Integrated Development Program Discussion Paper 2

Wheat Consumption Dynamics in Selected Countries in Asia and Africa:

Implications for Wheat Supply by 2030 and 2050

Khondoker Abdul Mottaleb, Kai Sonder, Santiago López Ridaura and Ayman Frija

CIMMYT
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ICARDA
Science for resilient livelihoods in dry areas

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Data availability

Data (Stata format) and do.file used for this study is publicly available from the URL: https://hdl.handle.net/11529/10548638.

Purpose of the series

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Executive Summary

Since its earliest cultivation some 10,000 years ago, wheat has played a fundamental role in ensuring global food security and continues to do so as the most widely cultivated crop in the world and the second-most consumed staple after rice. Applying the time series econometric estimation procedure, this study projected demand for wheat in seven rapidly emerging countries of Africa and Asia—Bangladesh, China, Ethiopia, India, Kenya, Nepal, and Pakistan—in 2030 and 2050. In projecting wheat demand, this study has considered changes in demography, per capita GDP, and urbanization, as well as wheat production and imports in the sampled countries.

There are compelling reasons to examine the future demand for wheat in emerging economies. It is projected that by 2050, the total global population is expected to reach between 8.9-10.6 billion (United Nations, 2019) compared with a global population of 7.8 billion in 2020 (World Bank, 2021a). Projections also show that by 2050, 68% of the global population will reside in urban areas compared with 56% in 2020 (World Bank, 2021a). The average per capita GDP at the constant price of 2010 is also projected to increase from 11,057 in 2019 (World Bank, 2021a) to 13,616 in 2032 (USDA, 2021). It is universally understood that with increases in income and urbanization as well as a lifestyle change, the dietary intake patterns of a nation typically evolve toward higher-value foods. The implications of dietary transitions on the future demand for wheat in the global south merits study.

For some, expected transitions towards higher-value food have substantiated policy suggestions for reduced investment in the research and development of major cereals. However, rapidly emerging economies in the global south are characterized by extreme poverty, with large swaths of their poorest reliant on cereals such as wheat, maize, and rice for their daily dietary energy intake. The critical importance of wheat in the context of predicted economic growth and demographic change highlights the need for understanding the future role of wheat in emerging countries, thus allowing for effective prioritization of public and global R&D investments in this sector.

Through the application of a simple time-series analysis method, this study demonstrated that wheat will continue to play a fundamental role in the diets of the sampled seven economically emerging developing countries. By 2030 and 2050, all sampled countries will face increases in yearly per capita wheat consumption. Populations and urbanization in the sampled countries are expected to increase significantly and many inhabitants will continue to face extreme poverty and rely heavily on staple cereals for their dietary energy. The study thus generates evidence for the need for continued support and investment in major cereals to ensure future food security in economically emerging developing countries.

Preface

Wheat continues to play a crucial role in ensuring global food and nutrition security. In addition to its role as a staple crop, wheat also offers a solution to changing dietary preferences emerging from global economic progress and lifestyle changes. The rise in awareness of micronutrient deficiency and the prevalence of non-communicable diseases linked to carbohydrate-based and energy-dense diets has fueled an argument towards greater research investment on non-cereal foods, such as vegetables, pulses, and fruits. Wheat and other cereals, however, remain among the most accessible and affordable sources of food for billions of people around the world, including more than 820 million who suffer from food insecurity. Supplying staple cereals such as wheat at an affordable price is crucial to supporting the livelihoods of the worlds' poor. Furthermore, wheat provides protein, vitamins and minerals, as well as dietary fiber; breeding innovations and changes in processing and consumption can boost these benefits. Based on econometric forecasting, this study indicates that in many economically emerging countries in Asia and Africa, wheat is gaining popularity, and will continue to play an important role in food security. These findings support strengthening investment in wheat R&D to ensure enhanced production of resilient and nutritious wheat varieties. I firmly hope that the findings of this study can help to raise the awareness of policymakers and donor agencies to sustain wheat R&D for global food and nutritional security.

Alison Bentley

Director, CIMMYT Global Wheat Program, and the CGIAR Research Program on Wheat (WHEAT).

1.0 Introduction

It is projected that by 2050, the total world population is expected to reach between 8.9-10.6 billion (United Nations, 2019) compared with 7.8 billion in 2020 (World Bank, 2021a). By 2050, an estimated 68% of the total world population will reside in urban areas compared with 56% in 2020 (World Bank, 2021a), and average per capita GDP at the constant price of 2015 is projected to increase from US$ 10,520 in 2019 (World Bank, 2021a) to US$ 13,616 in 2032 (USDA, 2021). The expected changes in demography and increases in per capita GDP and urbanization will have major implications on the future demand for food and major cereals, such as wheat, maize, and rice.

Several studies have estimated the future demand for major cereals at the global level in the context of demographic changes (Godfray et al., 2010; Ray et al., 2013; Tilman et al., 2011). Projections for global food demand show increases from 70% (FAO, 2009) to 110% (Tilman et al., 2011) by 2050. Ray et al. (Ray et al., 2013) suggested that to meet surges in demand, average yield growth rates for any agricultural commodity should be at least 2.4% per year compared with rates in 2005.

While existing studies provide important insights about the future demand for agricultural commodities more broadly, conducting commodity-specific studies at the country level is imperative, given the heterogeneity of dietary intake, cropping patterns, urbanization, demographic changes, and GDP growth rates across countries. As an example, at 260 kg/year per capita, Bangladesh is the highest rice-consuming country in the world, whereas Tunisia is the world's leading wheat consumer, with over 200 kg/year consumed per capita. Understanding country-level food consumption trends have important implications on food security policies.

Since its domestication some 10,000 years ago (Charmet, 2011; Faris, 2014), wheat has been crucial in ensuring humanity's food and nutritional security (Dixon, 2007; Dixon et al., 2009; Shiferaw et al., 2013). Wheat is currently the most cultivated crop in the world and the second most consumed staple after rice. For the triennium ending 2018, the average yearly per capita wheat consumption worldwide was 67 kg and supplied a daily calorie intake of 544 kcal per person, nearly 19% of the average daily calorie intake per person (FAO, 2021). This relative importance of wheat is expected to grow in the future, but with different speeds in different countries and regions. This study estimates the future demand for wheat in 2030 and 2050 in Bangladesh, China, Ethiopia, India, Kenya, Nepal, and Pakistan. The countries selected are characterized by rapidly growing economies and urbanization as well as major demographic shifts, factors with great potential to drive and change wheat consumption.

One aim of this study is to address policy suggestions for significant reductions in investment in the research and development of cereals that have stemmed from the nutrition transition discussions as well as concerns about diet-related over-nutrition and noncommunicable diseases. Dietary intake patterns of households and countries tend to evolve with increases in per capita income and urbanization as well as demographic changes (Mottaleb et al., 2018a; Pingali, 2006; Reardon et al., 2019, 2012). The nutrition transition concept describes an observed dietary evolution that occurs when, during the initial stages of economic development, cereals such as wheat, maize, and rice play a major role in ensuring food security but increases in income, urbanization, and lifestyle changes bring about a nutrition transition. According to the concept, households gradually begin to substitute coarse grain cereals with higher-value energy-dense foods, such as fish, meats, protein, and vegetables (Drewnowski and Popkin, 2009; Jakicic and Davis, 2011; Pingali, 2006; Pingali et al., 2019; Popkin, 2003, 1999; Reardon et al., 2014; Semba et al., 2008). As a consequence, some studies have suggested a shift in investment away from cereal crops towards noncereal crops, such as pulses and vegetables (Pingali, 2006; Pingali et al., 2019).

Reducing investments in major cereals could have a devastating impact on the food security of millions of people in economically emerging developing countries. An estimated 821 million people—10.9% of the world's population—do not have enough to eat (FAO et al., 2019). By 2050, the global population is expected to reach between 8.9 billion to 10.6 billion people, and an estimated 2 billion people will face hunger under the business-as-usual scenario (United Nations, 2019). In addition to abject hunger, hidden hunger in the form of overnutrition and undernutrition is also prevalent in developing and emerging economies (FAO, 2013). As the total population of the world in 2020 was 7.8 billion (World Bank, 2021a), the annual global costs of all forms of malnutrition were US $3.8 trillion, which is almost equivalent to Germany's total GDP which is 3.86 trillion (World Bank, 2021a) in 2019, the largest economy in Europe. Cereals like wheat are also a major source of protein in many of the emerging economies in Sub-Saharan Africa, Latin America, and Asia. Thus, to eliminate hunger by 2030, as per the United Nations (UN) Sustainable Development Goals (SDGs), more cereals as well as more nutrition enriched cereals must be supplied to food-insecure countries in Asia and Africa, regions with the greatest number of hunger-stricken people globally.

Interestingly, compared to coarse rice and maize, wheat is an income elastic food item. With increases in income and urbanization, and lifestyle changes, the demand for fine rice and wheat will increase across Asia and Africa (Gandhi et al., 2004; Mason et al., 2015; Mottaleb et al., 2018b; Nagarajan, 2005). This is critical information that should inform any policy discussion on agricultural investments, especially for emerging economies in the global south. Examining the future demand for wheat will help policymakers develop effective and targeted policies that have the potential to lift millions of people out of hunger.

A few studies have examined the demand for cereals in Nepal, Pakistan, India, and Bangladesh in 2025 and 2030 (Ganesh-Kumar et al., 2012a, 2012b; Nazli et al., 2012; Prasad et al., 2011). Prasad et al., (2011), using Nepal Living Standards Survey 2003/04 datasets and applying the Almost Ideal Demand System (AIDS) estimation procedure, estimated the national and per capita consumption of wheat, maize, and rice in Nepal. The study projected a yearly per capita wheat consumption in Nepal of 22 kg, and a national aggregate wheat consumption of around 895,000 tons (t) by 2030. In reality, Nepal's 2018 per capita wheat consumption was 50 kg—more than double the projection—and aggregate wheat consumption was 1.4 million t (FAOSTAT, 2021a). Through the use of Bangladesh's Household Income and Expenditure Survey (HIES) 2005 datasets and application of the Quadratic Almost Ideal Demand System (QUAIDS) estimation procedure, Ganesh-Kumar et al., (2012b) projected Bangladesh's 2030 aggregate wheat consumption at 1.4-1.5 million t. Once again, 2018 saw the actual aggregate consumption of wheat in Bangladesh rise to 3 million t (FAOSTAT, 2021a), surpassing the 2030 projection.

For India, several studies projected cereal and wheat demand, using per capita GDP and population growth rates. Chand (2007), estimated a yearly per capita wheat consumption of 49.8 kg and an aggregate consumption of 67.5 million t in 2020-21. Mittal (2008), projected a 2026 yearly per capita wheat consumption of 48.9 kg and aggregate wheat consumption of 65.9 million t. Kumar et al., (2009), projected a 2021-22 yearly per capita wheat consumption of 47.6 kg, and an aggregate wheat consumption of 73.5 million t. Applying the QUAIDS estimation procedure, Ganesh-Kumar et al., (2012a) projected a negative (-0.13) expenditure elasticity for wheat and projected the yearly per capita wheat consumption at 49.3kg in 2026, and the aggregate wheat consumption ranging from 63.3 to 69.4 million t by 2026, dependent on income growth rate assumptions. Yet, in 2018, the actual yearly wheat consumption of India surpassed the projections considerably, with a per capita consumption of 62 kg and an aggregate wheat consumption of 83.5 million t (FAOSTAT, 2021a).

For China, Rozelle and Huang (1998) projected that considering low- and high-income growth, yearly per capita wheat consumption in China would fall between 80-83 kg by 2020. In 2018 however, actual yearly per capita wheat consumption was 64 kg (FAOSTAT, 2021a). For Pakistan, applying the AIDS model estimation procedure and using the Household Integrated Economic Survey 2007-08 datasets, Nazil et al., (2012) forecasted that by 2019-20, yearly per capita wheat consumption for Pakistan would fall between 115-118 kg and the total demand for wheat will be 24.2 million t. In 2018 however, actual yearly per capita wheat consumption in Pakistan was 110 kg and the total wheat consumption was 23.3 million t (FAOSTAT, 2021a). This demonstrates that the majority of wheat consumption forecasts fall short in reality and highlights the need for consumption forecasting that uses innovative methods and models.

This study projected yearly per capita wheat consumption in the sampled countries for 2030 and 2050. In the estimation process, the Vector Error Correction (VEC) modeling approach was applied for all countries except Nepal. In the case of Nepal, the Autoregressive Integrated Moving Average (ARIMA) estimation model was used. The novelty of this study was the exclusive focus on wheat demand in 2030 and 2050 across the selected countries in Africa and Asia.

The findings show that in general, across all sampled countries, wheat is a fundamental staple that until at least 2050, will continue to play a crucial role in ensuring food security for millions of people in the global south. Based on these findings, continued investment in the research and development of major cereals such as wheat, maize, and rice will be necessary to overcome the food insecurity afflicting vulnerable people across Asia and Africa.

2.0 Current wheat consumption, production, and trade in the sampled countries

2.1 Consumption, production and trade

2.1.1 Bangladesh

In Bangladesh, wheat is the second most important staple crop after rice. For the triennium ending (TE) 2018, the average yearly per capita wheat consumption in Bangladesh was 19 kg, compared with 8.6 kg for TE1963. Figure 1 presents the trends of yearly per capita wheat consumption across the sampled countries from 1961 to 2018. Wheat yields in Bangladesh have increased continuously from 0.67 t/ha in TE1963 to nearly 3 t/ha in TE2019 and national wheat production has increased from 0.04 million to 1.1 million t over the same period (Table 1). Wheat currently supplies a daily calorie intake of 164 kcal per person. This comprises more than 6% of the daily per capita calorie intake average in the country. Despite this, wheat demand in Bangladesh is largely met through imports, as the country is characterized by short winters and a warm and humid climate that is unfavorable for wheat cultivation (Mottaleb et al., 2018b). Table 1 presents the area (million/ha), production (million/t), and yield (t/ha) of wheat in the sampled countries including Bangladesh during the period TE1961 - TE2019 and shows that while the wheat area in Bangladesh had increased from the period TE1963 to TE2003, this was followed by a drastic reduction (Table 1).

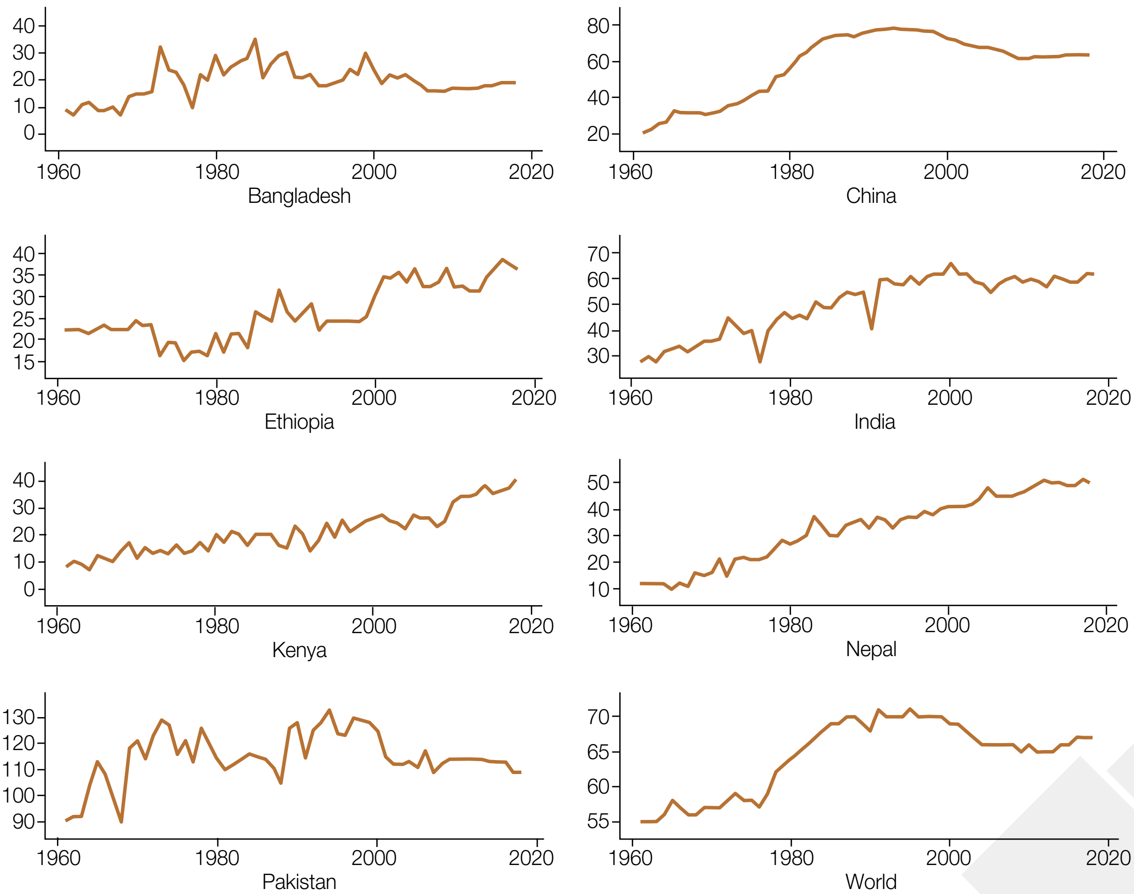


Figure 1. Trend of kg/per capita yearly wheat consumption in the selected countries and the world during 1961-2018. Y-axis: kg/per capita/ yearly. X-axis: year.

Source: FAOSTAT, (2021b).

Table 1. Area (million ha) production (million ton) and yield (ton/ha) in selected countries from 1961-2019.

Year	Bangladesh	China	Ethiopia	India	Kenya	Nepal	Pakistan	World
Land allocation to wheat (million ha)								
TE1963	0.06	24.5	0.92	13.4	0.10	0.11	4.9	206
TE1973	0.12	26.1	1.0	18.9	0.11	0.24	5.9	215.7
TE1983	0.55	28.4	0.65	22.7	0.11	0.43	7.2	236.0
TE1993	0.60	30.6	0.58	24.0	0.15	0.59	8.0	222.9
TE2003	0.74	23.5	1.13	25.8	0.14	0.66	8.1	212.3
TE2013	0.38	24.2	1.56	29.5	0.15	0.76	8.7	219.0
TE2019	0.37	24.2	1.74	29.9	0.13	0.72	8.8	216.1
Production (million ton)								
TE1963	0.04	16.5	0.66	11.3	0.1	0.14	4.0	235.3
TE1973	0.11	34.6	0.79	25.0	0.17	0.24	6.9	353.3
TE1983	1.1	69.8	0.75	38.9	0.24	0.55	11.7	472.0
TE1993	1.1	101.3	0.83	56.0	0.26	0.79	15.5	559.2
TE2003	1.6	90.2	1.55	69.4	0.31	1.25	18.8	576.8
TE2013	1.1	120.0	3.46	91.8	0.4	1.77	24.3	693.7
TE2019	1.1	133.1	4.7	100.7	0.3	1.9	25.4	757.2
Yield (ton/ha)								
TE1963	0.67	0.67	0.72	0.84	1.00	1.27	0.82	1.14
TE1973	0.92	1.33	0.79	1.32	1.55	1.00	1.18	1.64
TE1983	1.91	2.46	1.15	1.71	2.18	1.28	1.63	2.00
TE1993	1.80	3.31	1.43	2.33	1.73	1.34	1.93	2.51
TE2003	2.16	3.84	1.37	2.69	2.21	1.89	2.32	2.72
TE2013	2.82	4.96	2.22	3.11	2.67	2.33	2.79	3.17
TE2019	2.97	5.50	2.70	3.37	2.31	2.64	2.89	3.50

TE: Triennium average.
Source :FAOSTAT, (2021c).

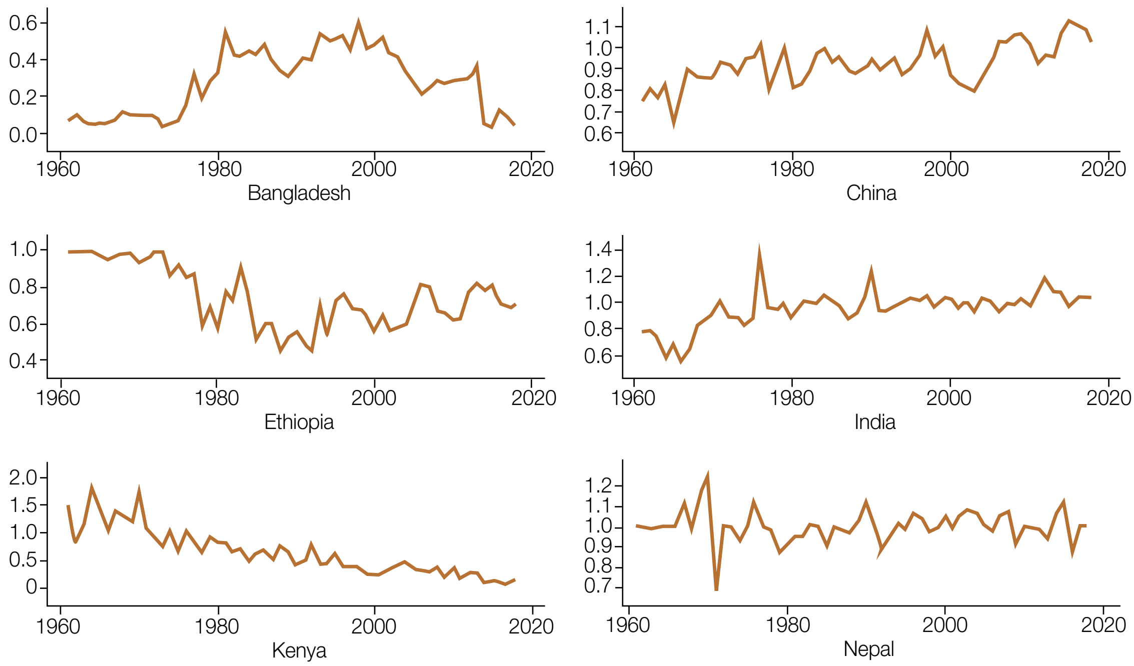
In February of 2016, an unprecedented wheat blast affected 15,000 ha of wheat area (Islam et al., 2016), comprising 3.4% of the total wheat area during the country's 2015-16 wheat season (BBS, 2018). Before 2016, wheat blast, caused by the wheat-constraining fungus *Magnaporthe oryzae* pathotype *Triticum* (MoT) was mostly confined to South America (Urashima et al., 2009). To curb the spread of wheat blast, the government of Bangladesh discouraged wheat cultivation across severely blast-affected districts (BBS, 2018). Alarmingly, in 2020, wheat blast also emerged in Zambia (Tembo et al., 2020).

Despite a substantial increase in wheat yield, domestic wheat production was never sufficient to meet Bangladesh's wheat demand. Figure 2 presents wheat production self-sufficiency trends in the sampled countries, where the self-sufficiency ratio is calculated as domestic production divided by domestic supply (where domestic supply equals domestic production minus exports plus imports). For Bangladesh, the trend shows that after 2000, the country's wheat production self-sufficiency ratio declined drastically. In 2019, Bangladesh imported 4.6 million t of wheat grain worth US$1.1 billion, making it the 13th largest wheat importer, globally. In TE2019, the country's wheat production constituted only 9% of its total wheat supply (Figure 2).

2.1.2 China

In China, a country with a population of 1.4 billion people and representing 18% of the world's total (World Bank, 2021a), wheat is the second most preferred staple after rice. Annual per capita wheat consumption increased significantly in China during 1980-2000 (Figure 1) and today, China is the world's foremost wheat consumer, with a total wheat food use of nearly 94 million t in 2018, representing nearly 19% of global wheat consumption that year. In TE2018, yearly per capita wheat consumption was 64 kg, supplying a daily calorie intake of 560 kcal per person and constituting 17.5% of each person's daily average total calorie intake.

By volume, China is the world's leading wheat producer, producing a total of 134 million t of wheat annually. With nearly 24 million ha of land allocated to wheat, China has the third most extensive land area dedicated to wheat amongst wheat-producing



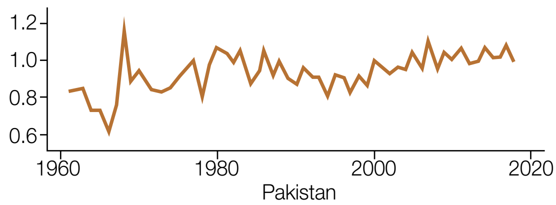


Figure 2. Trends of share of domestic wheat production to domestic supply (domestic product + net import) from 1961-2018 in the sampled countries. Y-axis: domestic wheat production/ domestic wheat supply, where domestic wheat supply = domestic production + net imports.
Source: FAOSTAT, (2021b)

countries, following only India and the Russian Federation. Though China's land allocation to wheat has declined substantially since the 1990s, a dramatic increase in wheat yields has contributed to an overall increase in total wheat production (Table 1), making the country self-sufficient for this crop since 2014 (Figure 2).

2.1.3 Ethiopia

In Ethiopia, wheat is the third most preferred staple crop, supplying 333 kcal or 14% of the daily average calorie intake per person. In TE2018, the yearly per capita total wheat consumption in Ethiopia was 37 kg (Figure 1), a figure that has been on the rise since 2000 (Figure 1). At 1.7 million ha in TE2019, Ethiopia's wheat area is the third largest in Africa (Table 1). and the country is Africa's second-largest wheat-producer with nearly 5 million t of wheat produced annually. While Ethiopia's wheat yields continue to rise, domestic wheat production has yet to meet the country's surging demand for the crop. In TE2018, nearly 70% of Ethiopia's total wheat demand was met from domestic production (Figure 2), while the remaining demand was met through wheat imports. In TE2019, Ethiopia imported 1.2 million t of wheat worth US$ 392.1 million (FAOSTAT, 2021d).

2.1.4 India

In India, the second-most populous country in the world, hosting a total of 1.36 billion people and representing more than 17% of the world's total population in 2019 (World Bank, 2021a), wheat is the second most preferred staple after rice. In TE2018, the total yearly wheat consumption per person was 61 kg, supplying a daily per capita calorie intake of 527 kcal and constituting 21% of the average daily total calorie intake per person. Since 2000, yearly per capita wheat consumption in India has oscillated around 62 kg (Figure 1). India is currently the second-largest wheat-consuming country in the world after China. In 2018, the country's total wheat consumption was just under 84 million t, representing almost 17% of the total share of wheat consumed globally.

With nearly 30 million ha of land allocated to wheat (Table 1), India leads the world in land allocation for wheat production. With a TE2019 average total wheat yield of 3.1 t/ha, wheat production in India exceeds 100 million t (Table 1). While the country saw a consistent increase in land allocation for wheat until 2016, there has been a declining trend in recent years (Table 1). Although India remains the world's forerunner in land allocation for wheat, the country remains a net wheat importer (Figure 2), however, since 2007, India has positioned itself as a wheat exporter to its neighboring countries.

2.1.5 Kenya

Wheat is the second most preferred staple in Kenya after maize. In TE2018, the yearly total wheat consumption per person was 38 kg, supplying a daily per capita calorie intake of 299 kcal and constituting nearly 14% of the total daily calorie intake per person. Yearly per capita wheat consumption in Kenya has seen a steady increase over the years (Figure 1). Despite its popularity after maize, Kenya relies on imports to meet its domestic wheat demand. In TE2019, land allocation to wheat in Kenya was 0.13 million ha, with an average yield of 2.2 t/ha. Domestic wheat production was less than 290,000 t (Table 1), meeting only 12% of the total wheat demand of the country (Figure 2). Recent years have seen a growing demand for wheat, resulting in the country's increased reliance on wheat imports (Figure 2).

2.1.6 Nepal

Wheat is the second most popular staple in Nepal after rice. In TE2018, the country's yearly per capita total wheat consumption was 50 kg, supplying a daily per capita calorie intake of 400 kcal and constituting more than 14% of the daily total calorie intake per person. Yearly per capita wheat consumption in Nepal has seen a steady increase since 2000 (Figure 1). To meet the country's growing demand for wheat, Nepal was successful in increasing land allocation for the crop (Table 1). In TE2019, the country's land allocation to wheat was 0.72 million ha, with an average yield of 2.64 t/ha and a total wheat output of 1.9 million t (Table 1). An almost entirely self-sufficient wheat producer (Figure 2), in TE2018, about 96% of the country's total wheat demand was met through its domestic wheat production (Figure 2).

2.1.7 Pakistan

Wheat is the principal staple crop of Pakistan. In TE2018, the country's yearly per capita total wheat consumption was 110 kg, supplying a daily per capita calorie intake of 920 kcal and constituting 37% of the total daily calorie intake per person. Since the 1990s, yearly per capita wheat consumption in Pakistan has been on a slight decline (Figure 1). While the country's wheat yield falls below the world average (Table 1), Pakistan has been highly successful in achieving wheat self-sufficiency, thanks to several strategic imports (Figure 2). In 2019, the country produced more than 24 million t of wheat with a yield of 2.8 t/ha from 8.7 million ha of land. The output was enough to meet 99% of Pakistan's total wheat demand for 2019 (Figure 2).

2.2 Economic and Demographic Changes and Future of Wheat Demand

In addition to the dynamic changes in wheat consumption, production, and trade, the sampled countries have undergone rapid demographic change and increases in per capita GDP (Tables 2 and 3). In 1961, the total world population was 3.1 billion with about 41% (1.3 billion) residing solely in the seven countries sampled. In 2019, with a world population of 7.7 billion, about 43% (3.3 billion people) reside in the seven sample countries (Table 2).

The speed of urbanization across the sample countries has been significant (Table 2). In 1991, 20% of the total population of Bangladesh, 27% of the total population of China, 13% of the total population of Ethiopia, 26% of the total population of India, 9% of the total population of Kenya, and 17% of the total population of Pakistan were living in urban areas. Contrasted with 2019, the rise in urbanization is considerable, with 37% of the total population of Bangladesh, 60% of the total population of China, 21% of the total population of Ethiopia, 34% of the total population of India, 28% of the total population of Kenya, and 37% of the total population of Pakistan, residing in urban areas (Table 2). Projections show that by 2050, 58% of the total population of Bangladesh, 80% of the total population of China, 39% of the total population of Ethiopia, 53% of the total population of India, 46% of the total population of Kenya, 37% the total population of Nepal and 52% of the total population of Pakistan, will be residing in urban areas (Table 2).

Except for Nepal, all sampled countries have managed to achieve steady increases in their per capita GDP (Table 2). Projections show that all sampled countries will maintain a positive per capita GDP growth rate until 2032, as well as associated increases in per capita real GDP (Table 2).

The projected population in 2030 and 2050 under low and high fertility rate assumptions for the sampled countries are presented in Table 3. Except for China, the projected population across sampled countries under both low and high fertility rate assumptions will be higher by 2030 and 2050 (Table 3). In China, assuming a high fertility rate, the population is expected to increase to 1.49 billion in 2030 and 1.5 billion in 2050. Assuming a low fertility rate, the projected population in 2050 will be lower than China's total population of 1.39 billion in 2018 (Table 3).

Given the broad acknowledgment that the dietary intake patterns of a nation evolve with changes in demography, income, and urbanization (Béné et al., 2019; Cockx et al., 2018; Huang and Bouis, 2001; Huang and David, 1993; Kearney, 2010; Mason et al., 2015; Mittal, 2007; Mottaleb et al., 2018c, 2018a; Pingali, 2006; Pinstrup-Andersen et al., 1999; Popkin, 2008; Regmi, 2001; Regmi and Dyck, 2001; Wilde, 1989), a deeper country-level understanding of the future demand of wheat is needed, in light of growth projections.

Table 2. Population (million), the share of urban population and GDP per capita (US $) in the sampled countries from 1961-2019.

Year	Bangladesh	China	Ethiopia	India	Kenya	Nepal	Pakistan	World
Population (million)								
1961	49	660	23	460	8	10	46	3072
1971	66	841	29	568	12	12	60	3761
1981	82	994	36	715	17	15	81	4511
1991	106	1151	50	891	25	19	111	5368
2001	130	1272	68	1075	33	24	146	6194
2011	149	1344	90	1250	43	27	183	7003
2019	163	1398	112	1366	53	29	217	7674
%Urban population								
1961	5	17	7	18	4	23	8	34
1971	8	17	9	20	4	25	11	37
1981	16	20	11	23	6	28	16	40
1991	20	27	13	26	9	31	17	43
2001	24	37	15	28	14	33	20	47
2011	31	51	18	31	17	35	24	52
2019	37	60	21	34	28	20	37	56
2050[a]	58	80	39	53	46	37	52	68
GDP (current US $)								
1961	384	141		336	267	313	480	3865
1971	381	238		394	275	459	705	5340
1981	375	360	229	438	297	577	889	6322
1991	416	786	187	576	367	752	900	7177
2001	541	1901	208	852	469	828	828	8223
2011	822	4961	369	1410	612	993	983	9739
2019	1856	10262	856	2100	1817	1071	1285	11442
2032[b]	2628	19060	1283	3428	2203	1787	1777	13616

Source: (World Bank, 2021a); [a]World Bank (2021b); [b]Real GDP per capita in 2010 price USDA (2021).

Table 3. Population in 2019 and projected population in 2030 and 2050 (million), in the sampled country by fertility rate assumptions.

Year	World	Bangladesh	China	Ethiopia	India	Kenya	Nepal	Pakistan
Population in 2018[a]	7592	161	1393	109	1353	51	28	212
Projected population[b]								
Year 2030								
Low variant	8363.5	174.4	1436.6	141.6	1467.8	64.8	32.4	257.0
High variant	8906.8	183.6	1492.1	148.3	1539.5	68.1	34.4	268.9
Year 2050								
Low variant	8733.5	172.6	1293.6	187.3	1 489.1	83.0	31.6	308.1
High variant	10587.8	212.9	1514.6	224.0	1793.4	100.4	39.3	368.9

Sources: [a]World Bank, (2021a); [b]United Nations, (2019)

3.0 Materials and methods

The examination of the future demand for wheat in the sampled seven countries relied on agricultural data sourced from the FAO (FAOSTAT) database, as well as the World Bank's World Development Indicators (WDI) data catalogue. Information on yearly per capita wheat consumption (kg), imports, domestic production, yields, and wheat area was retrieved from FAO online datasets. Urban population and per capita GPD data were collected from the World Bank's WDI catalogue.

The time series estimation procedure was applied to project yearly per capita wheat consumption in Bangladesh, China, Ethiopia, India, Kenya, and Pakistan as well as globally. The study intended to examine how and in which direction per capita GDP, the share of urban populations (%UR), domestic wheat production (DPR), and wheat imports (IMP) affect yearly per capita wheat consumption in the sampled countries. An initial suitability analysis of the Vector Autoregressive (VAR) model estimation procedure was conducted using Johansen's cointegration test. This procedure found that except for Nepal, all other sampled countries' variables are cointegrated, making the application of the VAR estimation procedure unsuitable. As an alternative, the Vector Error Correction (VEC) model estimation procedure was applied. The study's equations of interest are specified below.

$$\Delta \ln PC_t = \sigma + \sum^k_{i=1} \beta_i \Delta \ln PC_{t-i} + \sum^k_{j=1} \alpha_j \Delta \ln\%UR_{t-j} + \sum^k_{l=1} \varphi_j \Delta \ln GDP_{t-l} + \sum^k_{m=1} \gamma_m \Delta \ln DPR_{t-m} + \sum^k_{n=1} \theta_n \Delta \ln IMP_{t-n} + \lambda_1 ECT_{t-1} + \mu_{1t}$$

$$\Delta \ln\%URt = \phi + \sum^k_{i=1} \beta_i \Delta \ln PC_{t-i} + \sum^k_{j=1} \alpha_j \Delta \ln\%UR_{t-j} + \sum^k_{l=1} \varphi_j \Delta \ln GDP_{t-l} + \sum^k_{m=1} \gamma_m \Delta \ln DPR_{t-m} + \sum^k_{n=1} \theta_n \Delta \ln IMP_{t-n} + \lambda_2 ECT_{t-1} + \mu_{2t}$$

$$\Delta \ln GDP_t = \tau + \sum^k_{i=1} \beta_i \Delta \ln PC_{t-i} + \sum^k_{j=1} \alpha_j \Delta \ln\%UR_{t-j} + \sum^k_{l=1} \varphi_j \Delta \ln GDP_{t-l} + \sum^k_{m=1} \gamma_m \Delta \ln DPR_{t-m} + \sum^k_{n=1} \theta_n \Delta \ln IMP_{t-n} + \lambda_3 ECT_{t-1} + \mu_{3t}$$

$$\Delta \ln IMP_{t=v} + \sum^k_{i=1} \beta_i \Delta \ln PC_{t-i} + \sum^k_{j=1} \alpha_j \Delta \ln\%UR_{t-j} + \sum^k_{l=1} \varphi_j \Delta \ln GDP_{t-l} + \sum^k_{m=1} \gamma_m \Delta \ln DPR_{t-m} + \sum^k_{n=1} \theta_n \Delta \ln IMP_{t-n} + \lambda_4 ECT_{t-1} + \mu_{4t}$$

Where:

k-1	= the lag length is reduced by 1
$\beta_i, \alpha_j, \varphi_j, \gamma_m, \theta_v$	= short-run dynamic coefficients of the model's adjustment towards long-run equilibrium
λ_i	= speed of adjustment parameter with a negative sign
ECT_{t-1}	= the error correction term is the lagged value of the residuals obtained from the cointegration regression of the dependent variables on the regressors. Contains long-run information derived from the long-run cointegration relationship;
μ_{it}	= the residuals (stochastic error term/ impulses or innovations or shocks

For Nepal, no cointegration among the variables was found, suggesting an appropriate application of the VAR model estimation process to forecast yearly per capita wheat consumption in Nepal. Despite this, applying the VAR model estimation procedure did not provide any plausible results and it was decided to carry out a simpler univariate analysis, applying the autoregressive moving average (ARIMA, 3,0,4) estimation model. For Ethiopia and Kenya, the per capita GDP variable was excluded, as Ethiopia's per capita GDP data was not available for the period 1961-1980. For Kenya, the inclusion of GDP per capita in the model generated a conversion problem and overshot projected per capita wheat consumption.

Before applying the estimation procedure, the expected aggregate wheat consumption in sampled countries for 2030 and 2050 was calculated by multiplying the current amount of yearly wheat consumption per person (kg) by the projected population of the sampled countries in 2030 and 2050, under high and low fertility rate assumptions. The underlying assumption was that yearly per capita wheat consumption would remain the same until 2050. The projected aggregate wheat demand (only considering demographic changes), and econometrically estimated the projected per capita wheat consumption in 2030 and 2050 are presented in Table 4.

Table 4. Wheat consumption projection only by considering population dynamics and based on predicted consumption and population dynamics in the sampled countries.

Year	World	Bangladesh	China	Ethiopia	India	Kenya	Nepal	Pakistan
Yearly/cap/kg 2018	67	19	64	37	61	38	50	110
Total wheat consumed TE2018 (million ton)	508.7	3.1	89.1	4.0	82.5	2.0	1.4	23.3
Assuming current consumption rate will be constant								
Projected aggregate wheat demand in 2030 in million ton (considering only population dynamics)								
Low variant	560.4	3.3	91.9	5.2	89.5	2.5	1.6	28.3
	(10.1)	(6.4)	(3.1)	(30.0)	(8.5)	(25.0)	(14.3)	(21.5)
High variant	596.8	3.5	95.5	5.5	93.9	2.6	1.7	29.6
	(17.3)	(12.9)	(7.2)	(37.5)	(13.8)	(30.0)	(21.4)	(27.0)
Projected aggregate wheat demand in 2050 in million ton (considering only population dynamics)								
Low variant	585.1	3.3	82.8	6.9	90.8	3.2	1.6	33.9
	(15.0)	(6.5)	(-7.0)	(72.5)	(10.0)	(60.0)	(14.2)	(45.5)
High variant	709.4	4.0	96.9	8.3	109.4	3.8	2.0	40.6
	(39.5)	(29.0)	(8.8)	(107)	(32.6)	(90.0)	(42.9)	(74.2)
Econometric estimation								
Predicted consumption (yearly/cap/kg)								
2030	69.8	21.5	68.5	43.8	73.3	43.3	47.6	122.1
2050	74.8	29.1	70.6	53.4	96.2	63.5	44.0	128.1
Projected aggregate wheat demand in 2030 (million ton)								
Low variant	583.8	3.7	98.4	6.2	107.6	2.8	1.5	31.4
	(14.8)	(19.4)	(10.4)	(55.0)	(30.4)	(40.0)	(7.1)	(34.8)
High variant	621.7	3.9	102.2	6.5	112.8	2.9	1.6	32.8
	(22.2)	(25.8)	(14.7)	(62.5)	(36.7)	(45.0)	(14.3)	(40.8)
Projected aggregate wheat demand in 2050 (million ton)								
Low variant	653.3	5.0	91.3	10.0	143.3	5.3	1.4	39.5
	(28.4)	(61.3)	(2.5)	(150)	(73.7)	(165.0)	(0.00)	(69.5)
High variant	792.0	6.2	106.9	12.0	172.5	6.4	1.7	47.3
	(55.9)	(100)	(20.0)	(200)	(109.1)	(220)	(21.4)	(103)

Source: Authors' estimation.
Values in parenthesis and percentage change compared to TE2018 total wheat consumption.

4.0 Major findings and discussion

Yearly per capita wheat consumption projections and aggregate wheat demand for 2030 and 2050 are presented in Table 4. Population projections for 2030 and 2050 under low and high fertility rate assumptions were considered in this analysis.

4.1. World wheat consumption

The study first ran a projection for world wheat consumption in 2030 and 2050. The long-run relationship among yearly per capita wheat consumption, the percentage of urban people, total wheat production, and per capita GDP is explored in greater detail in Table 5.

The estimated error correction equation (ECT) for world wheat consumption is:

$ECT_{t-1} = \{lnPC_{t-1} + 0.11\ ln\%UR_{t-1} - 01.64\ lnPRO_{t-l} + 0.49GDP_{t-1} + 3.12\ lnIMP_{t-l} + 1.57\}$; setting the yearly per capita wheat consumption (PC) as the target variable, the estimated equation for world wheat consumption is as follows:

$$\Delta\, lnPC_t = 0.005 + 0.24\,\Delta\, lnPC_{t-1} - 0.41\,\Delta\, ln\%UR_{t-1} - 0.004\,\Delta\, lnGDP_{t-1} + 0.05\,\Delta\, lnDPR_{t-1} - 0.02\Delta\, lnIMP_{t-1} - 0.004\, ECT_{t-1}$$

Results show that in the long run, with other factors remaining the same, total wheat production ($p<0.00$) and the world's urban population ($p<0.00$) will impact yearly per capita wheat consumption positively and significantly. In contrast, average per capita GDP ($p<0.00$), and international trade ($p<0.00$) are expected to impact the world's yearly per capita wheat consumption negatively and significantly.

Aggregate world wheat demand projections for 2030 and 2050 are presented in Table 4 and have considered changes solely in world population, assuming low and high fertility rates and no change in the current level of yearly per capita world wheat

Table 5. Estimated functions applying the Vector Error Correction (VEC) model estimation procedure, explaining the relationship between yearly per capita wheat consumption (global average), global wheat trade, % global share of urban population, total wheat production in the world and world average GDP per capita.

	d.ln(Cons)	d.ln(Imp)	d.ln(%Urb)	d.ln(Pro)	d.ln(GDP)
ECT_{t-1}	-0.0042	-0.025	0.0057*	0.048***	-0.039***
	(0.00)	(0.03)	(0.00)	(0.02)	(0.01)
$d.ln(Cons)_{t-1}$	0.24*	1.68**	0.13	0.30	0.18
	(0.08)	(0.14)	(0.76)	(0.48)	(0.40)
$d.ln(Imp)_{t-1}$	-0.41**	-0.13	-0.54***	0.67	-0.30
	(0.18)	(0.97)	(0.11)	(0.62)	(0.51)
$d.ln(\%Urb)_{t-1}$	0.053	-0.24	-0.000081	-0.36***	-0.31***
	(0.04)	(0.21)	(0.02)	(0.13)	(0.11)
$d.ln(Pro)_{t-1}$	-0.0047	0.28	-0.012	0.12	0.55***
	(0.04)	(0.21)	(0.02)	(0.14)	(0.11)
$d.ln(GDP)_{t-1}$	-0.018	-0.21	-0.028*	-0.069	0.011
	(0.03)	(0.15)	(0.02)	(0.09)	(0.08)
Constant	0.0049	0.014	0.015***	0.026**	0.025**
	(0.00)	(0.02)	(0.00)	(0.01)	(0.01)
No. of observations			56		
AIC			-20.5		
HQIC			-19.9		
SBIC			-19.1		
Log likelihood			612.7		
R^2	0.23	0.29	0.63	0.50	0.73

Notes: Values in parentheses are standard errors. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.
Cons = yearly per capita wheat consumption in kg.
%Urb = % Urban population.
GDP = per capita GDP in nominal US $.
Imp = wheat import in million, ton (export=import for the world)
Pro = domestic wheat production in million tons.

consumption. Results show that by 2030, aggregate world consumption demand for wheat will be 10-17% more than the TE2018 total consumption amount of 508.7 million t (Table 4). By 2050, based on fertility rate assumptions, aggregate world wheat demand will fall between 585-709 million t, about 15-39% more than total wheat consumption in TE2018 (Table 4).

Yearly per capita world wheat consumption in 2030 and 2050 was forecasted using the Box-Jenkins method (Table 4). The required amount of wheat in 2030 and 2050 was estimated using world population projections assuming low and high fertility rates (Table 4). Figure 3 presents the (ln) actual yearly per capita wheat consumption for the period 1961-2018 and the (ln) projected yearly per capita world wheat consumption for the period 2019-2050.

The econometric estimation shows that by 2030 and 2050, yearly per capita world wheat consumption will increase to nearly 70 kg and 75 kg respectively, up from the current year per capita consumption of 67 kg (Table 4). By 2030, the world will require a wheat supply in the range of 583.8-621.7 million t or 15-22% more than the current amount of total world consumption of nearly 508 million t (Table 4). By 2050, the world will require a wheat supply in the range of 585-709 million t or 15-40% more than the total consumption amount in TE2018 (Table 4).

Currently, the triennium average (TE) 2019 world wheat yield is 3.5 t/ha, with216 million ha of land allocated for wheat production (Table 1). Assuming no change in yields until 2050, meeting the expected world demand for wheat will require either 22-57 million ha more of land allocated to wheat, or an increase in wheat yields in the range of 3.9-4.4 t/ha, assuming no change in land allocation to wheat.

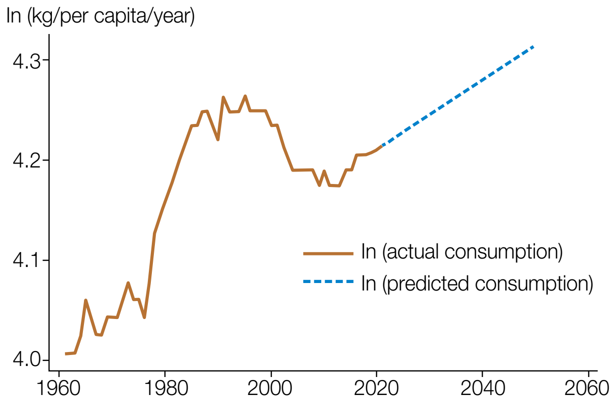


Figure 3. Actual (1961-2018) and predicted (2019-2050) yearly wheat consumption in kg in the world. (ln(kg/per capita/ year)), based on the Vector Error Correction (VEC) model estimation procedure.

4.2 Bangladesh

The long-run relationship between Bangladesh's yearly per capita wheat consumption, urban population (%), imports, domestic wheat production, and per capita GDP are detailed in Table 6.

Table 6. Estimated functions applying the Vector Error Correction (VEC) model estimation procedure, explaining the relationship between yearly per capita wheat consumption, wheat import, % share of urban population, domestic wheat production and GDP per capita in Bangladesh.

Dependent variables	d.ln(Cons)	d.ln(Imp)	d.ln(%Urb)	d.ln(Pro)	d.ln(GDP)
ECT_{t-1}	-0.026	1.81***	0.034	0.61	-0.035
	(0.26)	(0.47)	(0.05)	(0.45)	(0.04)
$d.ln(Cons)_{t-1}$	-0.48**	-1.02***	-0.015	-0.26	0.036
	(0.21)	(0.37)	(0.04)	(0.36)	(0.03)
$d.ln(Imp)_{t-1}$	0.086	0.16	0.016	0.13	0.0020
	(0.11)	(0.20)	(0.02)	(0.20)	(0.02)
$d.ln(\%Urb)_{t-1}$	-1.07	-0.85	-0.29**	0.47	0.19
	(0.76)	(1.36)	(0.13)	(1.31)	(0.13)
$d.ln(Pro)_{t-1}$	0.010	0.24	0.034**	0.081	-0.016
	(0.09)	(0.17)	(0.02)	(0.16)	(0.02)
$d.ln(GDP)_{t-1}$	-1.64**	-3.47**	-0.31**	-0.72	0.26*
	(0.81)	(1.45)	(0.14)	(1.39)	(0.14)
Constant	0.090*	0.0091	0.047***	-0.025	0.011
	(0.05)	(0.09)	(0.01)	(0.09)	(0.01)
No. of observations			56		
AIC			-5.58		
HQIC			-5.03		
SBIC			-4.17		
Log likelihood			195.3		
R^2	0.24	0.43	0.54	0.05	0.04

Notes: Values in parentheses are standard errors. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.
Cons = yearly per capita wheat consumption in kg.
Imp = wheat import in 1000, ton.
%Urb = % Urban population.
Pro = domestic wheat production in 1000 tons.
GDP = per capita GDP in nominal US $.

The estimated error correction equation (ECT) for Bangladesh is:

ECT_{t-1} = {$lnPC_{t-1}$ – 0.620 $lnIMP_{t-1}$ + 0.251 $ln\%UR$ – 0.188 $lnPRO_{t-l}$ -0.759 GDP_{t-1} – 2.568}; and setting the yearly per capita wheat consumption (PC) as the target variable, the estimated equation for Bangladesh, is as follows:

$$\Delta lnPC_t = 0.09 - 0.48\ \Delta lnPC_{t-1} - 1.07\ \Delta ln\%UR_{t-1} - 1.64\ \Delta lnGDP_{t-1} + 0.01\ \Delta lnDPR_{t-1} + 0.086\ \Delta lnIMP_{t-1} - 0.026ECT_{t-1}$$

Results show that in the long run, other factors remaining the same, domestic wheat production (p<0.00) and imports (p<0.00) will have a positive impact on yearly per capita wheat consumption. Conversely, the percentage share of the urban population (p<0.16) and GDP per capita (p<0.00) will have a negative impact.

Yearly per capita wheat consumption in Bangladesh in 2030 and 2050 was forecasted applying the Box-Jenkins method (Table 4). The amount of required wheat in 2030 and 2050 was estimated using population projections for 2030 and 2050 and low and high fertility rate assumptions (Table 4). Figure 4 presents (ln) actual yearly per capita wheat consumption for the period 1961-2018 and the (ln) projected yearly per capita wheat consumption of Bangladesh for the period 2019-2050.

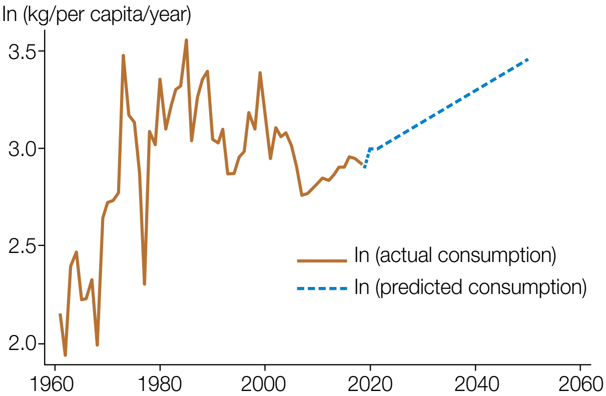


Figure 4. Actual (1961-2018) and predicted (2019-2050) yearly per capita wheat consumption in kg in Bangladesh. (ln(kg/per capita/year)), based on the Vector Error Correction (VEC) model estimation procedure.

Considering only the population forecasts for 2030 and 2050 and assuming no change in yearly per capita wheat consumption, Bangladesh will need to supply 3.3-3.5 million t of wheat in 2030 and 3.3-4.0 million t of wheat in 2050 (Table 4) to adequately meet its domestic wheat demand. The econometric estimation shows that by 2030 and 2050, Bangladesh's yearly per capita wheat consumption will increase to 21.5 kg and 29.1 kg, respectively, up from the current per capita consumption amount of 19 kg (Table 4). By 2030, the country will need to supply 3.7-3.9 million t or 19-26% more than the current total consumption amount of 3.1 million t (Table 4). By 2050, Bangladesh will need to supply 5-6.2 million t or 61-100% more than the current total consumption amount of 3.1 million t, to ensure that its population is food secure. (Table 4).

Bangladesh's current average wheat yield is 2.97 t/ha, with 0.37 million ha of land allocated for wheat production (Table 1). Assuming no change in yields until 2050, to meet domestic consumption, the country will need to allocate either 1.7-2.1 million ha of land to wheat production or increase its wheat yield to 13.5- 16.8 t/ha assuming no import.

4.3 China

The long-run relationship between China's yearly per capita wheat consumption and the variables of interest are detailed in Table 7.

The estimated error correction equation (ECT) for China is:

ECT_{t-1} = {$lnPC_{t-1}$ – 0.11 $lnIMP_{t-1}$ + 0.98 $ln\%UR_{t-1}$ – 0.0.27 $lnPRO_{t-l}$ – 0.29 GDP_{t-1} – 1.20}; and setting the yearly per capita wheat consumption (PC) as the target variable, the estimated equation for China, is as follows:

$$\Delta lnPC_t = 0.016 + 0.15\ \Delta lnPC_{t-1} + 0.94\ \Delta ln\%UR_{t-1}) + 0.16\ \Delta lnGDP_{t-1} - 0.09\ \Delta lnDPR_{t-1} - 0.003\ \Delta lnIMP_{t-1} - 0.169ECT_{t-1}$$

Results show that in the long run, other factors remaining the same, domestic wheat production (p<0.00), GDP per capita (p<0.05), and imports (p<0.00) have a positive impact on yearly per capita wheat consumption. Conversely, the percentage share of the urban population (p<0.00) will have a negative impact.

Yearly per capita wheat consumption in China in 2030 and 2050, was forecasted applying the Box-Jenkins method (Table 4). The amount of required wheat in 2030 and 2050 was estimated using population projections for 2030 and 2050 and low and high fertility rate assumptions (Table 4). Figure 5 presents (ln) actual yearly per capita wheat consumption for the period 1961-2018 and the (ln) projected yearly per capita wheat consumption of China for the period 2019-2050.

Table 7. Estimated functions applying the Vector Error Correction (VEC) model estimation procedure, explaining the relationship between yearly per capita wheat consumption, wheat import, % share of urban population, domestic wheat production and GDP per capita in China.

Dependent variables	d.ln(Cons)	d.ln(Imp)	d.ln(%Urb)	d.ln(Pro)	d.ln(GDP)
ECT_{t-1}	-0.17***	0.027	0.094***	-0.25***	0.044
	(0.03)	(0.41)	(0.01)	(0.06)	(0.04)
$d.ln(Cons)_{t-1}$	0.15	1.73	0.26***	0.21	0.14
	(0.13)	(2.00)	(0.07)	(0.31)	(0.18)
$d.ln(Imp)_{t-1}$	-0.0036	-0.072	0.0052	0.018	0.011
	(0.01)	(0.15)	(0.01)	(0.02)	(0.01)
$d.ln(\%Urb)_{t-1}$	0.93***	3.02	-0.24*	1.36**	0.46
	(0.23)	(3.52)	(0.13)	(0.54)	(0.32)
$d.ln(Pro)_{t-1}$	-0.087	-0.88	-0.012	-0.20	0.033
	(0.06)	(0.98)	(0.04)	(0.15)	(0.09)
$d.ln(GDP)_{t-1}$	0.16*	-2.00	-0.13***	0.61***	0.24*
	(0.09)	(1.40)	(0.05)	(0.21)	(0.13)
Constant	0.016*	0.073	0.016***	0.0093	0.034***
	(0.01)	(0.13)	(0.00)	(0.02)	(0.01)
No. of observations			56		
AIC			-13.9		
HQIC			-13.4		
SBIC			-12.5		
Log likelihood			427.96		
R^2	0.64	0.07	0.75	0.48	0.79

Notes: Values in parentheses are standard errors. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.
Cons = yearly per capita wheat consumption in kg.
Imp = wheat import in 1000, ton.
%Urb = % Urban population.
Pro = domestic wheat production in 1000 tons.
GDP =per capita GDP in nominal US $.

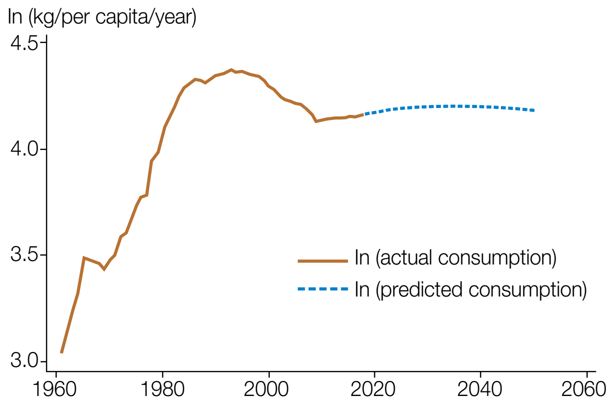


Figure 5. Actual (1961-2018) and predicted (2019-2050) yearly per capita wheat consumption in kg in China. (ln(kg/ per capita /year)), based on the Vector Error Correction (VEC) model estimation procedure.

Considering only the population forecasts for 2030 and 2050 and the current level of yearly per capita wheat consumption of 64 kg (Table 4) China will need to supply 82.8-95.5 million t of wheat by 2050, depending on low and high fertility rates. Under the low fertility rate assumption, the country does not need to produce more wheat to meet domestic wheat demand by 2030 and 2050 (Table 4). The econometric estimation shows that, by 2030 and 2050, the yearly per capita wheat consumption of China will increase to 68.5 kg and 70.6 kg respectively, up from the current yearly per capita consumption amount of 64 kg (Table 4). By 2030, China will need to supply 98.4-102.2 million t or 10-15% more wheat than the current total consumption amount of 3.1 million t (Table 4). By 2050, the country will need to supply 91.3-107 million t or 2.5-20% more wheat than the current total consumption amount of 89.1 million t in TE2018 (Table 4). The estimation shows that it is likely that China will be able to maintain the required wheat production to meet the projected demand. Similar to this projection, an OECD/FAO (2019) study estimated that by 2028, China's yearly per capita wheat consumption would amount to 62.6 kg, lower than the country's actual yearly per capita wheat consumption of 64 kg.

4.4 Ethiopia

The long-run relationship between Ethiopia's yearly per capita wheat consumption, urban population (%), imports, domestic wheat production, and per capita GDP are detailed in Table 8. The estimated error correction equation (ECT) for Ethiopia is[1]:

ECT_{t-1} ={$lnPC_{t-1}$ + 0.60 $lnIMP_{t-1}$) – 7.24 $ln\%UR_{t-1}$ – 1.26 $lnPRO_{t-l}$ – 2.758}; and setting the yearly per capita wheat consumption (PC) as the target variable, the estimated equation for Ethiopia, is as follows:

$$\Delta\, lnPC_t = -0.01 - 0.313\,\Delta\, lnPC_{t-1} + 0.13\,\Delta\, ln\%UR_{t-1} - 0.08\,\Delta\, lnDPR_{t-1} + 0.04\,\Delta\, lnIMP_{t-1} - 0.026\, ECT_{t-1}$$

[1] For Ethiopia, the information on the per capita nominal GDP from 1961- 1980 was not available, thus we could not include GDP per capita in our estimation process.

Table 8. Estimated functions applying the Vector Error Correction (VEC) model estimation procedure, explaining the relationship between yearly per capita wheat consumption, wheat import, % share of urban population, domestic wheat production and GDP per capita in Ethiopia.

Dependent variables	d.ln(Cons)	d.ln(Imp)	d.ln(%Urb)	d.ln(Pro)
ECT_{t-1}	-0.084**	-0.98***	0.020*	-0.080**
	(0.04)	(0.29)	(0.01)	(0.04)
$d.ln(Cons)_{t-1}$	-0.31**	-1.59	-0.038	0.39**
	(0.14)	(1.11)	(0.05)	(0.16)
$d.ln(Imp)_{t-1}$	0.042**	0.17	-0.0017	0.017
	(0.02)	(0.15)	(0.01)	(0.02)
$d.ln(\%Urb)_{t-1}$	0.13	-2.73	-0.27*	0.88*
	(0.43)	(3.38)	(0.14)	(0.48)
$d.ln(Pro)_{t-1}$	-0.085	-0.62	-0.0017	-0.28**
	(0.12)	(0.94)	(0.04)	(0.13)
Constant	-0.0099	0.00099	0.029***	0.0056
	(0.02)	(0.15)	(0.01)	(0.02)
No. of observations		56		
AIC		-4.15		
HQIC		-3.77		
SBIC		-3.17		
Log likelihood		143.1		
R^2	0.30	0.35	0.34	0.31

Notes: Values in parentheses are standard errors. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.
Cons = yearly per capita wheat consumption in kg. Imp = wheat import in 1000, ton.
%Urb = % Urban population. Pro = domestic wheat production in 1000 tons.

Results show that in the long run, other factors remaining the same, the percentage share of the urban population (p<0.00) will have a positive impact on yearly per capita wheat consumption, and conversely, imports and domestic production (p<0.00) will have a negative impact.

Yearly per capita wheat consumption in Ethiopia in 2030 and 2050, was forecasted applying the Box-Jenkins method (Table 4). The amount of required wheat in 2030 and 2050 was estimated using population projections for 2030 and 2050 and low and high fertility rate assumptions (Table 4). Figure 6 presents the (ln) actual yearly per capita wheat consumption for the period 1961-2018 and the (ln) projected yearly per capita wheat consumption of Ethiopia for the period 2019-2050.

Considering only the population forecasts for 2030 and 2050 and assuming no change in the current per capita consumption level, Ethiopia will need to supply 5.2-5.5 million t of wheat in 2030 and 6.9-8.3 million t of wheat in 2050 (Table 4), to adequately meet its domestic wheat demand. The econometric estimation shows that by 2030 and 2050, the yearly per capita wheat consumption of Ethiopia will increase to 43.8 kg and 53.4 kg respectively, up from the current yearly per capita wheat consumption amount of 37 kg (Table 4). By 2030, the country will need to supply 6.2-6.5 million t or 55-63% more wheat than the current total consumption amount of 4.0 million t (Table 4).

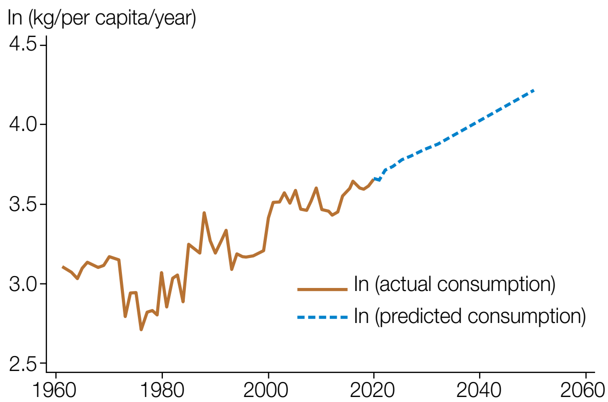


Figure 6. Actual (1961-2018) and predicted (2019-2050) yearly per capita wheat consumption in kg in Ethiopia. (ln(kg/ per capita/ year)), based on the Vector Error Correction (VEC) model estimation procedure.

By 2050, Ethiopia will need to supply 10-12 million t or 150-200% more wheat than the current total consumption amount (Table 4).

Ethiopia's current average wheat yield is 2.7 t/ha, with 1.74 million ha of land currently allocated for wheat production (Table 1). Assuming no change in yields until 2050, the country will need to allocate either 5.7-6.9 million ha of land for wheat production, or increase wheat yields to 5.74-6.89 t/ha, assuming no change in current land allocation to wheat, to meet its domestic wheat demand.

4.5 India

The long-run relationship between India's yearly per capita wheat consumption, urban population (%), imports, domestic wheat production, and per capita GDP are detailed in Table 9.

The estimated error correction equation (ECT) for India is:

$ECT_{t-1} = \{lnPC_{t-1} + 0.05\ lnIMP_{t-1} + 0.77\ ln\%UR_{t-1} - 0.44\ lnPRO_{t-1} - 0.16\ lnGDP_{t-1} - 1.10\}$; and setting the yearly per capita wheat consumption (PC) as the target variable, the estimated equation for India, is as follows:

$$\Delta\ lnPC_t = 0.01 - 0.34\ \Delta\ lnPC_{t-1} + 0.82\ \Delta\ ln\%UR_{t-1} - 0.02\ \Delta\ lnDPR_{t-1} - 0.45\ \Delta\ lnGDP_{t-1} + 0.003\ \Delta\ lnIMP_{t-1} - 0.09\ ECT_{t-1}$$

Results show that in the long run, other factors remaining the same, India's domestic production ($p<0.05$) will have a positive impact on yearly per capita wheat consumption, and conversely, imports ($p<0.00$) will have a negative impact. The estimation revealed that in India, the percentage share of the urban population and per capita GDP has no long-run influence on the country's wheat consumption.

Yearly per capita wheat consumption in India in 2030 and 2050, was forecasted applying the Box-Jenkins method (Table 4). The amount of required wheat in 2030 and 2050 was estimated using population projections for 2030 and 2050 and under low and high fertility rate assumptions (Table 4). Figure 7 presents the (ln) actual yearly per capita wheat consumption for the period 1961-2018 and the (ln) projected yearly per capita wheat consumption of India for the period 2019-2050.

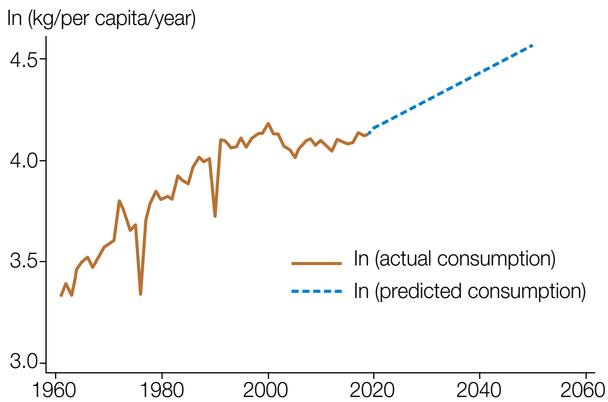


Figure 7. Actual (1961-2018) and predicted (2019-2050) yearly per capita wheat consumption in kg in India. (ln(kg/ per capita/ year)), based on the Vector Error Correction (VEC) model estimation procedure.

Table 9. Estimated functions applying the Vector Error Correction (VEC) model estimation procedure, explaining the relationship between yearly per capita wheat consumption, wheat import, % share of the urban population, domestic wheat production, and GDP per capita in India.

Dependent variables	d.ln(Cons)	d.ln(%Urb)	d.ln(Pro)	d.ln(GDP)	d.ln(Imp)
ECT_{t-1}	-0.088	-0.0082	0.22***	-0.064**	-9.94***
	(0.09)	(0.02)	(0.08)	(0.03)	(2.58)
$d.ln(Cons)_{t-1}$	-0.34**	-0.015	-0.13	0.000097	9.78**
	(0.14)	(0.02)	(0.12)	(0.04)	(3.99)
$d.ln(\%Urb)_{t-1}$	0.82	-0.32**	-0.10	-0.19	-2.81
	(0.77)	(0.13)	(0.68)	(0.23)	(22.13)
$d.ln(Pro)_{t-1}$	-0.019	0.040*	-0.060	-0.063	-7.71*
	(0.14)	(0.02)	(0.13)	(0.04)	(4.13)
$d.ln(GDP)_{t-1}$	0.0033	-0.0013	-0.0095**	0.0022	0.046
	(0.01)	(0.00)	(0.00)	(0.00)	(0.15)
$d.ln(Imp)_{t-1}$	-0.45	0.078	1.45***	0.021	-29.5**
	(0.48)	(0.08)	(0.42)	(0.14)	(13.69)
Constant	0.014	0.010**	0.021	0.029***	0.00013
	(0.02)	(0.00)	(0.02)	(0.01)	(0.70)
No. of observations			56		
AIC			-8.13		
HQIC			-7.58		
SBIC			-6.72		
Log likelihood			266.68		
R_2	0.23	0.47	0.37	0.35	0.61

Notes: Values in parentheses are standard errors. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.
Cons = yearly per capita wheat consumption in kg.
%Urb = % Urban population.
GDP = per capita GDP in nominal US $.
Imp = wheat import in 1000, ton.
Pro = domestic wheat production in 1000 tons.

Considering only the population forecasts for 2030 and 2050, India will need to supply 89.5-94 million t of wheat in 2030 and 91-109 million t of wheat in 2050 (Table 4) to adequately meet its domestic wheat demand. The estimation shows that by 2030 and 2050, the yearly per capita wheat consumption of India will increase to 73.3 kg and 96.2 kg respectively, up from the current yearly per capita consumption amount of 61 kg (Table 4). Our projection shows that by 2030, India will need to supply 108-113 million t or 30-37% more wheat than the current total consumption amount of 82.5 million t (Table 4). By 2050, India will need to supply 107-143 million t or 74-109% more wheat than the current total consumption amount (Table 4). These findings are similar to the findings of Gandhi (2004) and Nagaranjan (2005), which predicted an increase in wheat demand in India due to increases in income and urbanization.

India's current average wheat yield is 3.37 t/ha, with 29.9 million ha of land currently allocated for wheat production (Table 1). Assuming no change in yields until 2050, India will need to allocate either 42-51 million ha of land for wheat production, or increase wheat yields to 4.78-5.77 t/ha, to meet its domestic wheat demand. Similar to this projection, OECD/FAO (2019) projected that by 2028, yearly per capita wheat consumption of India will amount to 60.3 kg, lower than the country's actual yearly per capita wheat consumption amount of 61 kg in 2018.

4.6 Kenya

The long-run relationship between Kenya's yearly per capita wheat consumption, urban population (%), imports, domestic wheat production, and per capita GDP are detailed in Annexure Table 10.

The estimated error correction equation (ECT) for Kenya is:

$ECT_{t-1} = \{lnPC_{t-1} + lnDPR_{t-1} - 0.10\ lnIMP_{t-1} + 0.00\ ln\%UR_{t-1} - 5.047\}$; and setting the yearly per capita wheat consumption (PC) as the target variable, the estimated equation for Kenya, is as follows:

$$\Delta\ lnPC_t = 0.01 - 0.17\ \Delta\ lnPC_{t-1} + 0.35\ \Delta\ ln\%UR_{t-1} - 0.04\ \Delta\ lnDPR_{t-1} - 0.02\ \Delta\ lnIMP_{t-1} - 0.09\ ECT_{t-1}$$

Results show that in the long run, other factors remaining the same, Kenya's imports ($p<0.00$) will have a positive impact on domestic wheat consumption. It is worth noting that GDP per capita was excluded from the model as it overshot projected wheat demand.

Yearly per capita wheat consumption in Kenya in 2030 and 2050 was forecasted applying the Box-Jenkins method (Table 4). The amount of required wheat in 2030 and 2050 was estimated using population projections for 2030 and 2050 and low and high

Table 10. Estimated functions applying the Vector Error Correction (VEC) model estimation procedure, explaining the relationship between yearly per capita wheat consumption, wheat import, % share of urban population, domestic wheat production and GDP per capita in Kenya.

Dependent variables	d.ln(Cons)	d.ln(%Urb)	d.ln(Pro)	d.ln(Imp)
ECT_{t-1}	-0.54***	0.078	-0.092	0.088
	(0.17)	(0.05)	(0.24)	(1.54)
ECT_{t-2}	0.46***	-0.086**	0.23	2.82**
	(0.13)	(0.04)	(0.18)	(1.16)
ECT_{t-3}	-0.010	-0.010	-0.54***	1.21
	(0.11)	(0.03)	(0.16)	(1.04)
$d.ln(Cons)_{t-1}$	-0.17	-0.072	0.094	-1.17
	(0.15)	(0.04)	(0.21)	(1.35)
$d.ln(\%Urb)_{t-1}$	0.35	-0.34***	-0.46	4.49
	(0.44)	(0.13)	(0.62)	(4.00)
$d.ln(Pro)_{t-1}$	-0.039	0.042	-0.22	-1.01
	(0.11)	(0.03)	(0.15)	(0.99)
$d.ln(Imp)_{t-1}$	0.016	0.0015	-0.023	0.18
	(0.02)	(0.01)	(0.02)	(0.15)
Constant	0.0060	0.041***	-0.00025	0.00029
	(0.03)	(0.01)	(0.04)	(0.25)
No. of observations		56		
AIC		-0.07		
HQIC		0.42		
SBIC		1.19		
Log likelihood		36.95		
R^2	0.41	0.41	0.42	0.47

Notes: Values in parentheses are standard errors. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.
Cons = yearly per capita wheat consumption in kg.
%Urb = % Urban population.
Imp = wheat import in 1000, ton.
Pro = domestic wheat production in 1000 tons.

fertility rate assumptions (Table 4). Figure 8 presents the (ln) actual yearly per capita wheat consumption for the period 1961-2018 and the (ln) projected yearly per capita wheat consumption of Kenya for the period 2019-2050.

Considering only the population forecasts for 2030 and 2050, Kenya will need to supply 2.5-2.6 million t of wheat in 2030 and 3.2-3.8 million t of wheat in 2050 to adequately meet its domestic wheat demand (Table 4). The estimation shows that by 2030 and 2050, the yearly per capita wheat consumption of Kenya will increase to 43.3 kg and 63.5 kg respectively, up from the current yearly per capita consumption amount of 38 kg (Table 4). By 2030, Kenya will need to supply 2.8-2.9 million t or 40-45% more than the current total consumption amount of 2.0 million t (Table 4). By 2050, Kenya will need to supply 5.3-6.4 million t or 165-220% more wheat than the current total consumption amount (Table 4).

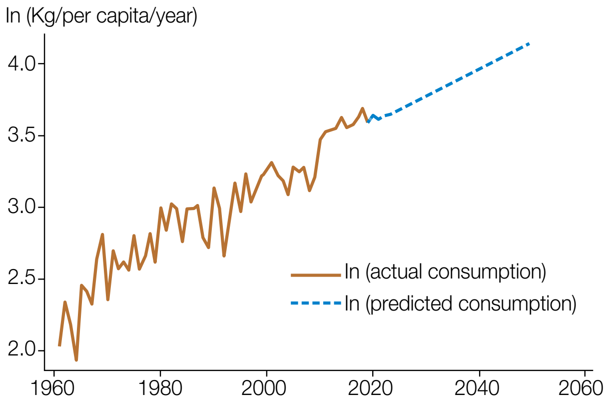


Figure 8. Actual (1961-2018) and predicted (2019-2050) yearly per capita wheat consumption in kg in Kenya. (ln(kg/ per capita/year)), based on the Vector Error Correction (VEC) model estimation procedure.

Kenya's current average wheat yield is 2.31 t/ha, with 0.13 million ha of land currently allocated for wheat production (Table 1). Assuming no change in yields until 2050, Kenya will need to allocate either 2.1-2.5 million ha of land for wheat production or increase its wheat yield to 37-44 t/ha—assuming no change in land allocation- to meet its domestic wheat demand.

4.7 Nepal

Table 11 presents the estimated functions that applied the ARIMA (3,0,4) model estimation procedure, detailing yearly per capita wheat consumption in Nepal.

$$lnPCt = 3.25 + 0.22\, lnPC_{t-1} - 0.01\, lnPC_{t-2} + 0.77\, lnPC_{t-3} + 0.48\, \mu_{t-1} + 0.84\, \mu_{t-2} - 0.24\, \mu_{t-3} + 0.06\, \mu_{t-4}$$

Table 11. Estimated functions applying the ARIMA (3,0,4) model estimation procedure, explaining yearly per capita wheat consumption in Nepal.

Dependent variable	ln(constant)
Constant	3.25*** (0.67)
ARMA	
l.ar	0.22 (0.22)
l2.ar	-0.0075 (0.21)
l3.ar	0.77*** (0.12)
lL.ma	0.48* (0.28)
lL2.ma	0.84 (1.00)
l3.ma	-0.24 (0.19)
lL4.ma	0.066 (0.20)
Sigma	0.093*** (0.01)
Observations	58
Log likelihood	52.0
Wald Chi²	370.8
Pro> Chi²	0.00

Note: Values in parentheses are standard errors. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

Yearly per capita wheat consumption in Nepal in 2030 and 2050 was forecasted applying the Box-Jenkins method (Table 4). The amount of required wheat in 2030 and 2050 was estimated using population projections for 2030 and 2050 and low and high fertility rate assumptions (Table 4). Figure 9 presents the (ln) actual yearly per capita wheat consumption for the period 1961-2018 and the (ln) projected yearly per capita wheat consumption of Nepal for the period 2019-2050.

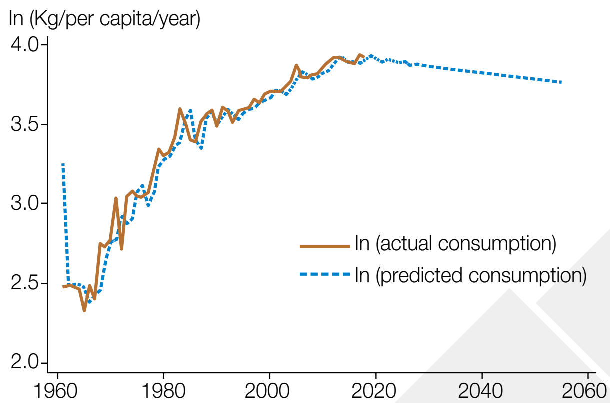


Figure 9. Actual (1961-2018) and predicted (2019-2050) yearly per capita wheat consumption in kg in Nepal. (ln(kg/per capita/year)), based on ARIMA (3,0,4) model estimation procedure.

Considering only the population forecasts for 2030 and 2050, Nepal will need to supply 1.6-1.7 million t of wheat in 2030 and 1.6-2.0 million t of wheat in 2050 (Table 4). The estimation shows that by 2030 and 2050, the yearly per capita wheat consumption of Nepal will decrease to 47.6 kg and 44 kg respectively, down from the current yearly per capita consumption amount of 50 kg (Table 4). By 2030, Nepal will need to supply 1.5-1.6 million t or 7.1-14.3% more than the current total consumption amount of 1.4 million t (Table 4). However, by 2050, Nepal will need to supply 1.4-1.7 million t of wheat or 0-21% more wheat than the current level of total consumption (Table 4).

4.8 Pakistan

Table 12 presents the estimated functions that detail the long-run relationship between yearly per capita wheat consumption and the remaining variables of interest for Pakistan.

The estimated error correction equation (ECT) for Pakistan is:

$ECT_{t-1} = lnPC_{t-1} + 1.17\ ln\%UR_{t-1} - 0.66\ lnPRO_{t-1} - 0.35\ lnGDP_{t-1} - 0.61\}$;

$ECT_{t-2} = lnIMP_{t-2} + 21.86\ ln\%UR_{t-2} - 12.28\ lnPRO_{t-1} + 3.56\ lnGDP_{t-1} + 24.48$; and setting the yearly per capita wheat consumption (PC) as the target variable, the estimated equation for Pakistan, is as follows:

$$\Delta\ lnPC_t = 0.02 + 0.05\ \Delta\ lnPC_{t-1} + 0.64\ \Delta\ ln\%UR_{t-1} - 0.03\ \Delta\ lnDPR_{t-1} + 0.21\ \Delta\ lnGDP_{t-1} + 0.001\ \Delta\ lnIMP_{t-1} - 0.58\ ECT_{t-1}$$

Results show that in the long run, other factors remaining the same, Pakistan's domestic production and per capita GDP will have a positive impact on yearly per capita wheat consumption, and conversely, the percentage share of the urban population will have a negative impact.

Yearly per capita wheat consumption in Pakistan in 2030 and 2050 was forecasted applying the Box-Jenkins method (Table 4). The amount of required wheat in 2030 and 2050 was estimated using population projections for 2030 and 2050 and low and high fertility rate assumptions (Table 4). Figure 10 presents the (ln) actual yearly per capita wheat consumption for the period 1961-2018 and the (ln) projected yearly per capita wheat consumption of Pakistan for the period 2019-2050.

Table 12. Estimated functions applying the Vector Error Correction (VEC) model estimation procedure, explaining the relationship between yearly per capita wheat consumption, wheat import, % share of urban population, domestic wheat production and GDP per capita in Pakistan.

Dependent variables	d.ln(Cons)	d.ln(Imp)	d.ln(%Urb)	d.ln(Pro)	d.ln(GDP)
ECT_{t-1}	-0.59***	7.53*	0.14*	0.063	0.11
	(0.12)	(4.11)	(0.07)	(0.22)	(0.08)
ECT_{t-2}	0.0048	-0.57***	-0.0049**	0.0089	-0.0090***
	(0.00)	(0.14)	(0.00)	(0.01)	(0.00)
$d.ln(Cons)_{t-1}$	0.054	-3.34	-0.064	0.039	-0.13
	(0.12)	(3.89)	(0.07)	(0.21)	(0.08)
$d.ln(Imp)_{t-1}$	0.0014	0.43**	0.0053*	0.00077	0.011***
	(0.01)	(0.17)	(0.00)	(0.01)	(0.00)
$d.ln(\%Urb)_{t-1}$	0.64***	-8.49	-0.44***	-0.15	0.23
	(0.24)	(7.87)	(0.14)	(0.42)	(0.16)
$d.ln(Pro)_{t-1}$	-0.033	-7.05**	0.098*	-0.26	0.035
	(0.09)	(3.09)	(0.05)	(0.16)	(0.06)
$d.ln(GDP)_{t-1}$	0.21	0.32	0.037	0.27	0.18
	(0.19)	(6.45)	(0.11)	(0.34)	(0.13)
Constant	0.016	0.00051	0.021***	0.039*	0.0032
	(0.01)	(0.38)	(0.01)	(0.02)	(0.01)
No. of observations	56				
AIC			-8.43		
HQIC			-7.90		
SBIC			-6.77		
Log likelihood			282.2		
R^2	0.47	0.37	0.47	0.26	0.40

Notes: Values in parentheses are standard errors. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.
Cons = yearly per capita wheat consumption in kg.
%Urb = % Urban population.
GDP = per capita GDP in nominal US $.
Imp = wheat import in 1000, ton.
Pro = domestic wheat production in 1000 tons.

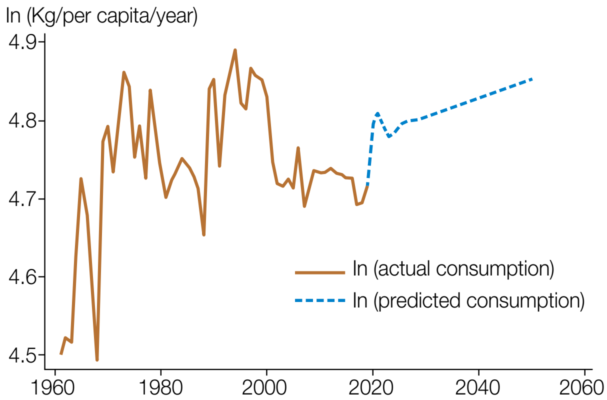


Figure 10. Actual (1961-2018) and predicted (2019-2050) yearly per capita wheat consumption in kg in Pakistan. (ln(kg/per capita/year)), based on the Vector Error Correction (VEC) model estimation procedure.

Considering only the population forecasts for 2030 and 2050, Pakistan will need to supply 28-30 million t of wheat in 2030 and 34-41 million t of wheat in 2050 to adequately meet its domestic wheat demand (Table 4).

The estimation shows that by 2030 and 2050, the yearly per capita wheat consumption of Pakistan will increase to 122 kg and 128 kg respectively, up from the current yearly per capita consumption amount of 110 kg (Table 4). By 2030, Pakistan will need to supply 31.4-33.0 million t or 35-41% more wheat than the current total consumption amount of 23.3 million t (Table 4). By 2050, the country will need to supply 40-47 million t or 70-103% more wheat than the current total consumption amount (Table 4).

Pakistan's current average wheat yield is 2.89 t/ha, with 8.8 million ha of land currently allocated for wheat production (Table 1). Assuming no change in yields until 2050, Pakistan will either need to allocate 13.8-16.3 million ha of land for wheat production or increase its wheat yield to 4.54-5.3 t/ha, to meet domestic wheat demand. Similar to this projection, OECD/FAO (2019), projected that by 2028, the yearly per capita wheat consumption of Pakistan would amount to 118.9 kg, close to this study's projection of 122 kg by 2030.

5. Conclusion and policy implications

Wheat has played a fundamental role in ensuring global food security since its domestication some 10,000 years ago. It is currently the most widely cultivated crop in the world and the second-most consumed staple after rice. The number of developing countries in the global south that have experienced significant urbanization and per capita GDP growth is considerable. Wheat is an integral part of the diets of millions of people in rapidly emerging countries, many of whom are food insecure. This study sought to understand the future demand for wheat in seven countries across Asia and Africa. Factors such as demography, GDP per capita, urbanization, and the production and import of wheat were taken into account for each country examined.

By applying VEC and ARIMA (3,0,4) estimation methods, the 2030 and 2050 demand for wheat was projected for Bangladesh, China, Ethiopia, India, Kenya, Nepal Pakistan, and worldwide. The estimation in this study shows that the previous year's wheat consumption significantly affects current year wheat consumption in Bangladesh, Ethiopia, India, and Nepal, yet is not significant in explaining per capita wheat consumption in the other sampled countries. While the per capita GDP significantly influences the yearly per capita wheat consumption in Bangladesh and China, it has no significant impact on yearly per capita wheat consumption in other sampled countries. Wheat imports seem to have a statistically significant influence on wheat consumption in Ethiopia but have no statistically significant influence on wheat consumption in any other sampled countries. Urbanization is a significant factor in explaining wheat consumption in China and Pakistan yet has no significant influence on wheat consumption in other countries.

At present, wheat is the second most important staple crop in Bangladesh, India, China, Kenya, and Nepal and is a principal staple grain in Pakistan. The projection shows that apart from Nepal, all sampled countries' yearly per capita wheat consumption is projected to increase by 2030 and 2050. The total 2030 and 2050 wheat consumption in Bangladesh, considering the projected population of the country, will increase by 19% and 61% respectively. For China, considering the projected population under the low-fertility rate assumption, wheat consumption will increase by more than 10% in 2030 and 2.5% in 2050. This study found that by 2030 and 2050, Ethiopia will need to increase its domestic wheat supply by 55% and 150% respectively. For India, by 2030 and 2050, the country must increase its wheat supply by 30% and 74%, respectively. By 2030 and 2050, it will be imperative that Kenya boost its domestic wheat supply by 40% and 165% respectively. For Nepal, the estimation showed that yearly per capita wheat consumption will decline slightly by 2030 and 2050. Given the projected population increase in the country, despite a low-fertility rate assumption, the aggregate wheat demand for Nepal is expected to increase until 2030 with no expected further change in 2050. For Pakistan, the forecast shows that by 2030 and 2050, will need to boost its domestic wheat supply by 35% and just under 70%, respectively.

Right now, of the 7.7 billion people on the planet, 821 million (10.9%) face hunger (FAO et al., 2019). By 2050, the world population is expected to increase to between 8.9 billion and 10.6 billion (United Nations, 2019) and with it, the number of hungry people is projected to reach 2 billion, most of whom will hail from the global south. As wheat demand continues to increase in the coming decades, a steady supply of affordable wheat, particularly in poverty-stricken developing countries in Asia and Africa, will have the potential to make a tremendous impact on eliminating global hunger. Given the reality of limited available agricultural land in the sampled countries and based on the findings, investment in the research and development of wheat and other major cereals is strongly urged. Harnessing genetic gains and enhancing crop yields have the potential to feed a burgeoning population and lift millions out of hunger by 2050.

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Notes

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