

Assessment of cereal self-sufficiency and food balance projection in Afghanistan

ABSTRACT

Aims: Afghanistan is overwhelmed with severe food shortages and food insecurity, in which a large percentage of the population lacks reliable access to food supplies. Cereals such as wheat, rice, and maize play a key role in the country's food security due to their importance in terms of consumption and production quantity. This paper estimates cereal self-sufficiency and then makes a food balance forecast of the three major food crops - wheat, rice, and maize - cultivated in Afghanistan over six-decades (1979 – 2030).

Methodology: Descriptive statistics, simple linear regression model, and coarse metric technique were employed to analyze the data from the United Nations Food and Agricultural Organization (FAO), United States Department of Agriculture PSD Database (USDA), and United Nations World Population Division databases to determine cereal self-sufficiency and food balance forecast.

Results Econometric analysis demonstrated that (1) Afghanistan is not yet self-sufficient in meeting grain consumption. (2) The production and consumption ratio declined from 0.9 to 0.54 from 1979 to 2018. (3) The gap of theoretical food imbalance will increase, and by the year 2030, cereal production will likely be sufficient for only 49.8 percentage of inhabitants, leaving a high shortage equivalent to the amount required by 24.4 million people. (4) Per capita cereal production will possibly decrease from 120.8 kg to 95.4 kg per person between 2018 and 2030.

Conclusion: By evaluating the quantitative food balance and the growing population change, this study presents an analysis of the emerging threat to Afghanistan's food security. Therefore, we recommended that the Afghanistan government should increase the size of public agricultural expenditure, improve the level of agriculture infrastructure, increase the cultivation area of cereals, and continue to introduce policy to achieve higher yield.

Keywords: Afghanistan, food security, cereal per capita production, cereal self-sufficiency.

1. INTRODUCTION

Afghanistan's agricultural sector supports almost 75% of the overall population's livelihoods and contributes around 28% of the gross domestic product (GDP) [1]. Therefore, the growth

of agriculture is vital to drive the country's economy and maintain food supply at the national level [2]. Agriculture provides income, food security, and job for more than 80% of the Afghanistan population and 44% of Afghanistan's households [3]. Therefore, Agriculture is still linked with low performance and is not adequate to produce food for the populace [4]. Besides, subsistence agriculture dominates Afghanistan's agriculture. More than half of the households produce primarily for their consumption [5]. Thus, it is a critical condition that requires urgent change for future growth, reduction of poverty, and export growth [6]. Additionally, in 2020, the World Bank indicated that 54% of Afghanistan's population was under the poverty line, and the COVID-19 pandemic will, predictably, aggravate the poverty level significantly [7]. Also, World Bank noted that the poverty rate might increase to between 61 % and 72 % in 2020 due to decreasing incomes and rising prices for food and other vital household goods [8]. More than 13.4 million people (about 37 %) in Afghanistan live in conditions of acute food malnourishment and food shortage [9]. Given the war and conflict in the last 40 years, this has mainly caused an increase in poverty and food insecurity [10]. Food security has long been the primary concern as it is the fundamental requirement for human survival and development in Afghanistan[11]. Afghanistan is the least food-secure country in the world, posing a warning to 60% of its populace [7]. The level of food insecurity has been aggravated by population growth and persistent war[12]. Food security in Afghanistan depends on three cereal crops: wheat, rice, and maize [13]. Most cereal grains are used for self-consumption in Afghanistan due to insufficient production capacity, while the wheat crop is the dominant agricultural product. It accounts for 82% of the total cereal consumption[14], and it the choice crop of more than 89% of Afghanistan's populace [15]. Wheat is cultivated in Afghanistan under both irrigated and rain-fed states. About 52% of the wheat area is allocated to irrigated wheat, contributing to 91% of the total wheat production. Even though Afghanistan's main grain crop, wheat production fails to meet domestic demand [16]. Approximately 1 million tons of wheat - equal to 25% of domestic required - are imported annually to sufficient domestic needs [17]. Consequently, Afghanistan is one of the world's chief wheat importers [18]. The second essential food crop in Afghanistan is rice [19], and Takhar, Baghlan, and Kunduz are the country's three top rice-producing provinces jointly called Afghanistan's grain basket. Keeping strategic rice has significant national food security, nutrition, and caloric intake [20; 21]. The average rice yield achieved 2.9 ton/ha with a total of 190000 ha lands cultivated and providing 532000 MMT [13]. Rice yield has improved from 3.22 t/ha to 3.50 t/ha in Afghanistan in the past year [22]. The average annual rice consumption per person was 17 kg [23]. Milled rice production was 33600 MMT between 2015 -2016, but the requirement for self-sufficiency was 623050 MMT. The current deficiency of milled rice has resulted in the import of 270250 MMT annually [21]. Maize is the third-largest grain crop in Afghanistan; it plays a vital role in Afghanistan's economy of development, where the population is quite malnourished [4]. The majority of people use an alternative source of food when conventional wheat and rice are scarce. However, maize is critical for Afghanistan's food security [24]. The productivity of maize fluctuated and is declining in recent years due to climate change. In 2017, maize production in Afghanistan was 173912 tons, a 44% reduction from the maize production of 20247 tons in 2017 [4]. Afghanistan cereal output has maintained a continued slow increase (fig. 1). The cereal yield (2136.3 kilograms per hectare) is low compared to that of Bangladesh, China, India, and Pakistan, which recorded output of 4411.2, 6222.3, 31608, 31708 kilograms per hectare, respectively[11]. On the other hand, the area used for cereal production has experienced a steady decline from 1979 to 2018 (fig. 2). Additionally, population (n) has moved up quicker than the area harvest; therefore, the per capita area harvested from 1979 to 2018 declined from 0.21 ha^{-1} to 0.05 ha^{-1} . So the per capita harvested area reduced over time. Also, interaction demonstrates limited natural resources with a growing population. Consequently, cereal self-sufficiency has always been a key policy objective and one of the fundamental food security issues in Afghanistan. Self-sufficiency is the capability of an area to sustain its own necessity for food, and it is dependent on consumption and production [25]. Afghanistan

food self-sufficiency is influenced by climate change [15], poverty and lack of food access [26], war and conflict [10], economic and demographic factors such as the growth of population, and lack of market [6]. Despite significant progress in understanding the impact of food self-sufficiency on food security and its underlying element, several previous research have concentrated on the qualitative evaluation of two aspects of food self-sufficiency (consumption and production). In our opinion, no previous researches have considered the historical patterns in the balance of food crop consumption and production and its impacts on the trends of self-sufficiency. Therefore, a clear understanding of such historical patterns is essential to identify the country's progress more effectively, considering the highly sensitive nature of food insecurity and poverty in Afghanistan. It is necessary to assess the balance between food crop production and consumption. The present study analyzes the past and future historical trends in primary cereal production and consumption balance by considering changes in the self-sufficiency ratio. The theoretical population without food based on agricultural per capita production from 1979 to 2030 will be examined.

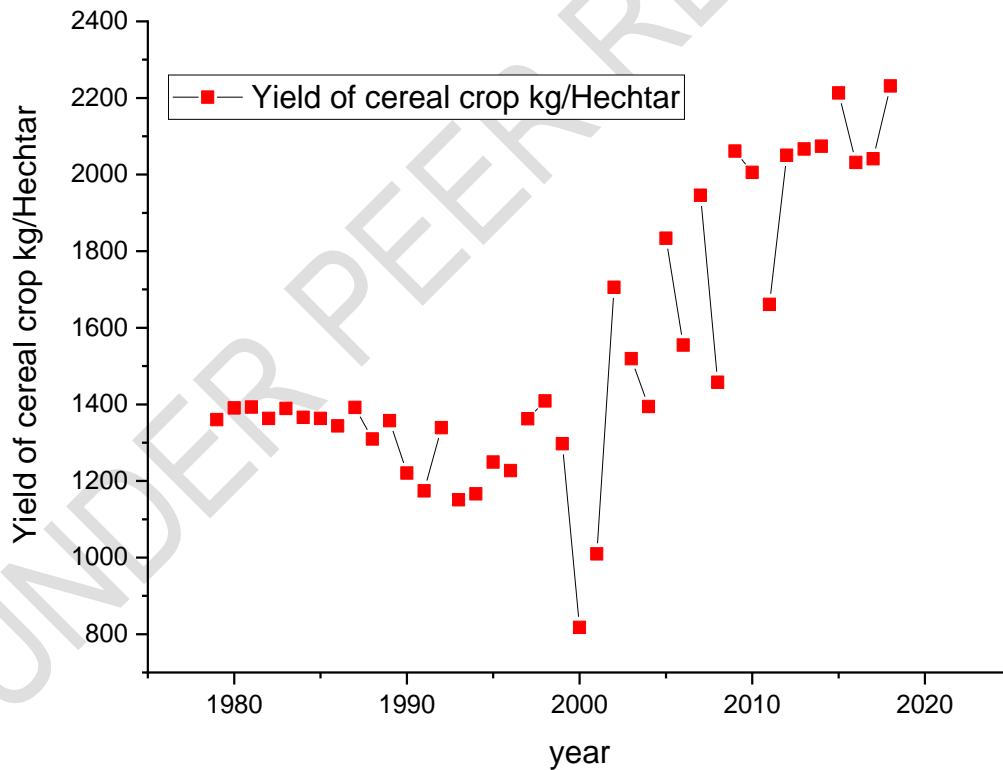


Fig.1 Yield of major cereal crop Kg/ha 1979 - 2018

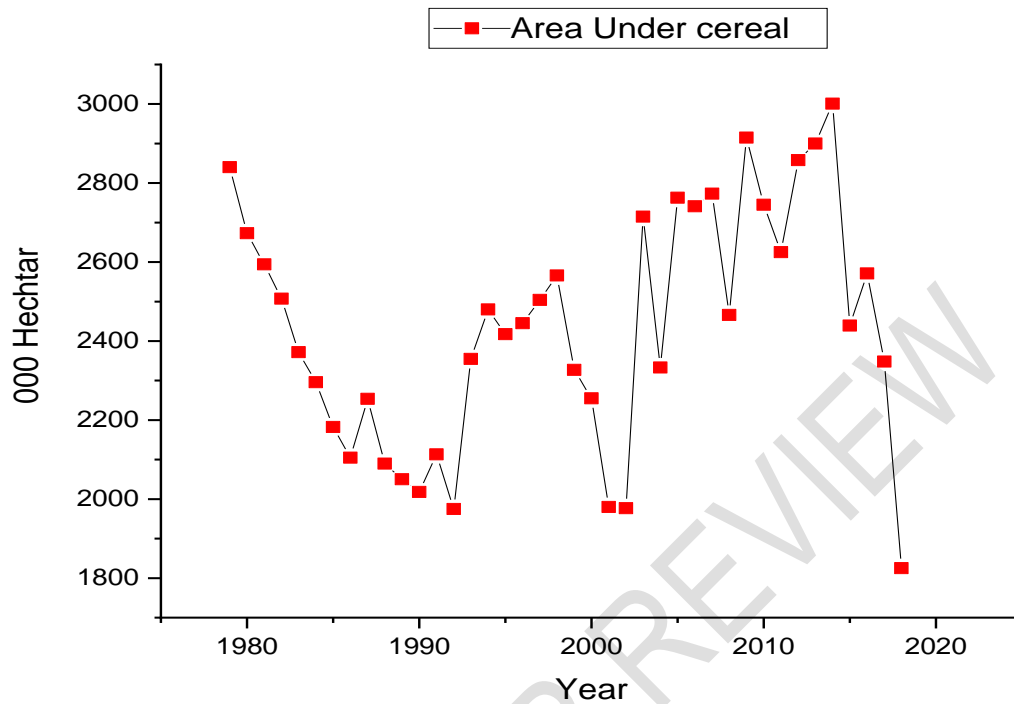


Fig. 2 Area under Major cereal crop production 1979-2018

2. MATERIAL AND METHODS

2.1. Data

This section aims to achieve the objective of this study of the three main food crops chosen for the analysis, namely wheat, rice, and maize, which provide around 80% of the total calories from food consumption [10]. This paper uses five sets of data (Table 1): population, as well as agricultural data on cereal, including area harvested (hectare “ha”), production (tones/hectare “MMT/ha”), consumption (tones), and yield (kilograms /hectare “kg/ha”) of those food crops were collected. The obtained data were of an annual time scale and covered the period of 1979 -2018. This data was used to estimate self-sufficient and theoretical food balance projections.

Table1. sources of cereal (production, consumption, harvested area, yield), and social data used in this study.

parameter	observed (0) predicted (p)	time period	source
cereal production statistics ^a	0	1979 - 2018	food and Agricultural Organization http://faostat.fao.org/
cereal consumption statistics ^b	0	1979 - 2018	United States Department of Agriculture https://www.fas.usda.gov
cereal harvested area statistics ^c	0	1979 - 2018	food and Agricultural Organization http://faostat.fao.org/

cereal Yield ^d	0	1979 - 2018	food and Agricultural Organization http://faostat.fao.org/
population data ^e	O& p	1979 - 2030	United Nation Population Division http://www.un.org/esapopulation/unpop.htm

a United Nation Food and Agricultural Organization(FAO) cereal production statistics; this data include major cereal crops (wheat, rice, and maize).

b, United States Department of Agriculture PSD Database (USDA) cereal consumption statistics, this data include major cereal crops (wheat, rice, and maize).

c, United Nations Food and Agricultural Organization(FAO) cereal Harvested area statistics; this data includes major cereal crops (wheat, rice, and maize).

d, United Nations Food and Agricultural Organization(FAO) cereal Yield statistics; this data includes major cereal crops (wheat, rice, and maize).

e, United Nations World Population Division. Mid-level population, estimate, and projection.

2.2. Methods

2.2.1. Cereal self-sufficiency

The calculation of self-sufficiency can be assessed as a basic equation of production and consumption. We use the proportion of production and consumption (p/c) as an indicator of self-sufficiency, where a country is a self-sufficiency at p/c=1 [27]. Production is the total major cereal production tones per year; domestic consumption depends on all possible uses of the country, including food, feed, seed, and industrial processing on the total three major cereal crop consumption across the country in tones per year. For a given consumption, we can calculate what amount of cereal grain production is required to make production meet consumption. The simple linear regression model is used to determine future value prediction of major cereal production and consumption [28]; the simple linear regression model is expressed as:

$$Y = \beta_0 + \beta_1 X \quad (1)$$

Where Y = the dependent variable

X = independent variable

β_0 = constant or intercept

β_1 = X's slope or coefficient.

2.2, 2. Food balance projections

Food security is a global issue and regional with fast-growing implications [29]. Continued population growth and consumption growth would rise in global food demand for at least the next 40 years [30]. Hence, the global political agenda has taken an essential role in decreasing malnutrition and hunger and increasing food security [31]. Therefore, increasing food security is a primary concern in Afghanistan. So, food availability is an essential element and has a severe role in increasing food security [32], [33]. Therefore, we will estimate food availability by using 1979–2018 time-series data on total grain yield, harvest area, and total population. Firstly, a simple equation is written to explain cereal per capita production(c (kg per person per year) in the term of total cereal harvested area (a (hectares), total population (n. (people)), and total grain yield annual (Y, (kg per ha per year)) the model is expressed as:

$$C = \frac{a}{n} y \quad (2)$$

This equation is a coarse metric that visibly ignores several substantial cereal consumptions related to nourishment, trade, vulnerability, and livelihoods of pastoral, etc [34], [35]. However, grain per capita production is a vital indicator availability of food, particularly in a large region of landlocked with huge agricultural inhabitants and high food insecurity regions [31]. Theoretically, cereal grain production per capita is impacted by positive and negative trends; however, harvested area per capita and yield patterns characterize cereal production per capita as a key determinant of food security. This section aims to recognize cereal production per capita to explore the change of per capita cereal production over time. Therefore the study uses the data over the 1979- 2018 period of time; cereal production per capita is a function of trends harvested area per capita and yield. However, this statistical framework can describe the per capita production variation. If we assume that these linear trends are continuous, we can project cereal grain production per capita values for the next decade. This study also illustrates that patterns in harvested areas, population, and yield appear to predominate in production decline variation overtime over climate factors. We describe “theoretical population without food” to better understand the human consequences of changing population and grain production interactions.

$$P = \frac{[ay]}{[ng]} g^{-1} \quad (3)$$

In this model, **P** is the hypothetical population’s foodless, estimated in the unit of persons. **(ay)** is cereal production annually (area times yield) (kg per year), **n** represents the number of people, and **g** represents the necessity of annual cereal (kg per person per year). In general, **g** significantly among cultures and livelihood groups. This study adopts the requirement of caloric 1900 calories/day with a standard caloric content of 3600 calories per Kg per cereal grain [36]. In general, this leads to a 190 kg annual grain requirement per person.

This estimate assumes the perfect sharing of cereal grain and that no grain is used for biofuels, alcohol, livestock, or other purposes [37]. This study also ignores imports and other sources of nutrition, although just an estimate of the availability of food. Eq. 3 provides a means of calculating the size of surpluses cereal deficits. Based on the previous literature, Afghanistan is a cereals deficient country [16]; hence, it might have theoretical food balances with huge negative values demonstrating millions of people in Afghanistan may experience deficiencies of food in the past and future. It is essential to remember that estimation assumes a low rate of baseline consumption.

3. RESULTS AND DISCUSSION

3.1. Cereal production and consumption

Afghanistan remains one of the countries with the lowest level of food security globally. Food security in Afghanistan is dependent on the top three cereal crops, namely wheat, rice, and maize [16]. Cereal represents more than 91% of Afghanistan's total crop production [11]. Yet, Afghanistan is a cereal deficient country, and cereal consumption rapidly increases over time, leading to an increasing deficit between domestic consumption and domestic production. Figure 3 indicated the deterioration of Afghanistan's capability to meet its own population’s demand for food crops in the last 40 years. Therefore, due to the slower increase in yield of major cereal crops (wheat, rice, and maize), two decades of civil strife

and political upheaval, prolonged drought (from 1998 to 2002), poor agricultural infrastructure, and high inefficiencies (technical, allocative and economic), the quantity of cereal produced was below the actual need for local consumption in Afghanistan [4; 16; 38; 39] Table (2).

Our result demonstrates that the ratio of production and consumption (p/c) of cereal grain self-sufficiency declined from 0.93 in 1979 to 0.54 by 2018 (Table.2). The result indicates that, with the exception years of 1987 -1998, Afghanistan was so far from being self-sufficient. It appears that the degree of cereal self-sufficiency ratio p/c differs from one year to another year due to the level of production and food consumption gap. A steadily growing population, slow increase of yield, and decrease land area under cereal production all aggravated the imbalance between production and consumption in Afghanistan. In addition, our forecast indicates that the production-consumption ratios (p/c) decrease from 0.69 in 2019 to 0.66 by 2030 (Table 3). Therefore, with the current production and consumption growth trend, Afghanistan cannot achieve cereal self-sufficiency in 2030. Even with increasing the current cereal yield level to 100%, cereal self-sufficiency cannot be achieved in Afghanistan.

Table2. Cereal production, consumption, and self-sufficiency ratio in Afghanistan (1970- 2018).

year	production(000 tons)	consumption (000 tons)	Self -sufficiency (%)
1979-1980	7579	8150	93.0
1981-1982	6979	8648	80.7
1983-1984	6431	8529	75.4
1985-1986	5803	8354	69.5
1987-1988	5875	5648	4.0
1989-1990	5041	4825	4.5
1991-1992	4731	4633	2.1
1993-1994	5602	5604	100.0
1995-1996	6020	6001	0.3
1997-1998	7025	6993	0.5
1999-2000	4863	5920	82.1
2001-2002	5371	7108	75.6
2003-2004	7377	8844	83.4
2005-2006	9328	10740	86.9
2007-2008	8991	13438	66.9
2009-2010	11514	14183	81.2
2011-2012	10220.1	13140	77.8
2013-2014	12216.6	15449	79.1
2015-2016	10622.4	17212	61.7
2017-2018	8865.3	16342	54.2

Source: Authors (2020)

Table3. Forecasted production, consumption of cereals, and self-sufficiency (2019 – 2030)

year	production(000 tons)	consumption (000 tons)	Self -sufficiency (%)
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2019	5158.1	7436.0	69.4
2020	5226.2	7567.3	69.1
2021	5294.3	7698.6	68.8
2022	5362.5	7829.9	68.5
2023	5430.6	7961.2	68.2
2024	5498.7	8092.6	67.9
2025	5566.9	8223.9	67.7
2026	5635.0	8355.2	67.4
2027	5703.1	8486.5	67.2
2028	5771.3	8617.8	67.0
2029	5839.4	8749.1	66.7
2020	5907.5	8880.4	66.5

Source: Authors (2020)

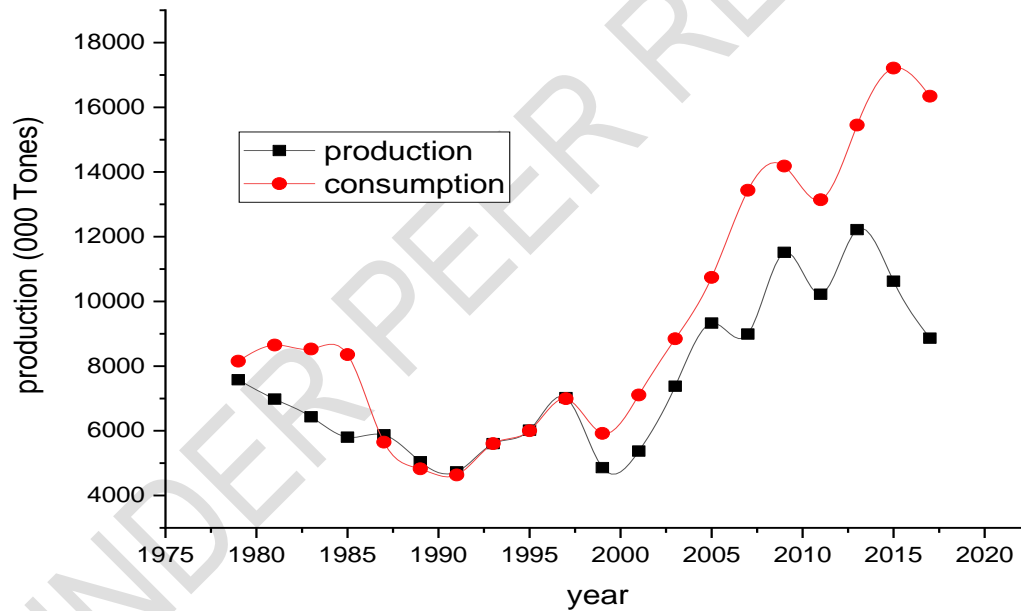


Fig.3. Time-series of cereal Production and consumption for 19790 – 2018 in Afghanistan.

3.2. Food balance analysis

Food availability is a primary element and has a vital role in increasing Afghanistan's food security [40]. Using the data on population, yields, and cereal cultivated areas described above, we assess the per capita production variation in time series, and by continuing these linear trends, and we forecast cereal grain production per capita values for the next decades.

Our statistical analysis demonstrates that, from 1979 to 2018, the total grain yield increased by 64%, but the harvested area decreased by 13.4% as a result of doubling of population, climate change, internal conflicts, and domestic wars, leading to an enormously declined cereal production per capita from 283.13 to 120.80 kg per person per year (Table 4). This result indicates that, due to the surprising growth rate of the population, slowly increased productivity, changing weather, land fragmentation, and declining cereal harvested area, grain per capita production in 2018, the per-capita production (120.80 kg per person) was 57.3% less than that of 1979 (283.13 kg per person). However, the use of grain crops for other uses like biofuels, alcohol, and feeding could re-expose millions of people to undernourishment and chronic food insecurity. Given the time series history of cereal crop from harvested area per capita and yield, grain appears fairly predictable; we may reasonably use the observed trends to forecast 2030 cereal production per capita. Table 5 forecasted 2018 to 2030 variations, expressed as Kg of grain per person per year and as percent changes compared to 2018. Our forecast demonstrates that cereal production per capita will be 95.4 kg per person per year in 2030; due to the changing population of 49 million people in 2030 (Table 5). This value is surprisingly lower than our arbitrary subsistence threshold of 190 kg, with an appreciable reduction (21%) less than in 2018. Our hypothetical food balance (Eq.3) proposes that the grain production may be sufficient for only 49.8% of the population and leaving a shortage equal to the amount needed by 24.4 million people (Table 5). Overall, cereal per capita production reduced from a low 120.8 kg per person per year in 2018 to a lower amount of 95.4 kilograms per person per year in 2030(Fig. 4). This decrees virtually triple the imbalance of theoretical food from -13.4 million people in 2018 to -24.4 million people in 2030 (Table 5).

This study suggests that Afghanistan will experience a progressive decline in food availability and a high level of food insecurity, and the per capita cereal production will reach dangerously low levels. Therefore, a very large increase in yield will be required to produce sufficient grain to feed the population in the future. For the current cereal consumption per capita, cereal yield will need to increase more than 100% from the 2018 level of 2183 kg per hectare per year to a very high yield of 4463 kg per hectare per year in 2030; this may not be technically feasible according to the current agricultural situation in Afghanistan.

Table 4. Cereal per capita production and theoretical food balance statistics for the period of 1970 – 2018

year	population ^a millions of people	Yield ^b kg ha ⁻¹	per capita Harvested ^c ha person ⁻¹	Per-capita production ^d kg person ⁻¹	Theoretical food Balance (millions ^e)
1979 - 1980	13.38	1375.22	0.21	283.13	6.56
1981 - 1982	13.03	1367.95	0.20	267.84	5.34
1983 - 1984	12.37	1377.49	0.19	259.88	4.55
1985 - 1986	11.84	1353.29	0.18	245.08	3.43
1987 - 1988	11.61	1350.88	0.19	253.00	3.85
1989 - 1990	12.14	1239.04	0.17	207.82	1.13
1991 - 1992	13.89	1156.70	0.15	170.94	-1.44
1993 - 1994	16.45	1158.44	0.15	170.35	-1.70
1995 - 1996	18.48	1238.12	0.13	162.94	-2.64
1997 - 1998	19.55	1385.32	0.13	179.66	-1.06

1999 - 2000	20.48	1057.56	0.11	119.21	-7.68
2001 -2002	22.10	1357.61	0.09	120.86	-7.97
2003 -2004	24.20	1456.66	0.10	152.85	-4.79
2005 - 2006	26.04	1694.21	0.11	179.35	-1.50
2007 - 2008	27.41	1701.87	0.10	164.39	-3.75
2009 - 2010	28.79	2033.44	0.10	200.12	1.51
2011 -2012	30.64	1855.69	0.09	166.41	-3.74
2013 -2014	32.82	2070.31	0.09	186.11	-0.67
2015 -2016	34.90	2122.41	0.07	152.25	-6.94
2017 - 2018	36.73	2136.33	0.06	120.80	-13.40

a, UN population estimates for 1979- 2018

b, the total FAO cereal yield for 1979-2018

c, the proportion of total cereals harvested area and population for 1979- 2018

d, per capita production, or the ratio of the total cereal production and population

e the theoretical food balance defined by Eq 3. This is a number of unfed people assuming a caloric cereal requirement of 190kg per person per year.

Table 5. **Projection of cereal per capita production and theoretical food balance statistics. These values were based on 2018- 2030 estimates of yields and per capita.**

year	per capita cereal production (kg person)	Change annual per capita production (2018 - 2030)		food balance (million)
		(kg person)	(%)	
2024	109.1	-11.7	-9.7	-18.6
2030	95.4	-13.7	- 12.6	-24.4

a. 2018-2030 yield and harvested area per capita were estimated based on (1979-2018) trends and used to derive estimates of 2030 per capita cereal production (Eq.2).

b. The change, in kilogram per person, between forecast 2030 and observed 2018 per capita cereal production

c. The difference, expressed variation, between projected 2030 and observed 2018 precipitate cereal production

d. Theoretical food balance (Eq.3), expressed in millions of people, based on annual cereal need of 190 kg per $person^{-1}$ per $year^{-1}$.

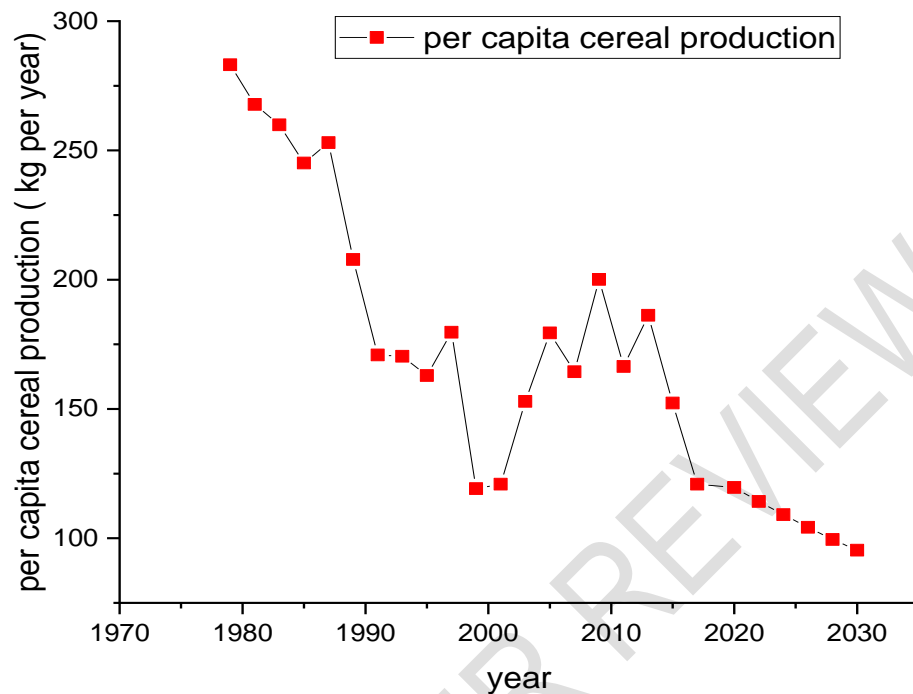


Fig.4 per capita production of major cereal crop in Kilogram per person per the year 1979 – 2030

4. CONCLUSION

The past trend in Afghanistan cereal crop production and consumption were examined to assess cereal crop self-sufficiency and cereal balance shed. Our findings indicate that the production-consumption ratios (p/c) unexpectedly declined and reflected in the level of self-sufficiency from almost 0.9 in 1979 to 0.54 by 2018 and was fluctuating over this period. However, it has become more unstable recently. The forecasted result of self-sufficiency in major cereal crops suggested that the self-sufficiency change rate will gradually decline. The decrease in sustainability ratio is manifested by the increasingly wide gap between food production and consumption growth. More importantly, our theoretical food balance forecasted recommends that grain production might be sufficient for nearly 49.8% of the inhabitants and leaving a shortage equal to the amount needed by 24.4 million people. Also, cereal per capita production will reduce from 120.8 kg per person per year in 2018 to a very low 95.4 kilograms per person per year in 2030. Food insecurity remains a critical problem in Afghanistan, requiring urgent government attention, interventional policies, and programs. Our study provides direction for ensuring cereal security in Afghanistan. To improve the cereal security level, meeting the demand for grain is the key. The production of grain should be enhanced. To this end, it is further recommended that the Afghanistan government

should increase the cultivation of cereals continuously and introduce a policy to achieve higher yield.

COMPETING INTERESTS DISCLAIMER:

AUTHORS HAVE DECLARED THAT NO COMPETING INTERESTS EXIST. THE PRODUCTS USED FOR THIS RESEARCH ARE COMMONLY AND PREDOMINANTLY USE PRODUCTS IN OUR AREA OF RESEARCH AND COUNTRY. THERE IS ABSOLUTELY NO CONFLICT OF INTEREST BETWEEN THE AUTHORS AND PRODUCERS OF THE PRODUCTS BECAUSE WE DO NOT INTEND TO USE THESE PRODUCTS AS AN AVENUE FOR ANY LITIGATION BUT FOR THE ADVANCEMENT OF KNOWLEDGE. ALSO, THE RESEARCH WAS NOT FUNDED BY THE PRODUCING COMPANY RATHER IT WAS FUNDED BY PERSONAL EFFORTS OF THE AUTHORS

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