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DYNAMICS OF GLOBAL HARVEST AND PRODUCTION OF CEREALS: EXPLORING TRENDS FOR 30-YEAR PERIOD

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Abstract: Cereals are the world's largest crops and the key source of staple food for millions of people globally. In this study, we analyse the trends in the production and growth of the most important and widely grown types of cereals cultivated as grain globally: 1) maize (corn), 2) wheat, 3) rice; 4) barley; 5) sorghum; 6) oats; 7) millet; 8) rye. The dataset on the produced cereals was collected from the Food and Agriculture Organization (FAO). Methods include the analysis of geospatial and economic data on the agricultural production of cereals for the period 1993-2023 and relevant literature review. The results revealed major trends in the agriculture production harvest of cereals at the global scale: the increase in production and yield quantities was noted for 4 crop types: maize, rice, wheat, millet. In contrast, barley, sorghum, oats and rye shown decrease in harvest in recent 30 years. The study contributes to the analysis of food security and crop availability for sustainable agricultural development.

Key words: *food security, agriculture, statistical analysis, crop, sustainability*

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INTRODUCTION

Food security and agricultural safety are one of the most important global challenges that impact humanity.

In the future decades, agricultural sector will need to produce more food to sustain world population with minimized environmental risks [1-5]. Crop production has variations in increased and decreased harvest globally. The cycles of harvest strongly depend on the environmental sustainability (soil fertility, water availability and temperature) and anthropogenic efforts (increased fertilizer applications, improved agricultural techniques, optimized crop varieties and sustainable agronomic management) [6-8]. The development of precision farming techniques improves crop harvest since farm companies adopt novel practices for process optimization [9-12].

Optimized irrigation techniques improves yield of cereals through proper soil management. Such measures contribute to the sustainable agriculture and ensures food. These include, for instance, improved fertilizers, organic matter and high-quality pest-resistant seeds [13-14]. Other techniques are based on crop rotation for sustainability of soil [15]. Such measures significantly improve the yield quality and quantity through a comprehensive crop management plan and adapting to favorable weather conditions and climate settings. Techniques acceptable in agriculture to maximize yields include strategic cereal succession planting [16] and vertical growing of plants [17-18].

Assessment of the dynamics of cereals as food inputs in cropland helps efficiently monitor and control the distribution of cereals as major staple food source for humanity. Statistical analysis and spatial evaluation of trends in food security improves analysis of crop growth and environmental sustainability. To better understand the flow of the main cereal types, trends and balance in crop availability and the environmental impacts on eight main types of cereals (maize, wheat, rice, barley, sorghum, oats, millet and rye) this study presents the estimation of cropping systems globally from 1993 to 2023.

MATERIAL AND METHODS

The data were collected from the Food and Agriculture Organization (FAO) database on 8 major types of cereals used globally as staple food: 1) maize (corn), 2) wheat, 3) rice; 4) barley; 5) sorghum; 6) oats; 7) millet; 8) rye. The methods include spatial analysis through visualization of maps, statistical analysis graphs and pie charts. The review of the relevant literature has been done on current trends in agriculture research regarding the global dynamics of crops, environmental sustainability and cereal production. The improved techniques of crop harvest in the context of agricultural development were reviewed in published works.

First, recent trends in land preparation (plowing, harrowing, laser leveling for water conservation) are developed and reported in studies on wheat, maize, rice and millet [19]. The techniques of seed sowing are described [20] and include the improved tillage for cereals to transplantation methods. The reports on water management in tropical areas were analyzed to explain recent increase in rice growth globally. These include, for instance, studies on rice cultivation in tropical climate (China, India, Thailand, Indonesia) and specific relief (terraces with leveled steps on slopes) [21-24].

Analysis of water conservation practices was done to evaluate preventive measures against soil erosion [25]. Finally, we considered reports on recent trends in agricultural chemistry and biochemical techniques which address the issues of environmental impacts and improve crop harvest through novel chemical fertilizers. Novel synthetically manufactured substances enhance soil fertility, and support improving crop yields through adding depleted nutrients [26].
These measures contribute to the sustainability of agricultural practices and improve harvest efficiency. Hence, recent trends in the global dynamics of crop production were reviewed and analyzed.

RESULTS AND DISCUSSION

The global dynamics of the production and yield quantities of maize (*Zea may L.*), rice (*Oryza sativa L.*), wheat (*Triticum aestivum L.*) and millet (*Panicum miliaceum L.*) for the period 1993 – 202 is visualized in Figure 1.

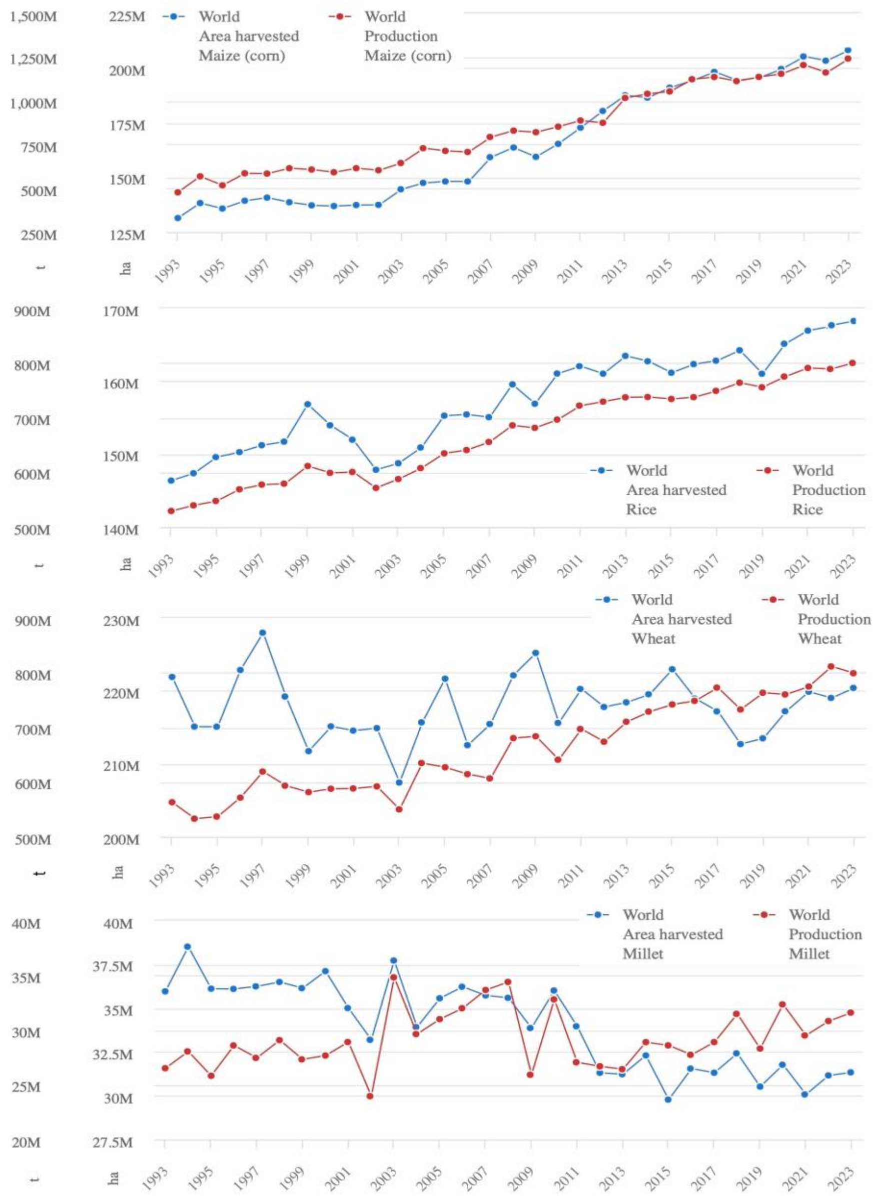

Figure 1. Increase in dynamics: cereals maize, rice, wheat, millet. Trends in production and yield quantities for the period 1993 – 2023. Data source: FAO. Compilation: author.

Over the past decades, the overall cereal food production in increased in maize, rice, wheat and millet increased. This is related to the increase in soil management practices, such as improved fertilizers and organic matter, optimizing irrigation techniques, and utilizing high-quality, pest-resistant seeds.

The maps in Figures 2–5 show the distribution of the production main cereals by countries: maize (Figure 2), rice (Figure 3), wheat (Figure 4) and millet (Figure 5) since 1993 to 2023. Globally, these cereal types are the world's most important staple food cereals.

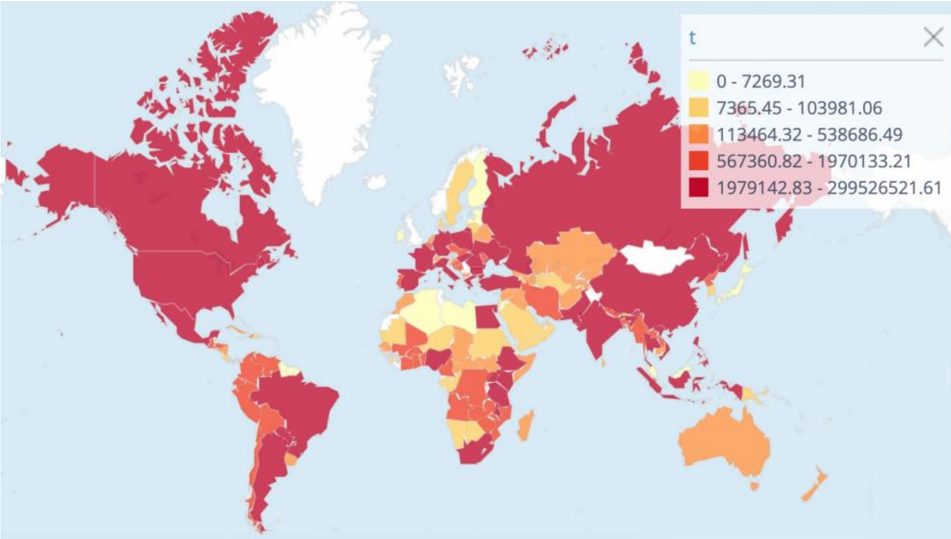

Figure 2. Maize: production quantities by country with average 1993 – 2023. Data: FAO.

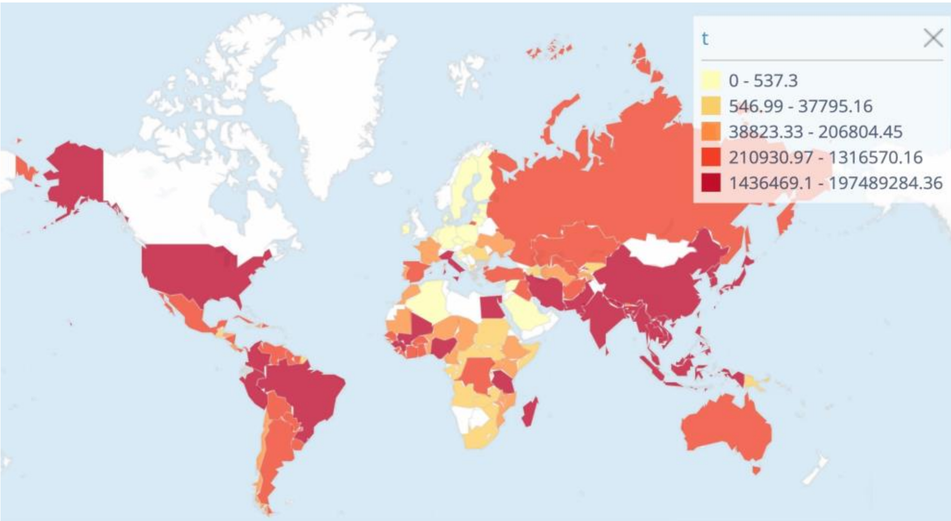

Figure 3. Rice: production quantities by country with average 1993 – 2023. Data: FAO.

Undoubtedly, the growth in these cereals is explained by the characteristics of these crops. Being versatile and adaptable to various weather conditions, these cereals are notable for high productivity which ensues large area of harvest globally. As a consequence, secured yields makes them crucial for global food security.

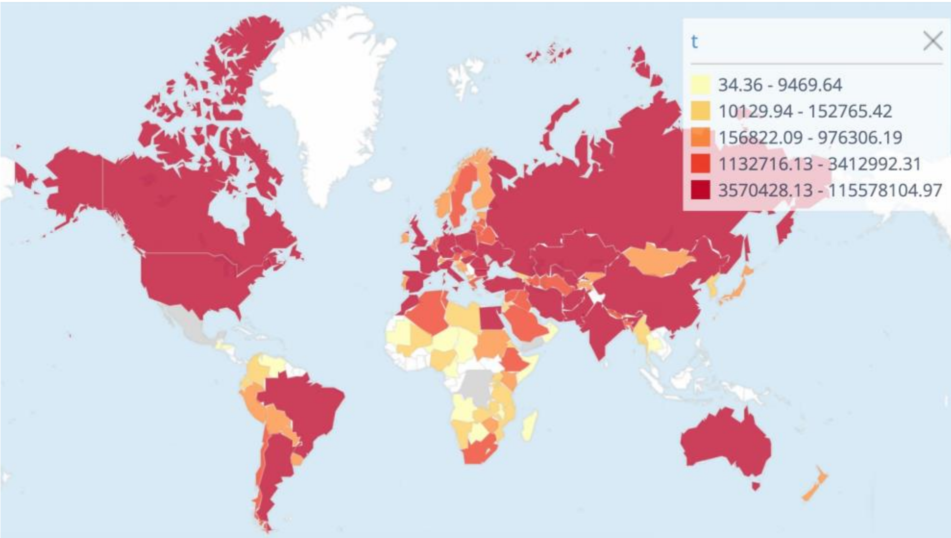

Figure 4. Wheat: production quantities by country with average 1993 – 2023. Data: FAO.

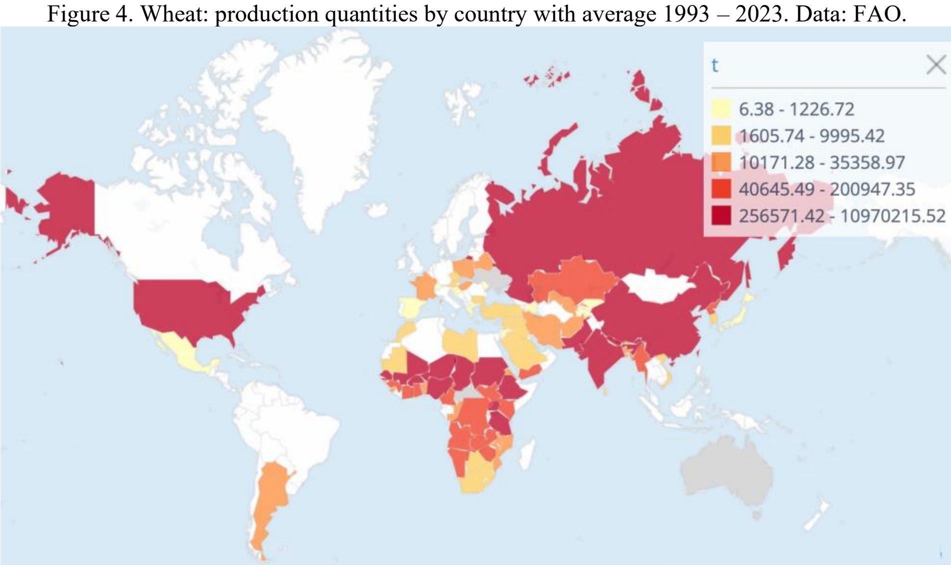

Figure 5. Millet: production quantities by country with average 1993 – 2023. Data: FAO.

High calories and quality of grains enable the use of these cereals as major staple food for humanity, but also additionally as a nourishment in livestock feed. Finally, these cereals can be stored for long periods due to resistivity to external storing conditions and properties of grain. The development of synthetic fertilizers in chemical agronomy along with the appropriate management and balanced applications contributed to the increase of crop yields. This has significantly improved cereals production with most popular types, such as wheat and maize and reduced yield gaps in the recent decades.

In contrast, recent trends show the decrease in the global production of the cereal's rye, barley, oats and sorghum, Figure 6.

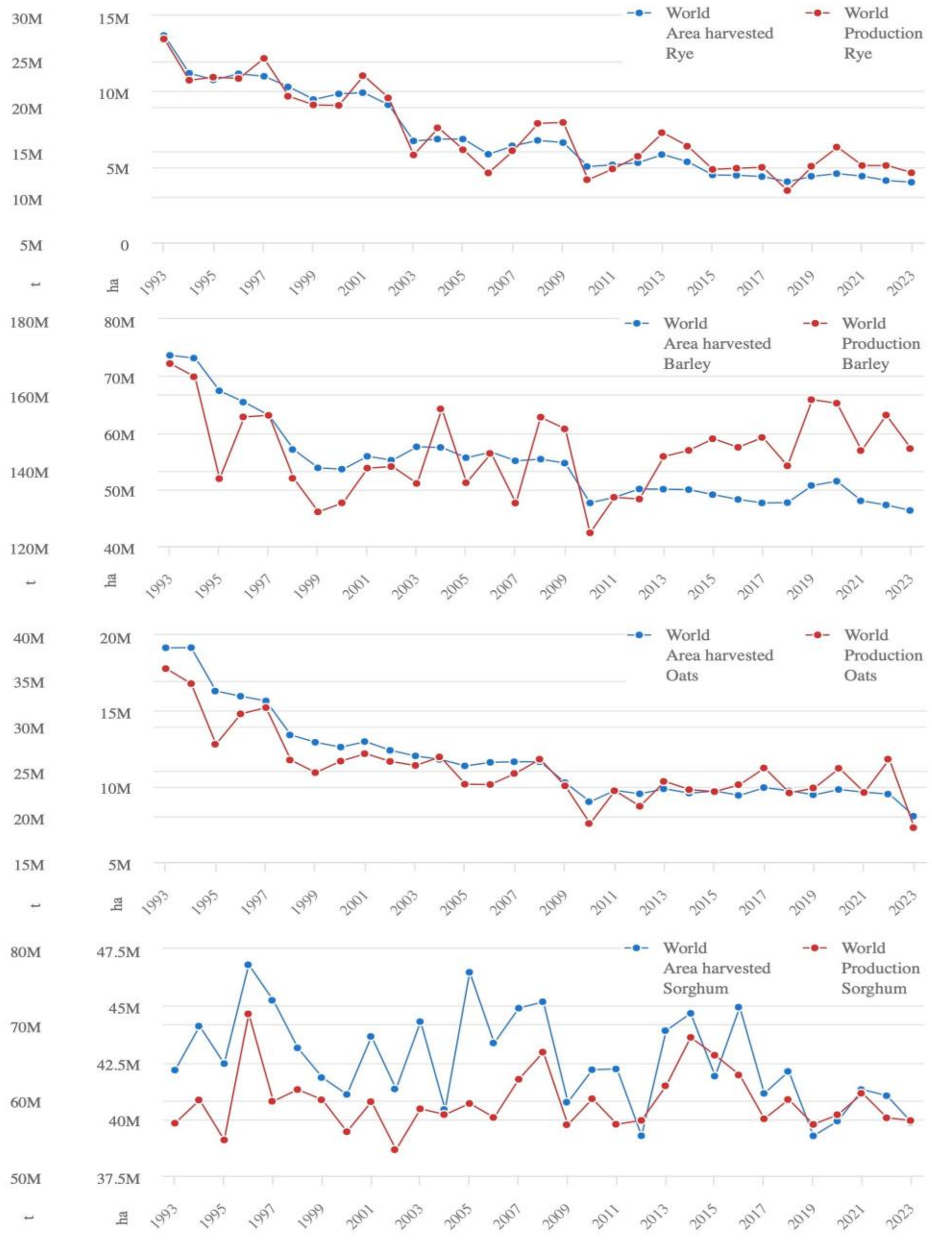

Figure 6. Decrease in dynamics: rye, barley, oats and sorghum. Trends for production and yield quantities of cereals for the period 1993 – 2023. Data source: FAO. Compilation: author.

Figure 7–10 show the distribution of the minor crop cereals globally: rye (Figure 7), barley (Figure 8), oats (Figure 9) and sorghum (Figure 10).

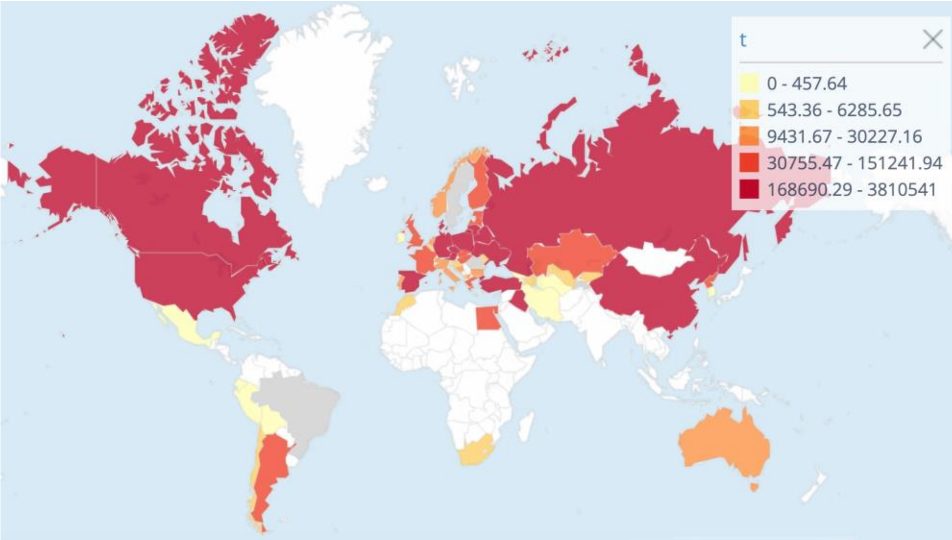

Figure 7. Rye: production quantities by country with average 1993 – 2023. Data: FAO.

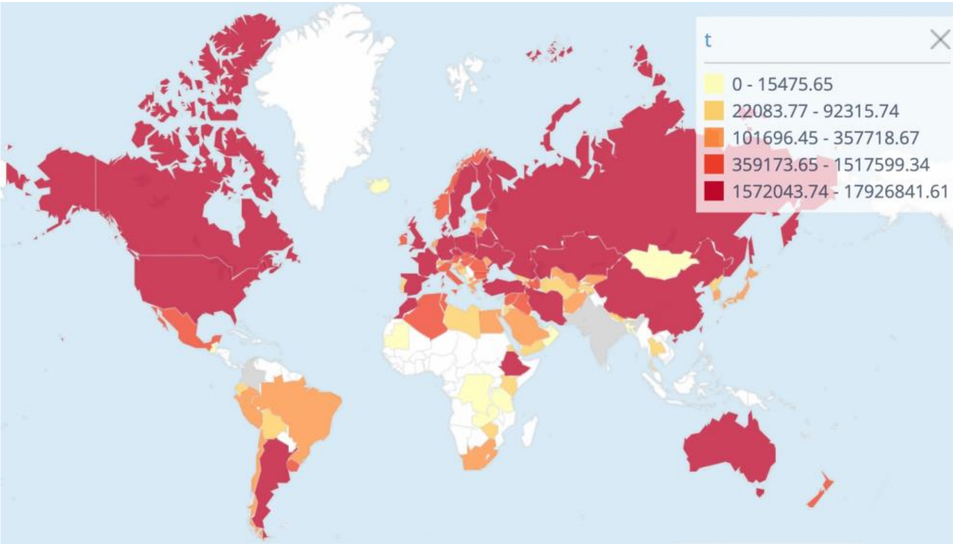

Figure 8. Barley: production quantities by country with average 1993 – 2023. Data: FAO.

Major reason for the decline in production of minor cereals is explained by the change in land use patterns toward major cereals (rice, maize, wheat and millet) as well as slower demand growth for these minor cereals (rye, barley, oats and sorghum) in important applications, such as animal feed and biofuels.

Besides, certain substantial effects originate from the climate change and weather events such as temperature warming, extreme heat and repetitive droughts, which negatively affects the yields.

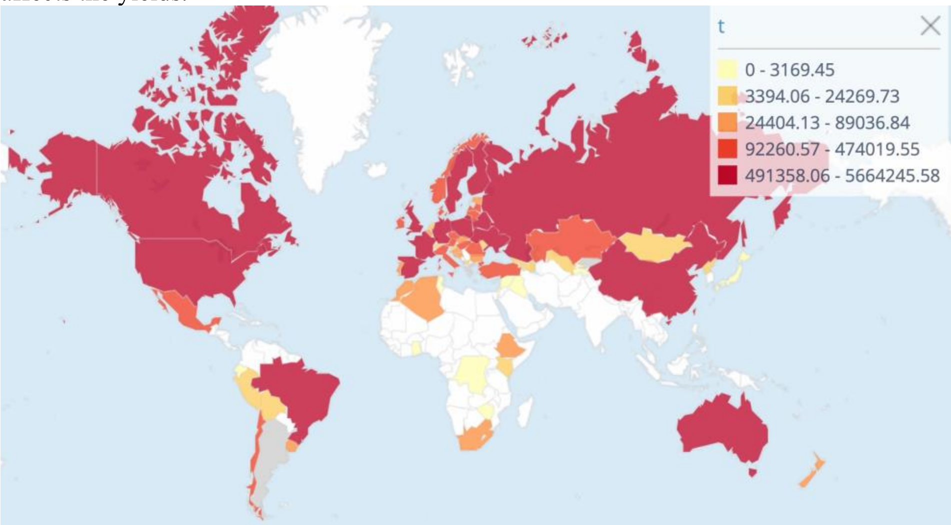

Figure 9. Oats: production quantities country with average 1993 – 2023. Data: FAO.

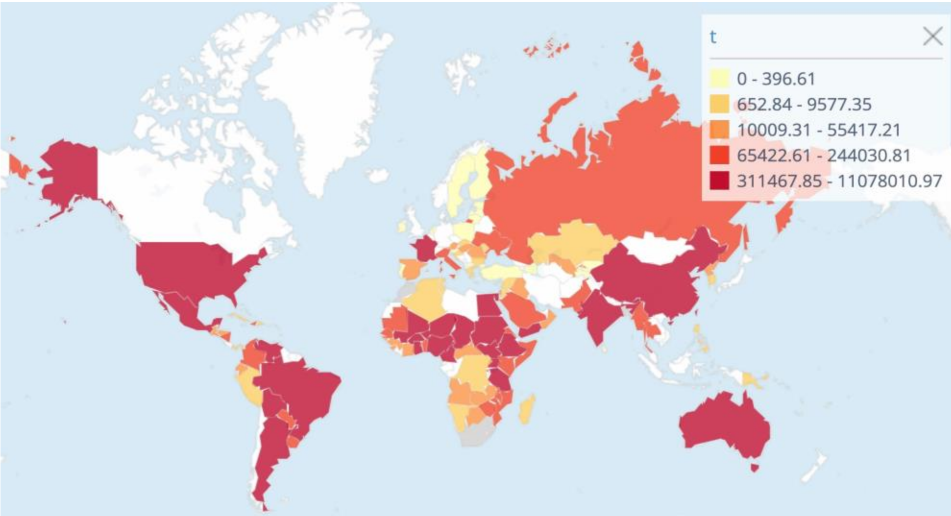

Figure 10. Sorghum: production quantities by country with average 1993 – 2023. Data: FAO.

The cumulative effects of these factors are the causes of the decline in minor cereals (rye, barley, oats and sorghum). Finally, the production volatility of minor cereals is also influenced by the geopolitical variables, including changes in land use practices, and the concentration of the production of these crops in selected areas due to globalization of the world food market.

Figure 11 shows the percentage of production share of major cereals by five global regions which illustrates the main producers of the crops globally.

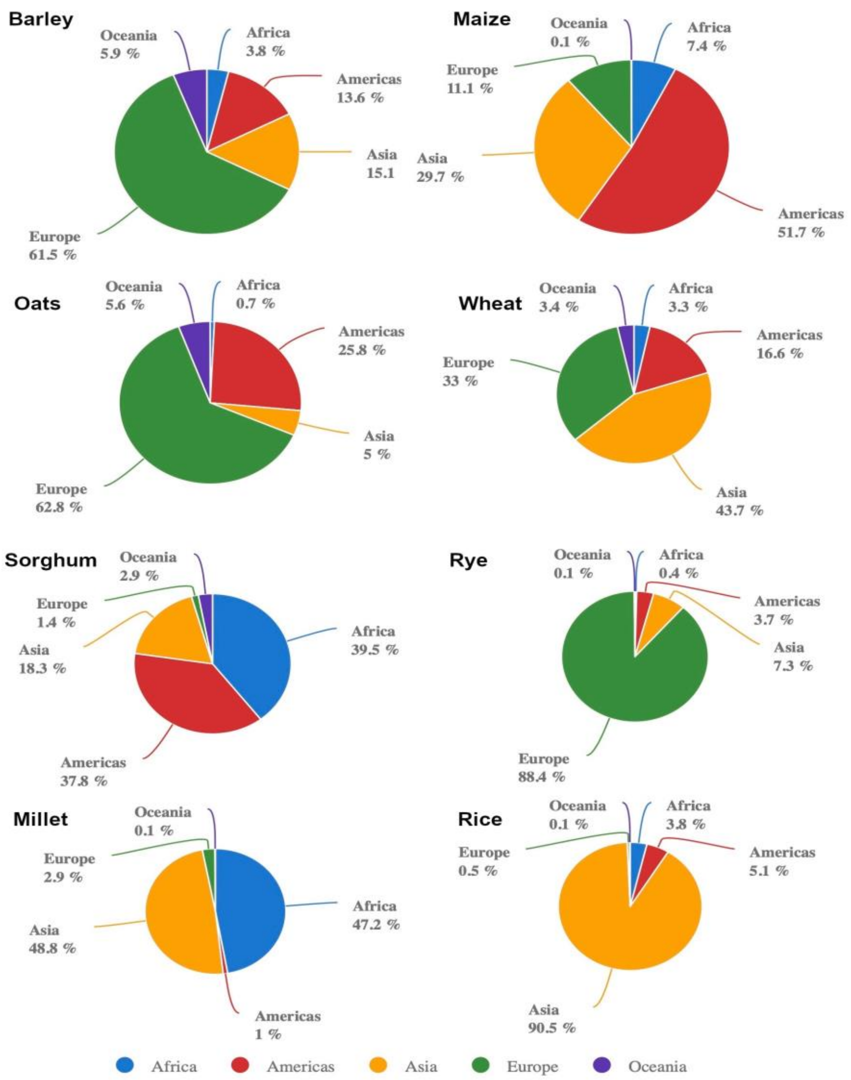

Figure 11. Percentage of production share of major cereals by five global regions for the period of 1993 – 2023. Data source: FAO. Compilation: author.

Development of the agricultural practices and novel technologies aimed at sustainable agriculture will drive an increase in global production of cereals and grain.
Overall, the FAO reports cereal consumption to be increased by 1.1% annually by 2034, mostly as a result of growing populations in Asia and Africa [27].

Accordingly, the rise of cereal production in Asia and the Americas will drive the increase in their use and consumption. The biggest challenge continues to be how to apply the potential of sustainable agriculture to contribute to the environmental protection and ecological monitoring [28-31]. The balance between safe fertilizers and economic growth may be difficult to achieve in the sector of agriculture. Nevertheless, the agricultural techniques and crop harvesting efforts are actively emerging and adopt novel technologies from the interdisciplinary sectors, including drones and nanotechnologies in agriculture, smart techniques of observation, safe substances as fertilizers and more.

Environmental monitoring and evaluating climate dynamics in the fertile lands for assessment of the external effects on land productivity is another valuable approach to sustainable agriculture [32-33]. Therefore, improving public knowledge, attitudes, and sustainable agricultural practices is essential for environmental management in order both to support successful harvest and maintained balanced nature conservation initiatives. To this end, current study highlighted current trends in cereal production globally using robust dataset from the FAO. The paper is target for interventions to enhance public awareness in sustainable agriculture and highlights recent dynamics in crop production during last 3 decades. In order to support sustainable agriculture practices and maintain production of minor crops (rye, barley, sorghum, oats), operative monitoring of agricultural data should be performed using multidisciplinary analysis. The latter includes spatial analysis (maps and cartographic referenced data), land management for nature conservation and biodiversity protection, and statistical analysis (visualization of graphs and plots). Hence, the measures on agricultural development and awareness of farmers and land managers should be supported through integrated data analysis and regular observations with detected trends in cereal production.

CONCLUSION

This study addressed the critical challenge of revealing trends in cereal production globally. The suggestion solutions are optimizing agriculture practices for maintaining and supporting minor cereals (rye, barley, sorghum and oats), water resource allocation in plant growing regions, land management measures in the areas characterized by fragmented terrain and complex relief patterns and use of sustainable fertilizers for protection of soil. By integrating statistical data analysis obtained from FAO with a literature review on current trends in agriculture practices, the presented study advances understanding of farming tendencies globally with example of 8 types of cereals: maize (corn), wheat, rice, barley, sorghum, oats, millet, rye. Optimization of agriculture practices by considering climate and environmental heterogeneity and the public need for food security ensures sustainable dynamics in agriculture and stable crop production.

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DINAMIKA GLOBALNE ŽETVE I PROIZVODNJE ŽITARICA: ISTRAŽIVANJE TRENDOVA ZA PERIOD OD 30 GODINA

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Apstrakt: Žitarice su najviše zastupljene kulture u Svetu, i ključni izvor osnovne hrane za milione ljudi širom Sveta. U ovoj studiji analiziraju se trendovi u proizvodnji i porastu najvažnijih i najrasprostranjenijih vrsta žitarica koje se gaje kao zrno širom Sveta:
1) kukuruz, 2) pšenica, 3) pirinač; 4) ječam; 5) sirak; 6) ovas; 7) proso; 8) raž.
Skup podataka za prikazani period o proizvedenim žitaricama, prikupljen je od Organizacije za hranu i poljoprivredu UN (FAO).
Metode obuhvataju analizu geoprostornih i ekonomskih podataka o poljoprivrednoj proizvodnji žitarica za period 1993-2023 sa pregledom relevantne literature.

Rezultati istraživanja su otkrili glavne trendove u poljoprivrednoj proizvodnji i žetvi žitarica na globalnom nivou: povećanje proizvodnje i prinosa je zabeleženo kod 4 vrste useva: kukuruz, pirinač, pšenica, proso. Nasuprot navedenom, ječam, sirak, ovas i raž pokazali su smanjenje obima žetve u poslednjih 30 godina.
Studija doprinosi analizi bezbednosti hrane i dostupnosti useva za održivi poljoprivredni razvoj.

Ključne reči: *Bezbednost hrane, poljoprivreda, statistička analiza, usev, održivost.*

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