, experience, health status, intelligence, training, clear judgment, and wisdom (James, 2021; Ndibe, 2022). Moreover, developing human capital can be categorized into six areas: a) medic care facilities and services, which encompass expenditures that improve life expectancy, strength, stamina, vigor, and vitality; b) on-the-job training, including traditional apprenticeships offered by companies; c) formal education through all three levels of basic education; d) adult education programs outside agriculture; e) single or family migrations in order to adapt to shifting job opportunities (factors mobility); and f) internal and external knowledge transfers, combined with technical assistance, expert opinions and recommendations (Ogunniyi, 2018; Ndibe, 2022).

It is important to recognize that human capital serves, both as driver and outcome of development of agro-economy. Developing human capital in agricultural sector is complex challenge, especially in the context of technological modernization of agricultural production. Addressing this challenge requires tackling a series of theoretical and practical issues aimed at securing the country's food independence, enhancing the competitiveness of agricultural products, improving the quality of life for rural populations, promoting innovation and innovative development of agro-industrial production, or boosting the productivity of agricultural labor (Zaika, Gridin, 2020).

Strengthening mentioned services is crucial for enhancing the capacity of farmers in Cameroon, particularly to face the challenges such as climate change, market fluctuations, or resource constraints. In Cameroon, where a substantial portion of the population depends on agriculture for their livelihoods, enhancing human capital is essential for achieving sustainable agricultural development and improving the well-being of rural communities.

Human capital development is critical driver of agricultural productivity in Cameroon. Enhancing skills and knowledge of agricultural workforce through education, training, and improved extension service can lead to significant improvements in farming output, nutritional stability, and reduction of poverty. Given the importance of agriculture to the Cameroonian economy, targeted investments in human capital are essential for achieving long-term development goals.

Relating to human capital development, agricultural production is essential for several reasons. Firstly, agriculture remains a vital sector in many developing countries, including Cameroon, where it contributes significantly to both GDP and employment (WB, 2021). By exploring the relationship between human capital and agricultural production, studies can identify the key areas where investment in education and training can lead to substantial improvements in productivity and sustainability.

Research in this area can provide valuable insights into how targeted educational programs and extension services can bridge the information gap among farmers and encourage innovations that enhance productivity.

For countries like Cameroon, where a significant share of population relies on agriculture for their livelihood, such a research is vital for designing effective interventions that can drive sustainable development. Therefore, studies that explore the impact of human capital on agricultural production can contribute to resilience of agricultural sector in the face of global challenges.

The link between human capital development and agricultural production is critical for enhancing productivity, promoting sustainable practices, and improving the overall well-being of rural populations. By providing evidence-based insights, this research can guide investments in education and training that are necessary for the long-term growth and sustainability of the agricultural sector. This study aims to analyze the effects of human capital development on agricultural production in Cameroon.

Literature Review

Theory on human capital

The human capital theory is rooted from work of economists such as Gary Becker and Theodore Schultz, who emphasized the importance of investing in individuals' skills, knowledge, and abilities to enhance productivity. Human capital theory posits that education, training, and health are forms of capital in which individuals and societies can invest to increase economic productivity (Schultz, 1961; Becker, 1964). This theory suggests that only physical capital (like mechanization, equipment, and contents of physical infrastructure) contributes to production, so does human capital, as a more educated and skilled workforce is more efficient, innovative, and capable of adapting to new technologies. In the context of agriculture, human capital development is critical for adopting improved agricultural practices, increasing efficiency, and responding to environmental and market changes. Farmers with better education and training are more likely to understand and implement advanced farming techniques, leading to higher yields and more sustainable agricultural practices (Evenson, Gollin, 2003). Mentioned theory underscores the need for continuous investment in education and skills development to ensure long-term economic growth and development, particularly in sectors like agriculture, where productivity gains can have significant impact on food security and poverty reduction.

Numerous empirical studies have researched the relations between human capital development and agricultural production, providing evidence to support the theoretical framework. For instance, a study by Shvakov et al. (2022) examined the components of human capital that are essential for development in modern conditions and propose a methodology to evaluate its adequacy for organizing effective agricultural production and ensuring national food security. They also provided a justification for government regulatory measures in the areas of education and labor migration, aimed at fostering the creation of human capital necessary for the efficient establishment of agricultural production and securing the food security at national level.

Similarly, Rasanjali et al. (2021) have been demonstrated that training programs led to increase in the use of high-yielding crop varieties. Additionally, their study revealed a significant difference in individuals' gross income, indicating that with proper instruction and guidance from agricultural instructors, farmers were able to achieve higher yields and consequently higher incomes.

In another study, Baiyegunhi (2024) validated the causal links between human capital (such as on-the-job training) and farmers' innovation behavior, which in turn enhances farm productivity. This highlights the importance of developing human capital to drive innovation and improve productivity in the sector of agriculture.

Osinowo et al. (2021) provided evidence that agricultural productivity increases with investments in human capital. Consequently, they recommended farmers' capacity building at the micro level, how this would advance crop, soil, and water management while also boosting the demand for and use of more efficient inputs to enhance agricultural productivity. James (2021) found that life expectancy is crucial factor influencing the growth of agriculture in Nigeria.

Karpova and Muravieva (2019) proposed methods for the effective utilization of human capital that could be adopted by agricultural companies, aiming to increase overall production profitability through enhanced human resources, viable growth of productivity, and more efficient appliance of both, fixed and current assets.

Methodology

Data sources

Data used for this study are mainly focused on Cameroon. Annual time series from 2000. to 2023. were gotten from secondary sources. The World Bank (WB) database indicators for Education and Health expenditures were used, as well as FAO statistics for land use, and fertilizer consumption, or International Labor Organization (ILO) for agricultural labor.

Techniques of data analysis

Quantile regression was used to analyze the impact of Education and Health expenditures on agricultural production.

Model specification

A major benefit of quantile regression is its robustness to outliers. Unlike ordinary least squares (OLS) regression, which minimizes the sum of squared residuals and can be heavily influenced by extreme values, quantile regression minimizes the sum of absolute residuals at each quantile. This makes it less sensitive to outliers, allowing for a more accurate representation of the underlying data distribution (Koenker, Bassett, 1978).

Quantile regression provides a more comprehensive analysis of the conditional distribution of the dependent variable by estimating the relationship between the independent variables and different points (quantiles) in the distribution of the dependent variable. This is particularly useful in time series datasets, where relationships may vary across different levels of the dependent variable, such as confrontation of periods of economic growth and recession (Cai, Stoyanov, 2014). While traditional time series models often assume a linear relationship between variables, quantile regression allows for the estimation of different slopes at different quantiles, thereby capturing the complexity of the relationship between variables over time (Koenker, 2005). Finally, quantile regression is advantageous when dealing with heteroscedasticity, situations where the variance of errors changes over time. Since it does not assume constant variance across the distribution, it can effectively model time series data where volatility, or risk is not constant, providing a more accurate picture of underlying dynamics (Koenker, Hallock, 2001). Mentioned method could be expressed by next mathematic model:

$$Qy_t = (\tau|\text{Education Expenditure}_t, \text{Fertizer Use}_t, \text{Health Expenditure}_t, \text{Agricultural Labour}_t, \text{Land Use}_t) \\ = \beta_0(\tau) + \beta_1(\tau)\text{Education Expenditure}_t + \beta_2(\tau)\text{Fertizer Use}_t \\ + \beta_3(\tau)\text{Health Expenditure}_t + \beta_4(\tau)\text{Agricultural Labour}_t + \beta_5(\tau)\text{Land Use}_t + \varepsilon_t$$

Where, Education Expenditure is measured in FCFA, Fertilizer Use is measured in kg/ha, Health Expenditure is measured in FCFA, Agricultural Labor is measured in number of persons, Land Use is measured in hectares, $\beta_{i,\tau}$ for i = 1, 2, 3, 4, and 5 are the coefficients associated with the independent variables at quantile τ, ε_t is the error term at time t.

The impact of varying scenarios of effect of Education and Health expenditures on agricultural production was assessed. Specifically, the simulating agricultural production (Y^*_{it}) model looks like:

$$E(f(X_i)) = \acute{\theta}_N = \frac{1}{N}\sum_{i=1}^{N} f(X_{it})$$

Where, X represents vector of agricultural production determinants, θ is the dependent variable (Y^*_{it})

$$Y^*_{it} = \beta_0 + +\beta_1(\tau)(\text{Education Expenditure}_t + \vartheta_{1,it}) + \\ \beta_2(\tau)\text{Fertilizer Use}_t + \beta_3(\tau)\text{Land Use}_t + \beta_4(\tau)\text{Agricultural Labour}_t + \\ \beta_5(\tau)(\text{Health Expenditure}_t + \vartheta_{5,it}) + \varepsilon_t$$

Where, $\vartheta_{1,it}$ *and* $\vartheta_{5,it}$ represent the uncertainty in the measurement of agricultural production. Considering the structure of this model, the behavior of agricultural production across different scenarios is analyzed. The simulation scenarios include assessing the effect of changes in Education and Health expenditure on agricultural production, each by 30%. The scenario analysis did not consider the effect of changes in the input factors on agricultural production. Thereby, limiting the policy advisory on how to revamp the agricultural production in Cameroon.

Results and Discussion

Impact of changes in education and health expenditures on agricultural production

The findings linked to effects of human capital development on agricultural production is presented in Table 1. They show that the pseudo R^2 is 0.78, showing that 78% of variation in agricultural production could be explained by selected variables used in model. In addition, findings show that education expenditure, health expenditure, agricultural labor, and land use positively and significantly increase agricultural production. In contrast, fertilizer use negatively and significantly decrease agricultural production. For instance, increased investment in education has a positive impact on agricultural production. Education enhances the skills and knowledge of farmers, leading to better decision-making, adoption of modern techniques, and ultimately higher productivity. This aligns with Ninh (2021), who was determined that education positively influences the output of rice farming households in Vietnam.

Table 1. Impact of human capital development on agricultural production

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Education Expenditure	0.232669	0.076414	3.044853***	0.0070
Fertilizer Use	-0.234268	0.083123	-2.818322***	0.0114
Health Expenditure	0.539680	0.084315	6.400757***	0.0000
Agricultural Labor	1.000732	0.189009	5.294629***	0.0000
Land Use	2.074484	0.676954	3.064440***	0.0067
C	-16.57927	7.699532	-2.153283	0.0451
Pseudo R-squared	0.783138	Mean dependent var		22.32137
Adjusted R-squared	0.722898	S.D. dependent var		0.627122
S.E. of regression	0.405390	Objective		1.060511
Quantile dependent var	22.33729	Restr. Objective		4.890245
Sparsity	0.059611	Quasi-LR statistic		513.9611
Prob (Quasi-LR stat)	0.000000	-		-

Source: Author's analysis.

Note: *** is significant at 1% level of probability.

Health expenditure is also positively linked to agricultural production. Healthier farmers are more productive, as good health reduces absenteeism due to illness and increases the physical and mental capacity to work effectively. As highlighted by Tenriawaru et al. (2021), the allocation of funds to the health sector appears to influence the enhancement of health outcomes, which in turn impacts the agricultural sector by contributing to consistent year-on-year growth in the production of key commodities.

The amount of land available and its efficient use directly impact agricultural production. Expanding arable land and optimizing its use through practices like crop rotation and sustainable farming leads to higher output. "Effective land use management plays a critical role in boosting agricultural yields" as has been noted by Allen and Ulimwengu (2015).

Availability of labor is crucial for agricultural production, as more labor force dedicated to farming activities generally leads to increase in productivity, especially in labor-intensive agricultural practices. According to Ursu et al. (2023), agricultural labor force plays crucial role in determining production levels.

The relationship between agricultural production and fertilizer use can be negative, particularly when fertilizers are overused or used inefficiently. Excessive fertilizers application can lead to soil degradation, reduced soil fertility over time, and environmental harm, all of which negatively affect agricultural output. "Excessive reliance on fertilizers has been associated with diminishing returns in crop yields and long-term soil health deterioration", as was observed by Zheng et al. (2022).

Impact of changes in education and health expenditures on agricultural production

The impact of changes in education and health expenditures on agricultural production were analyzed by the use of four scenarios. The figures presented (Figure 1-4.) show that when both education and health expenditures increase, agricultural production tends to rise. Investment in education equips farmers with the skills and knowledge necessary to adopt modern farming techniques, leading to higher productivity and profitability. Simultaneously, improved health services enhance the physical and mental well-being of the agricultural labor force, reducing absenteeism and increasing efficiency, as was noted by Kabiru (2020). Combined impact of increased education and health expenditures significantly enhances agricultural productivity, as farmers become better educated and healthier, allowing them to perform activities more efficiently. On the other hand, a decrease in education and health expenditures usually results in a decline in agricultural production. In developing countries, at households involved in agriculture, financial strain due to illness can severely impact their investment and production choices. Limited access to timely healthcare can further hinder production, leading to income losses that may continue over an extended period (Liu et al., 2024).

In scenario where education expenditure decreases while health expenditure increases, agricultural production may still decline. Although improved health conditions can sustain, the physical capacity of the workforce, lack of education restricts the adoption of advanced agricultural practices and technologies. Even with better health services, reduced investment in education can hinder agricultural productivity, as observed by Ninh (2021).

An increase in education expenditure combined with decrease in health expenditure presents a mixed outcome. While better education can empower farmers with advanced knowledge and skills, reduced health expenditure may lead to a decline in workforce efficiency due to increased illness and absenteeism. Increased educational investments may improve farming techniques, but without adequate health care, the productivity level in the agricultural sector is likely to decline as pointed out by Tenriawaru et al. (2021).

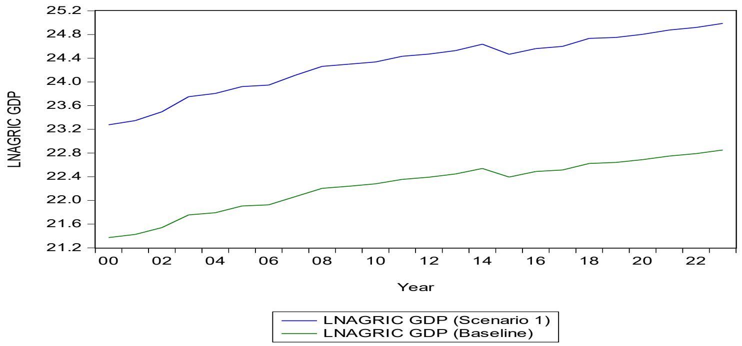

Figure 1. Impact of increases in education and health expenditures on agricultural production

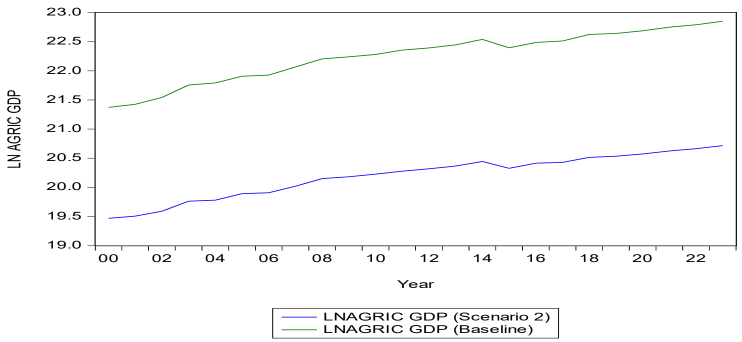

Figure 2. Impact of decreases in education and health expenditures on agricultural production

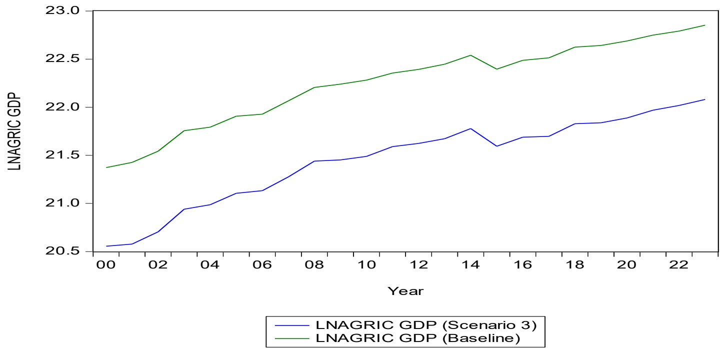

Figure 3. Impact of decrease in education expenditure and increase in health expenditure on agricultural production

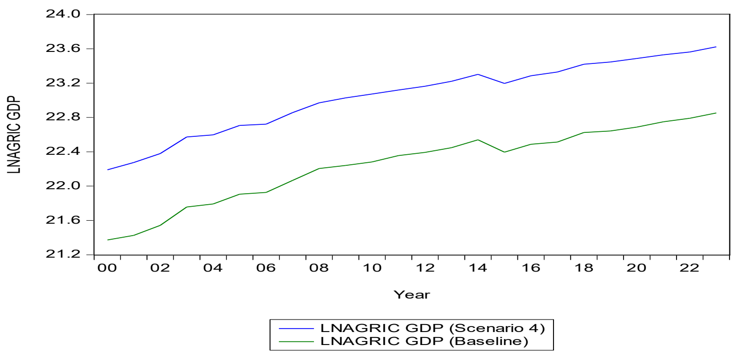

Figure 4. Impact of increase in education expenditure and decrease in health expenditure on agricultural production

The summary statistics presented in Table 2. shows that the combined increases of public health and education expenditures (Scenario 1.) ranges between 23.27 and 24.98 with the average of 24.30, as compared with the average baseline of 22.24. This shows how important are the investments in the education and health sectors for the sustainability of the agricultural sector.

Table 2. Summary statistics

Element	Baseline	Scenario 1.	Scenario 2.	Scenario 3.	Scenario 4.
Mean	22.24985	24.30509	20.19462	21.45548	23.04423
Median	22.37444	24.44923	20.29761	21.59233	23.14192
Maximum	22.85208	24.98825	20.71592	22.08128	23.62289
Minimum	21.37268	23.27736	19.46801	20.55605	22.18932
Std. Dev.	0.435105	0.496953	0.373534	0.450227	0.420636
Skewness	-0.600761	-0.640989	-0.550394	-0.641494	-0.553934
Kurtosis	2.290415	2.388414	2.170204	2.351545	2.227074
Jarque-Bera	1.947164	2.017503	1.900297	2.066553	1.824785
Probability	0.377728	0.364674	0.386684	0.355839	0.401562
Sum	533.9965	583.3221	484.6709	514.9316	553.0614
Sum Sq. Dev.	4.354272	5.680141	3.209134	4.662192	4.069506
Observations	24	24	24	24	24

Source: Author's computation

For the decreases in public education and health expenditures, it ranges between 19.46 and 20.71 with average of 20.19, as compare with the average baseline of 22.24. This shows that limited investment in training and health transforms into drastic reduction in agricultural output. For the decrease in public education and increase in health expenditures, it ranges between 20.55 and 22.08 with average of 21.45, as compare with the average baseline of 22.24. This shows that limited investment in training could significantly impact on agricultural production. Finally, for the increase in public education and decrease in health expenditures, it ranges between 22.18 and 23.62 with average of 23.04, as compare with the average baseline of 22.24. This shows that limited investment in health sector significantly affect labor productivity which translate into a decrease in agricultural production.

Conclusion and Recommendations

This study reveals that education expenditure, health expenditure, agricultural labor, and land use are positively and significantly associated with increased agricultural production. These factors collectively contribute to better decision-making, adoption of modern techniques, and improved labor efficiency, all of which enhance agricultural output. Conversely, fertilizer use, when applied excessively or inefficiently, has a negative and significant impact on agricultural production, leading to soil degradation and reduced productivity.

The analysis of different scenarios highlights that balanced investments in both education and health are crucial for sustaining agricultural productivity. Increases in both education and health expenditures significantly boost agricultural output, while reductions in these expenditures lead to declines in productivity. Mixed scenarios where one expenditure increases while the other decreases demonstrate the complex interplay between these factors and importance of their simultaneous enhancement to achieve optimal agricultural outcomes. According to previous, it is recommended:

I. To maximize agricultural productivity, the Cameroonian government and stakeholders should prioritize and increase investments in both education and health sectors. This dual approach will empower farmers with the necessary skills and ensure healthy workforce capable to implement modern agricultural practices effectively.

II. Agricultural policies should focus on promoting the efficient and sustainable use of fertilizers. Farmers should be educated to proper apply the fertilizers due to prevention of soil degradation and to ensure long-term productivity. Encouraging the use of organic fertilizers and integrated soil fertility management practices can also mitigate the negative effects associated with excessive fertilizers use.

III. Expanding arable land and optimizing its use through sustainable farming practices, such as crop rotation and conservation agriculture, should be encouraged. Effective land management strategies will contribute to higher agricultural yields and long-term sustainability.

IV. Given the significant role of labor in agricultural production, there should be initiatives aimed at developing agricultural labor force. This includes training programs to improve labor skills and efforts to attract more workers into the agricultural sector, particularly in regions where mechanization is limited.

V. Policymakers should adopt a balanced approach to human capital development by ensuring that both education and health expenditures are simultaneously enhanced. This will prevent the negative effects seen in scenarios where one is increased at the expense of other, thereby sustaining and improving agricultural productivity in Cameroon.

In further research steps it could be essential to evaluate the sensitivity of input factors on agricultural production to support effective policy advocacy.

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SMART AGRICULTURE, DATA AND AI IN THE CONTEXT OF COBIT 2019: ANALYSIS OF POTENTIALS AND RISKS[1]

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Abstract

Modern agriculture, which is becoming an increasingly interesting topic in scientific circles, has been commonly linked to widely widespread application in practice. Actually, it represents a comprehensive integration of smart solutions in agriculture, dominantly driven by progress in data analysis and artificial intelligence, and as such represents a direct and unambiguous significant shift in modern agricultural structures. The aim of the paper is to consider the potential benefits and associated risks in the implementation of smart agriculture. By presenting the essential elements of smart agriculture, and above all the decision-making process with the application of artificial intelligence and large-scale data management, the paper aims to provide a balanced perspective on how these technologies can improve business success in agriculture. At the same time, the subject of the work is consideration of the challenges of managing information technologies in smart agriculture. The results of the work provide a significant contribution to risk management using the various possibilities of smart agriculture. Derived conclusion shows that the main risks in new technologies use in agriculture in many countries is insufficient knowledge towards technology and high costs of its use, while its greatest potential is increasing the incomes with the less engagement of human factor.

Key words: Smart agriculture, COBIT 2019, artificial intelligence.

JEL[5]: O00, O32, Q10

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Introduction

Sudden transformation that haven't bypass the sector of agriculture was caused by digital technologies, among which tools for the analysis of large amounts of data, as well as artificial intelligence (AI), stand out. Modern, smart agriculture (Photo 1.), which is actually the application of modern technology to traditional agricultural activities, brings increased productivity and efficiency, followed by increased volume and gained quality of agri-food outputs (products), while preserving the sustainability of the environment and applying the smart management under the scarce resources (Paarlberg, 2009; Subeesh, Mehta, 2021; Audia, Sugiantoro, 2022). By basing their activity on real-time data and numerous activities driven by advanced digital technologies and AI, agricultural producers can optimize crop yields, eliminate or decrease environmental impact and improve overall operational efficiency (Javaid et al., 2022; Haidar, 2024).

Photo 1. Smart agriculture

Source: Authors by https://create.microsoft.com/en-us/features/ai-image-generator

However, implementation of the concept of modern, smart agriculture accelerates new challenges, such those created in data management, application costs, data sorting, or data storage, but also these linked to cyber security and compliance with legal regulations and international food safety practices (Zhu et al., 2018; Osinga et al., 2022).

The sheer volume of data generated by the application of modern tools, which combined with the complexity of AI algorithms, requires very extensive governance to address the risks and provide all benefits of used technologies are fully realized (Kallem, 2012). Among them, one of the most relevant is COBIT 2019, a globally well-known management framework, which enables structured approach to solving previously mentioned challenges (De Haes et al., 2020; Amorim et al., 2021). It offers principles, practices and tools that can contribute to better data management when applying the concept of smart agriculture, primarily in the protection of applied information technologies from cyber security and related risks (Rupnik et al., 2021).

Methodological Framework

Performed research encompasses methods commonly used in social sciences, such as desktop research, as well as analysis and synthesis, which facilitate a better understanding of the observed topic, while drawing appropriate conclusions. Methods used are supported by theoretical perception and understanding of “Smart Agriculture” data and AI in the context of COBIT 2019, identifying key segments and impacts of mentioned framework on current state of agriculture. Writing the paper involved the use of available scientific and professional literature sources.

This research aims to analyze the potentials and risks towards the integration of smart agriculture in the context of COBIT 2019. By exploring the interconnections and entanglements between AI, data analytics and governance patterns, paper aims to secure unique, contemporary, and comprehensive insight and understanding how these elements can be aligned to improve agricultural production while mitigating occurred risk.

Results and Discussion

COBIT 2019

COBIT 2019 in its title corresponds to Control Objectives for Information and Related Technologies. It is a complex framework established to help organizations to manage applied information technology. It is designed by the Information Systems Audit and Control Association (ISACA). It is built on previous versions of COBIT, providing updated management guidance (Thabit, 2021; Kesuma et al., 2022). COBIT 2019 is very applicable in various activities, including agricultural production, ensuring that applied information systems, involving AI and other processes, support business goals, while they are subject to effective risk management, complying with relevant legislation and regulations. COBIT 2019 is designed to be adaptable, allowing agricultural producers to adapt the framework to their activities, offering a clear and measurable approach to management (Birkstedt et al., 2023; Smit, 2023).

The framework defines management as a system of setting goals, assessing risks and ensuring mutual compliance, clearly identifying the components that make up the management system (Figure 1.). COBIT 2019 framework is based on result management system that can significantly help agricultural producers to assess and improve the maturity of their data management practices, risks and potentials. It provides detailed guidelines for implementing appropriate performance metrics and very clear and unambiguous maturity models for monitoring progress. It includes a design guide and implementation guide, which offer practical advice on how to adapt and apply the framework within someone who owns farming system. These guides help align the framework with business goals and address specific management challenges (Nachrowi et al., 2020; Rusman et al., 2022).

Figure 1. COBIT 2019. elements

Processes	• Describe how information processes should be structured and subject to management.
Organizational structures	• Define roles and responsibilities within organization (farm, agricultural company).
Principles, policies and frameworks	• Provide guidance on decision-making.
Culture, ethics and behavior	• Relate to human resource management and cultural aspects of management.
Information	• Ensure that accurate and timely information is available for decision making.
Services, infrastructure and applications	• Refers to the technology and tools needed to support management.
People, skills and competences	• Focuses on ensuring that farm or agricultural company have necessary skills and expertise.

Source: ISACA, 2018.

COBIT 2019. emphasizes understanding all stakeholder imperatives, ensuring that information technology management in agricultural production is aligned with business goals and provide added value. This includes balancing stakeholder expectations and effective risk management (Chawviang, Kiattisin, 2022). Agricultural producers can use COBIT 2019 to establish robust management framework that aligns application of new technologies and AI with production goals, while providing tools and processes to identify, assess and mitigate different risks (De Goede et al., 2022). System supports agricultural producers to understand the complexity of regulatory environment by ensuring that implemented processes and related information technologies in agriculture complying with relevant laws and agricultural products safety standards (Audia, Sugiantoro, 2022; Radjulan et al., 2024).

Potentials

Smart agriculture, through its integration of contemporary technologies, as are the new digital tools, use of drones, application of AI, big data analysis and numerous other innovative technologies, offers a wide range of advantages that transform traditional agricultural activities by giving them a new, modern meaning (Goel et al., 2021; Fuentes Peñailillo et al., 2024).

These benefits affect not only the efficiency and productivity of agricultural operations, but also contribute to environmental sustainability, economic growth and food security. Smart agriculture enables precise application of inputs as are water, mineral and organic fertilizers, agro-chemicals, or animal feed. Using system data and AI-driven analysis, farmers can use and apply inputs exactly where and when they are required, decreasing waste and optimizing their use. Involvement of autonomous machines, drones and robots reduces the need for manual labor, what is surely useful in remote areas or areas facing labor shortage (Shafi et al., 2019; Shaikh et al., 2022). Activities such as planting, weeding, fertilizing, irrigating, or harvesting can be automated, saving time and reducing labor costs (Subić et al., 2017).

By applying modern AI-assisted data analysis techniques, it is possible to analyze the state of soil and crops' health, weather patterns, etc. to enable insight that optimizes planting and irrigation schedules, and nutrient management (Javaid et al., 2023). This leads to higher crop yields and better products' quality. Continuous monitoring of crops and livestock using smart sensors and drones provides real-time data, allowing farmers to make informed decisions quickly. This can prevent crop losses due to pests, diseases or adverse weather conditions. On the other hand, precision farming techniques minimize the excessive use of chemicals, which leads to a reduction in environmental pollution and a lower risk of chemical residues in food (Bongiovanni, Lowenberg Deboer, 2004; Liang, Shah, 2023). Smart irrigation systems use data sets and predefine procedures to apply water just where and when it is required, decreasing water loss and helping to conserve this highly sensitive resource, especially in agricultural production. This is especially important on agricultural arable land that faces water shortages (Bwambale et al., 2022).

By optimizing the use of water and agro-chemicals, it is possible to further reduce input costs. Farmers can achieve better results with fewer resources, leading to higher yields per hectare. At the same time, timely detection of pests and other threats through real-time monitoring enables timely interventions, reduction in crop losses and general improvement in gained yields. The ability of smart agriculture to increase productivity ensures that more food can be produced on the same area of arable land. Simultaneously, it contributes to conversion of uncultivable land into arable land, capable for producing large quantities of quality agri-food products. Advanced technologies support farmers adapt to changing climates by providing data-driven insights into how best to manage crops in different weather conditions (Agrimonti et al., 2020; Maraveas et al., 2022).

Data analytics can optimize feeding schedules and breeding programs, ensuring livestock are healthier, facilitate grow, or reproduction more efficiently. Smart agriculture gives farmers access to vast amounts of data, which, when analyzed, can lead to better decision-making. Farmers can plan production cycle more effectively, or better predict outcomes and adjust their strategies based on data-driven insights. Historical data and predictive analytics enable long-term planning, helping farmers anticipate future challenges and opportunities, such as changes in market demand or climate change (Coble et al., 2018; Jakovljevic et al., 2024).

Smart agriculture technologies enable product tracking from farm to fork, increasing transparency in supply chain. This is very important for consumers who demand visibility of origin and quality of used food (Qureshi et al., 2022). Better planning and real-time data can help reduce post-harvest losses by ensuring crops are timely harvested, stored and transported under optimal conditions, reducing food waste. The adoption of smart agriculture technologies can stimulate economic growth in rural territories through the increase in farm productivity, creating new jobs opportunities in technology-driven agriculture, and attracting investment in agricultural technology. Farmers who adopt smart agriculture can produce higher quality and larger quantities of products at a lower cost, making them more competitive in local and global markets (Ranganathan et al., 2022; Franzel et al., 2019).

Smart agricultural technologies can be adapted to fit the specific needs of different crops, regions, or farming practices. This adaptability ensures that the benefits of smart agriculture can be realized in a variety of agricultural contexts, from large commercial farms to smallholder operations. So, smart agriculture offers a few benefits that advance the economic viability and overall sustainability of agricultural practices. By using advanced technologies, farmers can achieve greater control over their operations, decrease environmental impacts and support the worldwide food security, while improving their economic performances. As these technologies continue to develop, the potential for smart agriculture to revolutionize the agricultural sector will only increase (Mwongera et al., 2017; Birkstedt et al., 2023).

Risks

There are numerous risks that smart agriculture brings. These risks can have significant implications for agricultural producers, but also for consumers and real-life cycle of agri-food products. Understanding and managing risks is essential for the successful and sustainable involvement of smart agriculture (Komarek et al., 2020). Appliance of advanced technologies and connected systems produce huge datasets, including sensitive information. This data is vulnerable to cyber-attacks, what can lead to data breaches, theft or manipulation. Cybercriminals can target agricultural systems with malware or ransomware, potentially disrupting critical operations such as irrigation, fertilization, or harvesting. Such attacks can cause significant financial losses and downtime. These vulnerabilities can be exploited to gain unauthorized access to agricultural systems, leading to potential sabotage or data manipulation (Balyan et al., 2024; Ali et al., 2024).

Collecting data from various sources, including farmers, employees and customers, raises data privacy concerns. If personal information is not properly secured, it could be exposed or misused, leading to legal and ethical issues. In many cases, it can be unclear who owns the data, and disputes over data ownership and rights of use can arise, especially when third-party service providers are involved (Wiseman et al., 2019).

As farms rely more and more on technology, any malfunction or breakdown in mentioned systems can have serious consequences. The adoption of smart agriculture requires a certain level of technical expertise, which may be lacking in some farming communities. Farmers who do not possess the necessary skills to operate and maintain new technologies may struggle to realize their full benefits (Farooq et al., 2020). The effectiveness of smart agriculture depends mostly on the accuracy of data collected by smart devices. However, these devices can sometimes produce inaccurate or incomplete data due to technical problems, environmental factors, or calibration errors. Decisions based on faulty data can lead to suboptimal outcomes. The sheer volume of data generated by a smart agriculture system can be overwhelming, making it difficult for farmers to effectively process and act on the information. Agricultural producers may struggle to keep up with these changes, which can lead to non-compliance and associated penalties. The use of proprietary technologies and algorithms in smart agriculture can lead to intellectual property disputes, especially when third-party vendors are involved. Farmers may face legal challenges if they are deemed to be infringing patents or copyrights. Although smart agriculture aims to promote sustainability, there is a risk that over-reliance on technology can lead to unintended environmental consequences. Proper disposal and recycling of these devices are essential to prevent risks and threats to environmental sustainability (Issad et al., 2019; Sacco et al., 2021; Sinha, Dhanalakshmi, 2022).

The use of modern technologies can contribute to instability in agricultural products market. If many farmers adopt these technologies at the same time, it could lead to oversupply, falling prices and reduced profitability. The high cost of smart farming technologies can widen the gap between large, technologically advanced farms and smaller, traditional farms (Bashiru et al., 2024). This could affect increased economic disparities within the sector of agriculture, or to displacement of jobs, especially in regions where agriculture is the main source of employment. So, mentioned could have a significant social and economic impact on rural communities. AI-driven systems used in smart agriculture can inadvertently introduce biases into decision-making processes. As smart agriculture involves the use of complex technologies, determining liability in cases of system failures, data breaches or environmental damage can be challenging. Farmers and technology suppliers may face legal disputes over liability and compensation. In regions where, smart agriculture systems rely on cloud-based services, data may be transferred across borders, leading to legal issues related to data sovereignty and international data protection laws (Mayakannan et al., 2023; Naibaho, Cahyono, 2024).

The risks associated with smart agriculture are multiple and require careful consideration and management. An effective governance framework, such as COBIT 2019, generally plays key role in agri-business and significantly help agricultural producers to manage these risks, ensuring that adoption of smart agriculture technologies initiate sustainable and resilient practices. By addressing cybersecurity, data privacy, regulatory compliance, and other risks, stakeholders can maximize benefits of smart agriculture while minimizing potential negative impacts (ISACA, 2018).

Conclusion

COBIT 2019 is a powerful and flexible framework for managing innovations in agricultural production, and above all excellent tool that provides agricultural producers with the opportunities and guidelines needed to effectively manage their capacities. By aligning applied technologies with business goals, adequately managing risks and ensuring a satisfactory level of compliance, COBIT 2019 helps agricultural producers to navigate the complexities of the digital age, delivering value while maintaining control over their resource environment. Its adaptability and integration with other standards make it an essential tool for risk management in the digital world. The integration of smart agriculture, driven by data analytics and artificial intelligence, represents a transformative opportunity for the agricultural sector, offering significant potential to improve production outcomes in every sense.

Paper highlights the importance of structured approach to managing the risks and potentials of smart agriculture. By using the principles, processes and tools offered by COBIT 2019, agricultural producers can not only optimize the use of AI and data, but also protect themselves from the inherent risks associated with mentioned technologies. Effective governance, as outlined in COBIT 2019, ensures that the benefits of smart agriculture are realized while minimizing a several risks, including system failures and regulatory non-compliance.

However, successful implementation of smart agriculture requires a balance between innovation and risk management. In this context, COBIT 2019 represents the most interesting framework for achieving previously defined balance, enabling agricultural producers to exploit the full potential of AI and big data-based agriculture, while maintaining tight governance and control. As agriculture continues to evolve, adoption of a governance framework, such as COBIT 2019 could be crucial to ensure that technological advances result in improved quality of agri-food products (Sherly, Fianty, 2024).

In many countries there still exist insufficient knowledge related to new technologies, while high costs of their use as the main risks of utilization in agriculture. On the other side, their huge potential lies in increased incomes with less engagement of the human factor. Paper significance is in integration of smart agriculture and AI with risk management through the COBIT 2019 framework, facilitating efficiency, data security, and sustainability in agriculture. It also provides basic guidelines for responsible and secure implementation of emerging technologies in agri-business. In subsequent steps, research could be focused on assessing farmers' readiness to adopt advanced technologies underlying the smart agriculture and AI application.

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MONOGRAPH REVIEW

AGRO-ECONOMY: A SHORT HISTORY
(*Agroekonomija: Kratka istorija*)

Zoran M. Njegovan, Ph.D., Full Professor (in retirement)

Monograph published by the Institute of Agricultural Economics (IAE), Belgrade, Serbia, 2023. (501 pages)

The monograph "Agro-economy: A short history" has been written by the Prof. Dr. Zoran M. Njegovan, while it was published in 2023. Within the publication, on 501 pages author has been presented the historical aspect of the development of agro-economy as a separate scientific discipline. This is a second monograph written by the Prof. Dr. Zoran Njegovan, a distinguished university professor and scientists (Faculty of Agriculture, University in Novi Sad), oriented to the observed topic. In previous monograph "Agri-culture: A short history", which was published in 2018., author has also, on over 500 pages, presented the development of this existential economic activity, coming from its emerging, as the author states in "ancient times", up to the characteristics and challenges of contemporary global agriculture. In both capital publications, on over 1,000 pages, the author deals with and presents a historical period of thousands of years, but also very complex topics, in a concise and comprehensible manner. It is clear that this is the characteristic of only authors who knows the subject matter extremely well, while they have rich experience.

The monograph "Agro-economy: A short history" contains three thematic units. In the first one, the importance and emerging of agro-economy as a scientific discipline is presented. In the second one is discussed about the differentiation of agro-economy, while in the third and most extensive part of the book, the detailed development of agro-economic thought and concept in Europe, the United States of America and Serbia has been presented. As was stated in the monograph reviews "in line to used methodological framework, the monograph contains two streams that are mutual intertwine and summarized: theoretical and historiographical aspect".

The author of the monograph states that the "roots" of agro-economic thought are settled in the 17th and 18th century, while pointing to the inextricable connection between the development of agro-economy with the development of economy, primarily political economy. Author has also warning that the emergence of certain scientific discipline must not and cannot be strictly linked to specific historical moment. As he underlines "it is always a process that takes a wider or narrower period of time for civilizational socio-economic preparation". Furthermore, in the first thematic unit, he considers the social economy of agriculture, the business economics in agriculture, as well as the development of the agrarian policy.

Within the differentiation of agro-economy, author states that "Agrarian marketing" and "Cooperation in agriculture" were singled out first. He explains mentioned sequence in agro-economic history as a consequence of "the need to solve the problems of marketing agricultural and food products, in the conditions of the existence of large commodity producers on the one hand, and small, mostly family – small scale commodity farms, on the other side". After that, there comes to separation of "Rural Sociology" and "Agrarian Advisory Work", while so soon development of "Agrarian (Economic) Geography" and "Agrarian (Economic) History".

As part of the analysis of the development of agro-economic thought, the author in detail, systematically, but very concisely follows its historical link in France, Great Britain, Germany, Russia, or the United States of America, as well as in Serbia. One of the book reviewers, Prof. Dr. Radovan Pejanović points out that "an impressive list of literature references and sources" was used in this historical presentation, what "turns to the conclusion that author has covered the researched topic, both historically, scientifically and professionally".

Within the analysis of the development of agro-economic thought in Serbia, the author deals with the period of the Serbian enlightenment, the period of emerging and development of agro-economics and agro-economic thought, as well as the historical school and civic thought, or the emergence of cooperatives and the cooperative movement. Also, in this part of book, author analyzes agro-economics in Serbia between the two world wars, while listing the main representatives of agro-economic thought in Serbia after the II WW. By his own confession, although the author was guided by a "rational-speculative approach" in the book, when evaluating the contributions of certain agro-economists, he "could not avoid a kind of subjectivity". That's exactly why reviewer Prof. Dr. Drago Cvijanović points out that this monograph is unique, considering that "the author have not avoided to give his personal touch to the studied and presented material".

According to reviewer Dr. Radomir Popović, "in contemporary scientific production in Serbia, there are extremely few synthetized historical reviews such as this one turned to the development of agro-economy, written by Zoran

Njegovan, primarily due to the used approach and wideness of scientific scope", which includes "the period from the emergence of agro-economy as a scientific discipline, until the end of the 20^{th} century".

Finally, it is important to say that the publisher of this monograph is the Institute for Agricultural Economics in Belgrade, while the co-publishers are the Economics Institute in Belgrade and the Center for Agrarian History in Novi Sad, three highly reputable scientific institutions in whose history the author Prof. Dr. Zoran M. Njegovan has been recorded his work, scientific and teaching contribution.

Dr. Gordana Radović

Institute of Agricultural Economics (IAE), Belgrade, Serbia

SCIENTIFIC POLICY AND INSTRUCTIONS TO AUTHORS

The Western Balkan Journal of Agricultural Economics and Rural Development (WBJAERD) is an international scientific journal, published semi-annually by the Institute of Agricultural Economics (IAE) from Belgrade. Journal is generally oriented to the topics linked to agricultural economics and rural development. It mainly includes original scientific articles, as well as technical and review articles.

The Western Balkan Journal of Agricultural Economics and Rural Development (WBJAERD) accepts only articles on English language submitted electronically to the e-mail address marko_j@iep.bg.ac.rs

Submission of articles to the WBJAERD implies that their content has not been previously published, or they are not under the consideration for publication elsewhere. Publication of article has to be approved by all authors with signed declaration (avoiding the conflict of interests). Publisher reserves right to verify originality of submitted article (testing by antiplagiarism software).

Review process

The articles submitted to the WBJAERD will be reviewed (double blind review). Article readiness for publication requires two positive reviews that are in line to the generally accepted scientific standards (assigned reviewers independently evaluate the article giving the positive or negative review). Throughout the positive review they could require from author(s) or suggest certain level of corrections. In case of antagonistic reviews the final decision will be on the Editor-in-Chief.

Technical requirements for the article preparation

Article has to be prepared in Word for Windows.

Paper format: Envelope B5 or B5 (ISO) - w*idth* 176 mm x *height* 250 mm

Page margins: top/bottom/left/right 2,5 cm.

Font: Times New Roman (TNR), size 12, alignment Fully Justified, spacing single, spacing between the paragraphs 6 pt, without indentation the first line of paragraph.

***Article size*:** Article should be no less than 6 pages, or it should maximally has 30.000 characters (without spaces). According to articles' quality, Editorial board could accept longer or shorter articles.

***Title of the article*:** TNR size 12, capital letters, bold, cantered, maximally in two lines.

***Subtitles of the article*:** TNR size 12, bold, cantered, only first letter capital, maximally in two lines.

***Name and surname of the author (co-authors*):** one line below the article's title, TNR size 12, bold, cantered, only first letter capital (e.g. Anđela Marković). In footnote must be specified: academic/scientific title, institution, full address, phone no. and e-mail address.

***Footnotes*:** TNR size 10, spacing single.

***Abstract*:** one line below the (co)authors' name, TNR size 12, italic, maximally 250 words. It could include all essential elements of the article (goals, used methodology, significant results and conclusions).

***Key words*:** one line below the abstract, TNR size 12, maximally 5 words.

***JEL classification*:** one line below the key words, TNR size 12, maximally three JEL codes (http://www.aeaweb.org/jel/jel_class_system.php).

***Tables/graphs/figures/schemes*:** should be entered within text and properly numerated. Title must be one line below the last paragraph and one line above the table/graph/figure/scheme, TNR size 12, and alignment justified. Text within the table should be TNR size 10. Source of data shown in table/graph/figure/scheme should be one line below table, in TNR size 10, alignment justified.

***Literature*:** List of used literature should be set at the end of article, alphabetically by the surname of first author. It should include only references that are really used/quoted within the article. All references should be in original. Properly mark all parts within the article that includes used/quoted part of certain literature source (e.g. Marković, 2019; Marković, Janković, 2019; Marković et al., 2019).

***Presentation of used literature references (examples)*:**

a) Journals and other periodical publications:

Marković, A., Janković, B., Marković, A. (2019). Title of article. *Title of the journal*, volume (number), pages.

b) Books:

Marković, A., Janković, B., Marković, A. (2019). *Title*. Publisher, publishers' location (city/country).

c) Chapters in book, Articles in proceedings

Marković, A., Janković, B., Marković, A. (2019). *Title of chapter, article.* In: Title of book/proceedings, Editor(s), date and location of the scientific meeting, Publisher, publishers' location, pages.

d) Master/doctoral thesis

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e) Institution as an author of the publication

Title of institution (2019). *Title of publication*. Publisher, publishers' location.

If used/quoted literature source has been accessible at the internet, after presentation of literature source in one of previously defined form, full link to the webpage (published material) could be also specified.

JOURNAL'S SCOPE AND EDITORIAL POLICY

Journal's Scope

Main thematic field of the journal is defined by the scientific field of agroeconomy and rural development. In journal are mainly published original and review scientific articles, as well as professional articles and short reviews of significant books from the domain of agroeconomy and rural development. Published papers are strongly linked to one of the following themes:

- economics of agricultural production and processing
- rural development
- agricultural policy and sustainability of agriculture
- agro-tourism
- strategic planning in agriculture
- agro-marketing
- association in agriculture
- use of new, clean technologies in agriculture
- organization of agricultural production
- education and knowledge transfer in agro-complex
- extension services in agriculture
- market of agro-food products

Reviewing procedure

Peer reviewers

Western Balkan Journal of Agricultural Economics and Rural Development uses double-blind review system for all papers. Each manuscript is reviewed by at least two reviewers. The reviewers act independently and they are not aware of each other's identities. The reviewers are selected solely according to whether they have the relevant expertise for evaluating a manuscript. They must not be from the same institution as the author(s) of the manuscript, nor be their co-authors in the recent past. No suggestions of individual reviewers by the author(s) of the manuscript will be accepted.

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Peer review process

Manuscripts are sent for review only if they pass the initial evaluation regarding their form and thematic scope. A special care is taken that the initial evaluation does not last more than necessary.

Under normal circumstances, the review process takes up to four weeks, and only exceptionally up to three months. The total period from the submission of a manuscript until the moment of its accepting for publication takes an average of 90 days.

During the review process the Editor-in-Chief may require authors to provide additional information (including raw data) if they are necessary for the evaluation of the manuscript. These materials shall be kept confidential and must not be used for any other purposes.

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- Publishing an erratum, e.g. if the error was made by editorial staff.

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