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Wheat Production Outlook in Kenya amidst the Ukraine Crisis

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THE UKRAINE CRISIS AND AFRICAN ECONOMIES

Introduction

The Ukraine-Russia crisis has disrupted the global wheat trade as exports from Russia and Ukraine are restricted, and other major wheat exporters have limited or banned wheat exports altogether.

During a period of trade disruptions, increasing local production is one of the options that can be utilized to manage the crisis. Accurate and timely information on food crop production can enable countries to decide on how best to utilize available and expected food stocks, design timely policies to protect vulnerable sections of the population, and plan how to address food deficits through imports. This information is helpful as it enables various stakeholders within the country, including policy makers, traders, and farmers to better plan and respond to crises more effectively. Without this type of information, stakeholders would be unable to plan effectively, and trade disruptions could deteriorate into food security crises.

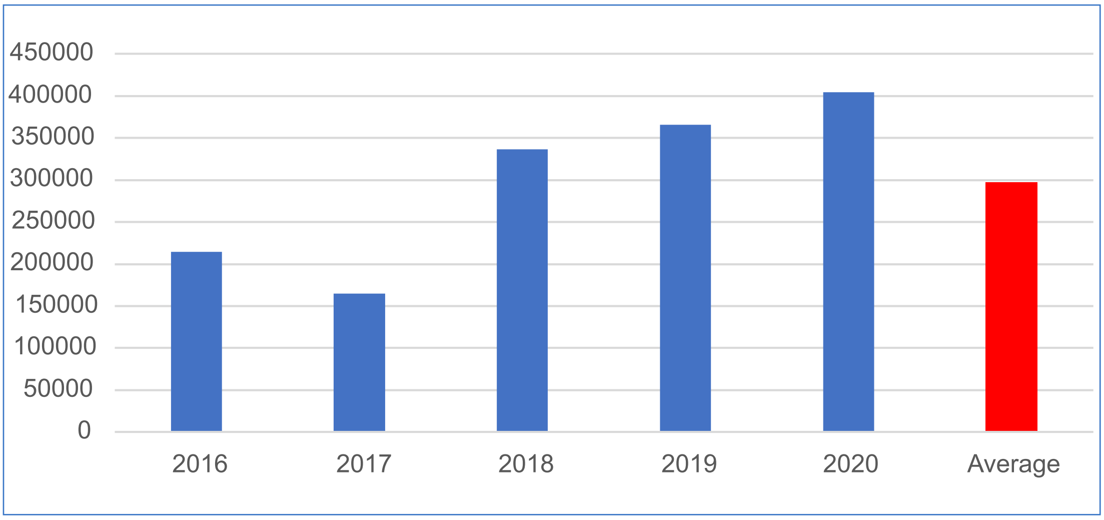
The data scientists at AKADEMIYA2063 used the Africa Crop Production (AfCP) model developed in-house to predict wheat production in Kenya. The model uses satellite remote sensing data as explanatory variables and machine learning techniques as a predictive modeling framework to provide production level information before the harvesting period at the pixel-level. The remote sensing data enables the unique characterization of features on the earth surface on several wavelengths, eliminating the need for a physical human presence on the ground.

Remote sensing also enables production of more extensive and better-quality data within a shorter period. On the other hand, machine learning makes it possible to extract the many hidden features within vast amounts of data to unlock the mechanisms behind the inner workings of very complex systems. In this brief, the two techniques mentioned above have been combined to forecast the quantity and spatial distribution of wheat production in Kenya amidst the ongoing Ukraine-Russia crisis.

2. Wheat Production and Demand Trends in Kenya

Wheat is the second most important food crop in Kenya after maize. Wheat has become even more prominent because of the rising population and the associated increases in urbanization. This has translated into changes in food preferences favoring consumption of easy-to-prepare meals and fast foods such as bread, biscuits, pasta, and noodles, among others. For the past five years (2016-2020), wheat production in Kenya has averaged around 300,000 metric tons (MT), as shown in Figure 1.

Figure 1: *Wheat Production in Kenya (2016-2020)*



Source: FAOSTAT, 2022

This local wheat production is insufficient to meet domestic demand, and the deficit is typically met through imports. As shown in Table 1, over the past five years, Kenya has imported approximately 1,800,000 MT of wheat annually and exported (re-exported) only less than 1% of this. The country is therefore highly dependent on wheat imports and is directly vulnerable to global trade disruptions.

Table 1: *Kenya Wheat Imports and Exports (2016-2020)*

Year	Imports (MT)	Exports (MT)	Exports (as % of Imports)
2016	1,526,755		
2017	1,854,954	15,115	0.81
2018	1,736,730	2,738	0.16
2019	1,998,802	5,205	0.26
2020	1,882,400	1,039	0.06
Average	1,799,928.2	6,024.25	0.33

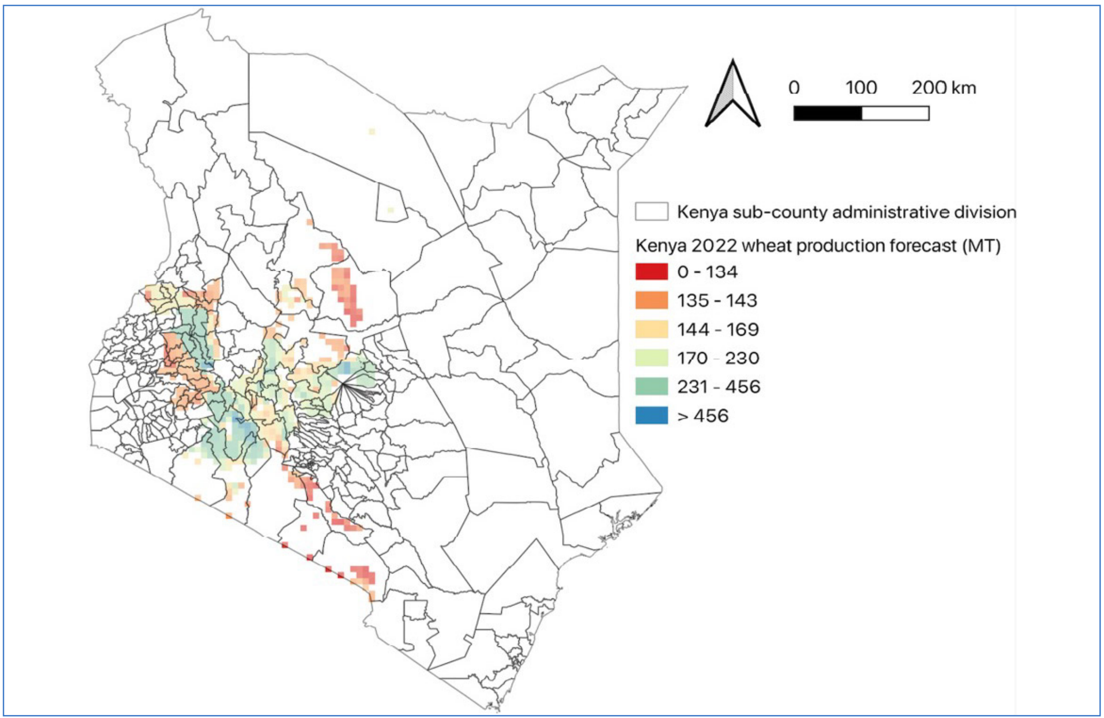
Data source: FAOSTAT, 2022

In 2020, Kenya imported 32% of its wheat from the Russian Federation while in 2019, imports from Ukraine accounted for 11% of its total imports. On average, imports into Kenya from the two countries account for about 40% of the total wheat imported. The country is therefore highly dependent on imports from the warring countries.

3. Projected Wheat Production for the Upcoming Harvest Season

The Kenya wheat production forecasts have been computed using the Africa Crop Production (AfCP) model. The model used satellite-based, bio-geophysical time-series data such as the normalized difference vegetation index (NDVI), land surface temperatures (LST), rainfall quantities, and evapotranspiration rates as explanatory variables. An artificial neural network was built to learn the relationships between the same bio-geophysical data and staple food crop production data that was available at the pixel-level. The projections were carried out before the start of the wheat growing season. A random forest predictor was therefore used to forecast in-season bio-geophysical data profiles, and the outputs used as inputs for the AfCP model to predict Kenyan wheat production several months before the actual harvest. Projections of Kenya's 2022 wheat production based on the AfCP model are presented in Figure 2 below. The pixels considered for this map are from areas where wheat is usually grown, and they have a size of ten-by-ten kilometers. The top five wheat producing sub-counties in 2022 are projected to be Narok North, Buuri, Narok South, Kesses, and Narok East, with total production levels of 56,000 MT, 22,000 MT, 21,000 MT, 20,000 MT, and 8,000 MT respectively. Interestingly, wheat production seems to follow a radial spatial distribution centered around Nakuru, i.e., the closer the location is to Nakuru, the higher the production. Projected 2022 wheat production for all sub-counties can be found in Table 2.

Figure 2: *Kenya Wheat Production Forecast for 2022*



Wheat production forecast at a pixel-level size of ten-by-ten kilometers. The boundaries and names shown as well as the designations used on maps do not imply official endorsement or acceptance by AKADEMIYA2063.

Source: *Authors*

4. Projected Changes in Wheat Production compared to the 2021 Season

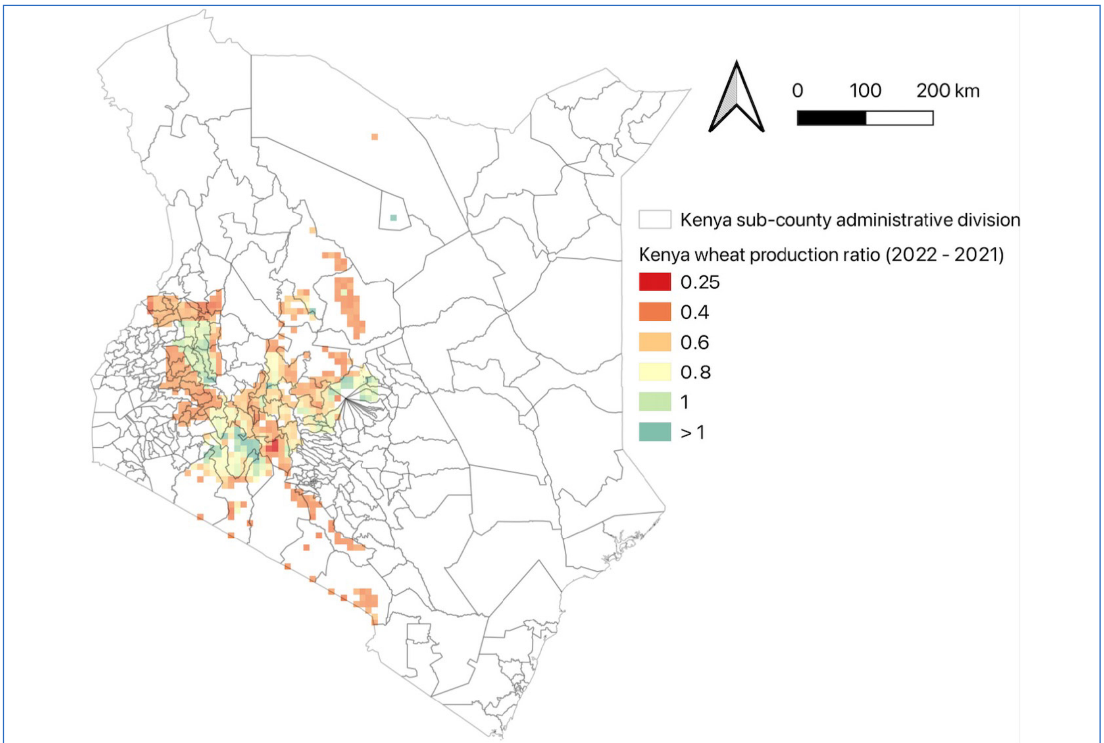
We compared wheat production levels for the 2021 and 2022 seasons by computing and mapping their ratios at the pixel-level. The analysis allows for detailed assessment of where wheat production is expected to increase or decrease and so provides critical information for planning of interventions to respond to possible supply disruptions.

At the national level, Kenya is expected to experience a decrease in wheat production by 18% between the 2021 and 2022 seasons. In 2021, the country produced 330,516 MT while our forecast estimates an overall production of 270,831 MT for 2022. However, national-level data mask geographical variations across wheat producing areas. The pixel-level data, shown in Figure 3 below, reveals substantial differences across sub-counties.[1]

Not all sub-counties will experience a decrease in wheat production in 2022 relative to 2021. For instance, 2022 wheat production is expected to increase in Maara (8.2%), Kesses (9.0%), Narok North (8.8%), Buuri (3.7%), Saku (24.9%), Bomet East (7.0%), and Likuyani (0.5%). In contrast, the sharpest wheat production declines are expected in Marakwet East (-56%), Kajiado Central (-55.5%), Pokot South (-59.0%), and Kilome (-55.0%).

Among the top five wheat producing sub-counties (Narok North, Buuri, Narok South, Kesses, and Narok East), three are expected to experience an increase in wheat production in 2022 compared to 2021. These are Narok North, Buuri, and Kesses with a change in production of 8.7%, 3.7%, and 9%, respectively. The highest increase is expected in Saku, Marsabit county with a 25% increase. Among the 124 sub-counties analyzed in this brief, 26% of them are expected to see a decline in wheat production that is equal to or greater than 50%.

Figure 3: *Comparison between 2022 and 2021 Wheat Production in Kenya*



A ratio greater than one means greater wheat production in 2022 than 2021, while a ratio below one means the opposite. The boundaries and names shown, as well as the designations used in maps do not imply official endorsement or acceptance by AKADEMIYA2063.

Source: *Authors*

5. Status of Crop Growing Conditions

Drought conditions and other developments related to climate change are among the key drivers in production of wheat and other crops. This brief therefore assesses possible changes in crop growing conditions by tracking predicted anomalies among bio-geophysical parameters used in the forecasting model.* The parameters were aggregated from January to June of each year for the past 20 years. The aggregated 2022 data were then compared with

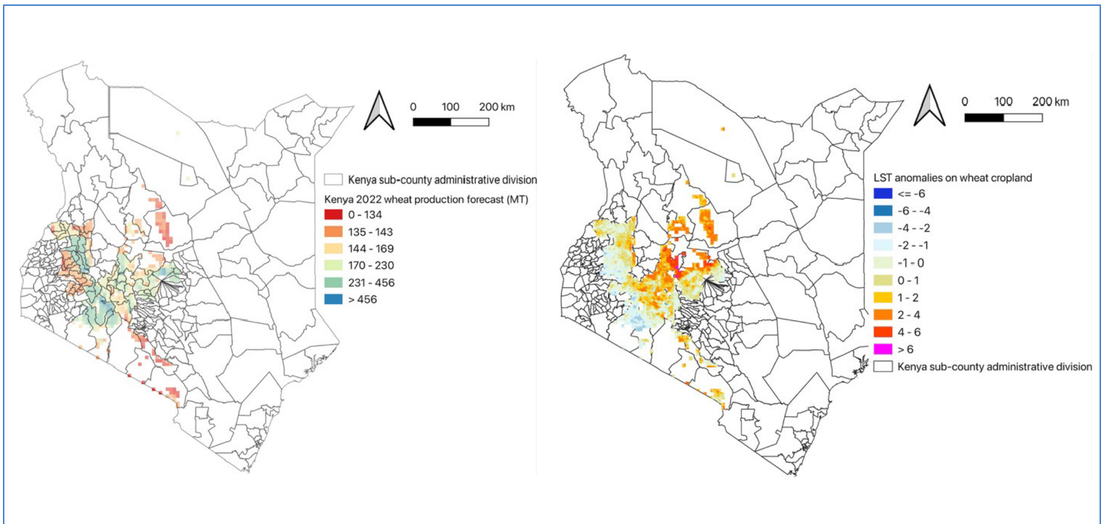
* Due lack of data availability, evapotranspiration was not included in the anomaly assessment.

the previous 20-year trends. Because it is still early in the wheat growing season, information on possible anomalies in future growing conditions can help to predict any climate-related shocks that may impact the upcoming wheat harvest.

Figure 4 combines two maps – the map on the left is a wheat production forecast while the one on the right presents land surface temperature anomalies. Wheat production areas covered by the study such as Trans-Nzoia and Nyandarua counties are projected to experience temperatures that are lower than usual. In contrast, other wheat growing areas such as Kajiado, Nakuru and West Pokot counties are expected to experience land surface temperatures that are higher than normal. The two extremes in land surface temperatures will have a negative impact on wheat production forecast. Figure 4 shows that at locations with the highest (above 4 degrees Centigrade) and lowest (below 4 degrees Centigrade) land surface temperature anomalies, wheat production is at its lowest level. In contrast, wheat production is expected to reach its highest level at locations with moderate land surface temperature anomalies (between -4.0 and +4.0 degrees Centigrade). As shown in Table 2 in the Annex, counties like Uasin-Gishu and Narok that exhibit moderate temperatures are forecast to have similar or higher wheat production in 2022 compared to 2021. Some sub-counties in Uasin-Gishu such as Kesses, and Narok North in Narok County are forecast to have higher wheat production in 2022 compared to 2021.

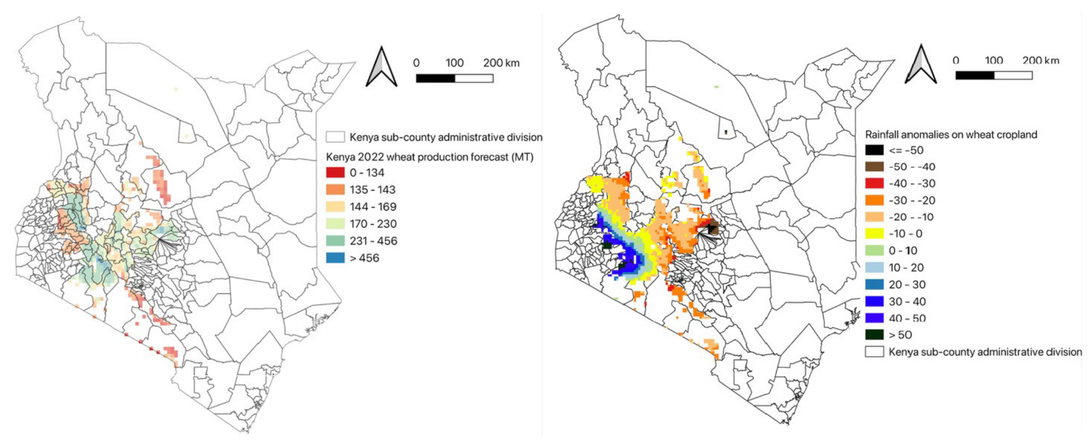
Positive rainfall anomaly trends are expected in the North, Central and South Rift regions of the country (see Figure 5). Similar to temperature anomalies, areas with more negative rainfall anomalies seem to show lower wheat production than areas with moderate to high positive anomalies. Based on Figure 4, areas such as Narok North sub-county and most areas in Uasin-Gishu counties exhibit high and positive rainfall anomalies and are also forecast to produce greater or similar wheat quantities in 2022 than in 2021.

Figure 4: *Kenya 2022 Wheat Production Forecast (left); Kenya 2022 Land Surface Temperature Anomalies (right)*



Note: *The boundaries, names and designations shown on maps do not imply official endorsement or acceptance by AKADEMIYA2063.*

Figure 5: Kenya 2022 Wheat Production Forecast (left); Kenya 2022 Rainfall Anomalies (right)



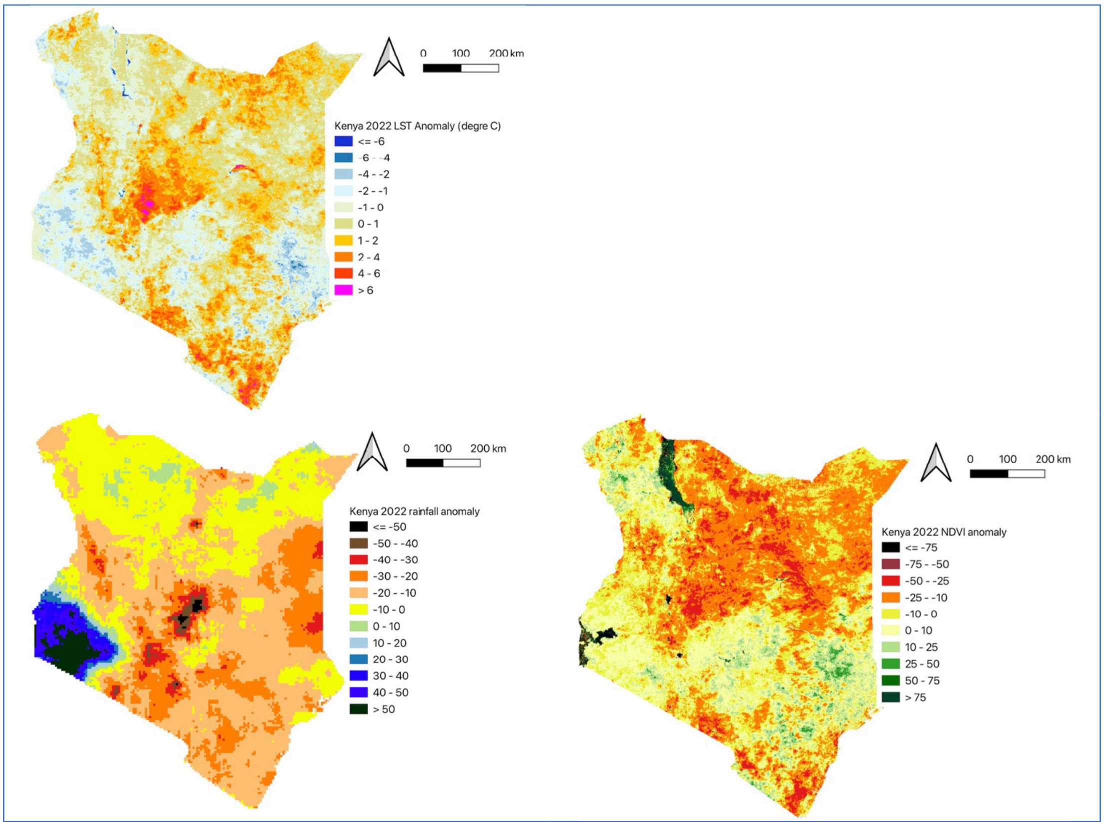
Source: Authors, 2022

***Note:** The boundaries, names, and designations shown on maps do not imply official endorsement or acceptance by AKADEMIYA2063.*

6. Land Surface Temperature, Rainfall, and Normalized Difference Vegetation Index (NDVI) Anomalies

Figure 6 shows the spatial correlations between anomalies in land surface temperatures, rainfall and vegetation index distribution across the country. The temperature and rainfall anomalies have not negatively impacted the vegetation cover (greenness) in the lower eastern part of the country (Tana River and Lamu counties). The temperature anomalies indicate an ongoing drought, which is currently being experienced in most parts of the country and is reflected in vegetation cover.

Figure 6: Kenya 2022 Land Surface Temperature, Rainfall, and Normalized Difference Vegetation Index Anomalies



Source: Authors, 2022

***Note:** The boundaries, names, and designations shown on maps do not imply official endorsement or acceptance by AKADEMIYA2063.*

7. Conclusion

Amid the ongoing Ukraine crisis, access to timely, disaggregated, and accurate agricultural production data is essential to assess the vulnerability of communities and plan for possible interventions. Access to such a dataset has long been a significant hurdle for African countries. Thanks to more readily available remotely sensed data and new developments in machine learning techniques, it is now possible to have advanced knowledge about crop production and yields not just prior to harvest-times but even before farmers start sowing. Scientists at AKADEMIYA2063 have developed the AfCP model which is currently being used to provide production and yield forecasts for eight major crops across 44 African countries. The information is accessible on the open-access platform Africa Agriculture Watch (AAgWa).

The AfCP model was used to predict the 2022 Kenya wheat production forecast at the pixel-level. The key findings indicate that the country as a whole is expected to experience an overall decline in wheat production of 18% in comparison to 2021 production. The results also show production variations in various areas across the country, indicating zones where wheat production is expected to rise above or fall below 2021 levels. Finally, the study offers details on expected anomalies in bio-geophysical conditions during the coming season across wheat growing areas to raise awareness on the anticipated impacts of climate variability on the country's wheat production.

Annex

Table 2: Kenya Level 2 (Sub-county) Wheat Production in 2021, 2022, and 2022-2021 ratio.

County	Sub-county	2021 wheat production (MT)	2022 wheat production (MT)	Wheat production ratio (2022/2021)
Elgeyo-Marakwet	Marakwet West	1,459.35	726.19	0.50
Elgeyo-Marakwet	Marakwet East	2,331.11	1,022.86	0.44
Homa Bay	Kabondo Kasipul	27.66	13.44	0.49
Isiolo	Isiolo North	216.04	136.71	0.63
Kajiado	Kajiado Central	1,221.95	544.01	0.45
Kajiado	Kajiado North	274.89	130.54	0.47
Kajiado	Kajiado East	4,406.21	2,068.86	0.47
Kajiado	Kajiado West	2,425.92	1,139.46	0.47
Kajiado	Kajiado South	4,263.86	2,119.71	0.50
Tharaka-Nithi	Maara	57.43	62.13	1.08
Trans-Nzoia	Saboti	2,084.56	1,093.88	0.52
Trans-Nzoia	Kwanza	1,041.08	587.29	0.56
Trans-Nzoia	Cherangany	2,726.33	1,524.93	0.56
Trans-Nzoia	Kiminini	1,396.29	788.64	0.56
Trans-Nzoia	Endebess	2,149.98	1,118.99	0.52
Uasin-Gishu	Kapseret	3,968.66	3,670.56	0.92
Uasin-Gishu	Ainabkoi	6,756.86	6,506.79	0.96
Turkana	Turkana East	246.97	125.28	0.51
Vihiga	Hamisi	25.61	13.52	0.53
Uasin-Gishu	Moiben	7,727.33	7,494.32	0.97
Uasin-Gishu	Kesses	18,625.67	20,313.43	1.09
Uasin-Gishu	Turbo	2,683.72	2,543.07	0.95
Uasin-Gishu	Soy	7,322.82	6,593.14	0.90
West Pokot	Pokot South	745.34	306.92	0.41
West Pokot	Kapenguria	68.48	37.12	0.54
West Pokot	Sigor	52.83	25.49	0.48
Nakuru	Bahati	3,640.41	2,724.24	0.75
Nairobi	Langata	21.87	10.43	0.48
Nakuru	Nakuru Town East	725.63	343.92	0.47
Nakuru	Naivasha	7,658.63	4,242.36	0.55
Nakuru	Njoro	3,437.30	2,452.16	0.71
Nakuru	Nakuru Town West	538.73	290.54	0.54
Nakuru	Kuresoi North	5,561.80	4,261.87	0.77
Nakuru	Gilgil	5,270.55	3,016.09	0.57
Nakuru	Molo	4,189.26	3,157.02	0.75
Nakuru	Kuresoi South	4,278.31	3,652.12	0.85
Nandi	Mosop	3,296.64	2,024.01	0.61
Nandi	Emgwen	1,413.43	735.67	0.52
Nandi	Tinderet	1,784.12	918.13	0.51
Nandi	Nandi Hills	1,926.90	1,229.42	0.64

Nakuru	Subukia	1,008.53	601.91	0.60
Nakuru	Rongai	3,534.53	2,095.54	0.59
Nandi	Chesumei	1,696.59	1,234.21	0.73
Nandi	Aldai	1,133.75	595.70	0.53
Narok	Narok West	8,454.86	6,906.06	0.82
Narok	Narok South	23,890.44	21,802.60	0.91
Narok	Kilgoris	0.15	0.09	0.58
Narok	Narok North	52,010.06	56,585.43	1.09
Narok	Narok East	9,411.96	8,894.55	0.95
Nyandarua	Ol Jorok	2,677.09	2,100.95	0.78
Nyandarua	Ndaragwa	2,054.69	1,288.64	0.63
Nyeri	Kieni	6,780.03	5,070.72	0.75
Nyandarua	Ol Kalou	2,027.58	1,400.22	0.69
Nyamira	North Mugirango	48.53	23.58	0.49
Nyandarua	Kipipiri	1,726.47	1,194.78	0.69
Nyandarua	Kinangop	3,473.44	2,417.06	0.70
Samburu	Samburu East	7,693.63	3,754.83	0.49
Nyeri	Tetu	1,883.01	1,568.59	0.83
Samburu	Samburu West	3,290.23	2,035.14	0.62
Samburu	Samburu North	3,522.56	1,899.95	0.54
Nyeri	Mukurweini	654.28	560.68	0.86
Nyeri	Mathira	1,537.80	1,208.16	0.79
Nyeri	Othaya	675.21	563.39	0.83
Nyeri	Nyeri Town	701.69	536.41	0.76
Taita Taveta	Taveta	30.49	15.49	0.51
Laikipia	Laikipia North	6,397.24	3,309.66	0.52
Laikipia	Laikipia East	4,894.82	2,760.47	0.56
Laikipia	Laikipia West	11,650.04	8,749.12	0.75
Machakos	Mavoko	92.19	45.39	0.49
Makueni	Kilome	47.74	21.48	0.45
Makueni	Kibwezi West	32.73	16.79	0.51
Marsabit	North Horr	388.46	201.55	0.52
Meru	Buuri	21,203.31	21,989.72	1.04
Marsabit	Saku	172.48	215.37	1.25
Marsabit	Laisamis	0.38	0.23	0.60
Meru	South Imenti	2,031.92	1,919.35	0.94
Meru	North Imenti	1,191.46	1,145.05	0.96
Meru	Tigania West	144.64	128.34	0.89
Meru	Central Imenti	1,287.20	1,195.78	0.93
Murang'a	Gatanga	70.93	49.30	0.69
Murang'a	Mathioya	169.57	146.83	0.87
Murang'a	Kigumo	7.55	5.25	0.69
Kericho	Ainamoi	720.06	353.18	0.49

Kakamega	Shinyalu	317.47	162.87	0.51
Kakamega	Malava	146.66	70.07	0.48
Kiambu	Gatundu North	6.08	4.53	0.74
Kericho	Sigowet/Soin	1,202.18	598.21	0.50
Kiambu	Gatundu South	2.53	1.88	0.74
Kericho	Bureti	266.81	141.11	0.53
Kericho	Belgut	1,768.84	910.31	0.51
Kericho	Kipkelion West	1,208.87	587.05	0.49
Kericho	Kipkelion East	3,452.91	2,237.96	0.65
Kiambu	Lari	236.66	182.98	0.77
Kiambu	Kikuyu	7.96	3.72	0.47
Kiambu	Limuru	144.93	68.53	0.47
Kirinyaga	Kirinyaga Central	77.02	42.74	0.55
Kirinyaga	Gichugu	0.54	0.45	0.83
Kirinyaga	Ndia	85.51	59.19	0.69
Kisumu	Kisumu East	0.65	0.34	0.53
Kisumu	Nyakach	28.51	13.85	0.49
Kisumu	Muhoroni	588.18	297.66	0.51
Kisumu	Nyando	12.20	6.26	0.51
Baringo	Mogotio	149.22	77.68	0.52
Baringo	Eldama Ravine	430.06	326.41	0.76
Bomet	Bomet Central	43.57	36.13	0.83
Baringo	Tiaty	248.29	123.81	0.50
Baringo	Baringo Central	23.62	11.93	0.51
Baringo	Baringo South	598.68	384.85	0.64
Baringo	Baringo North	227.42	126.30	0.56
Bungoma	Kimilili	136.89	79.44	0.58
Bomet	Chepalungu	4.13	3.13	0.76
Bomet	Bomet East	987.27	1,056.27	1.07
Bomet	Konoin	662.91	453.27	0.68
Bungoma	Tongaren	338.90	194.87	0.58
Bungoma	Lugari	84.17	80.51	0.96
Bungoma	Likuyani	702.89	706.71	1.01
Bungoma	Mt. Elgon	313.65	157.43	0.50
Elgeyo-Marakwet	Keiyo South	4,001.97	2,809.12	0.70
Elgeyo-Marakwet	Keiyo North	2,811.34	2,032.53	0.72

A ratio below one means wheat production in 2021 is greater than in 2022. A ratio above one means wheat production in 2022 is greater than in 2021. Both 2021 and 2022 data were extracted from the Africa Agriculture Watch (AAgWa) platform (www.aagwa.org).

Endnotes

[1] Interactive versions of the maps presented here can be found on AKADEMIYA2063's Africa Agriculture Watch platform (AAgWa, www.aagwa.org).

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