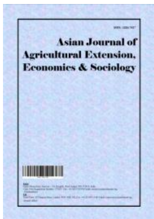

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Assessment of Cereal Self-sufficiency and Food Balance Projection in Afghanistan

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Authors' contributions

This work was carried out in collaboration among all authors. Author ZH managed conceptualization, supervision of the study, reviewed the manuscript, and funding acquisition. Author SAS performed investigation, collected the data, designed the study, performed the statistical analysis and prepared the original draft of the manuscript. Author WY reviewed the manuscript. Author SYA managed the data collection. Author ME assisted with the statistical analysis. All authors have read and agreed to the published version of the manuscript.

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ABSTRACT

Aims: Afghanistan is overwhelmed with food insecurity, thus severe food shortages in which a large percentage of the population lacks reliable access to food supplies. Cereals such as wheat, rice, and maize play a vital 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).

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Methodology: Descriptive statistics, ARIMA 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 0.55 from 1979 to 2030. (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, Agriculture's growth is vital to drive the country's economy and maintain food supply at the national level [2]. Agriculture provides income, food security, and employment opportunities 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 food provided by households is for personal 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 in 2020 between 61 % and 72 % due to decreasing incomes and increase prices for food and other essential 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 domestics demand [16]. Approximately 1 million tons of wheat - equal to 25 % of domestics required - are imported annually to be 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 18 years [22]. The average annual rice consumption per person was 17 kg [23]. Milled rice production was 33600 million metric tons (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 million metric tons (MMT) annually [21]. Maize is the third-largest grain crop in Afghanistan; it plays a key role in Afghanistan's economy of development, where the inhabitants are 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 [25]. 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 from1979 to 2018 declined from 0.21 to 0.05ha^{-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 [26]. Afghanistan food self-sufficiency is influenced by climate change [15], poverty and lack of food access [27], war and conflict [10], economic and demographic factors such as the growth of population, and lack of market [6]. All of these have a direct impact on food availability, food self-sufficiency, and increase food import [27,28,29]. However, under this situation, the implication of future cereal security deserves great attention.

A number of studies examined cereal self-sufficiency and prediction in the context of developing countries [30,31,32]. Van et al. [30] used production: consumption ratio to assess rice self-sufficiency in 2025 in eight African countries, and their result demonstrated that with increasing population, diet change, and yield increase on existing land areas, such nations could not be self-sufficient. Similarly, Zakari, Seydou [33] applied an econometric model

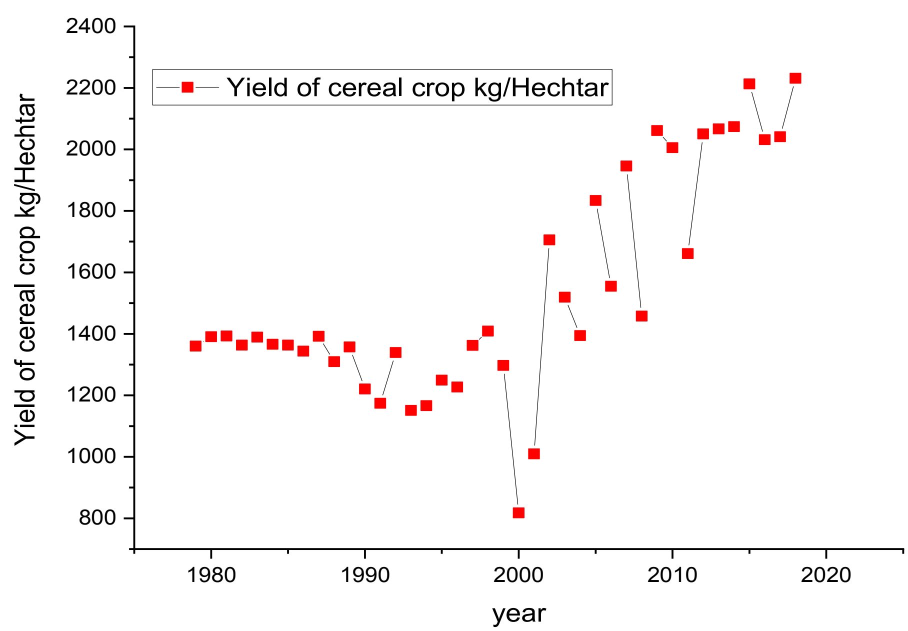

Fig. 1. Yield of major cereal crop Kg/ha 1979 - 2018

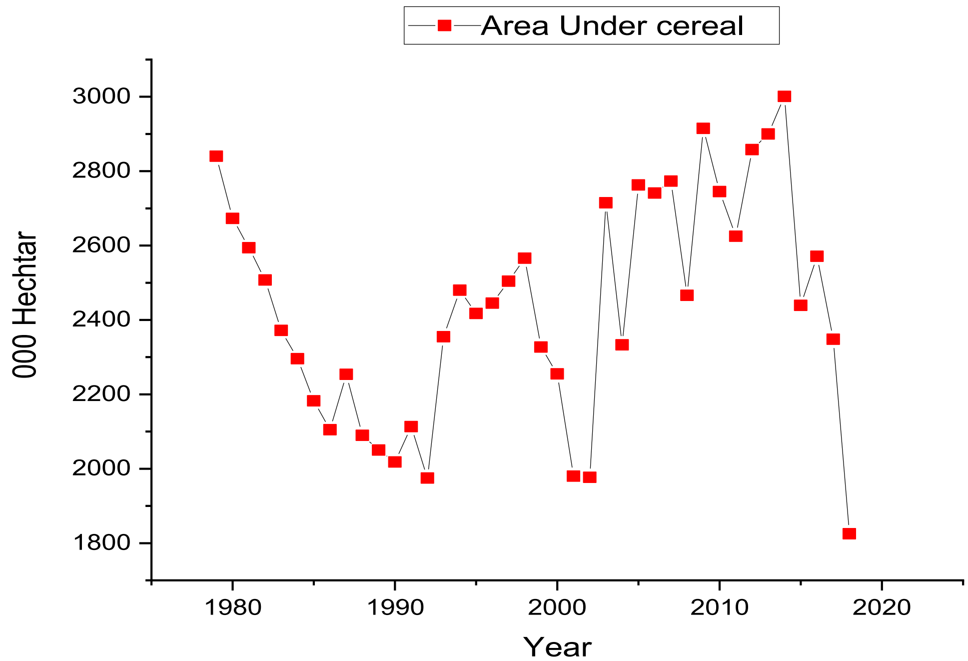

Fig. 2. Area under Major cereal crop production 1979-2018

Co-integration and vector error correction approaches to examine the impact of Niger food imports and food aid on domestic food production; the result indicated that food import and food aid have no significant effect on Niger domestic production in the long-run. A possible explanation is that the study supported self-sufficiency by domestic production. Also, Elmulthum [31] used a simple linear regression to forecast cereal self-sufficiency in Sudan and found that the self-sufficiency ratio was less than 100% almost all the time, and Sudan will continue to suffer from food insecurity. In addition, very few studies used per capita production to forecast future cereal self-sufficiency [34,35]. In Afghanistan, previous research has focused on the qualitative evaluation of two aspects of food self-sufficiency (consumption and production) [11,16,36]. In our opinion, no previous research has 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.

2. MATERIALS 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.

Table 1. 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 $\mathrm{statistics}^{a}$	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 Nations Food and Agricultural Organization(FAO) cereal production statistics 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 ratio. We use the proportion of production and consumption (p/c) as measure of self-sufficiency, where a country is self-sufficiency at p/c=1 [30]. 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.

2.2.2 Model description

The ARIMA model was used to forecast major cereal production and consumption in Afghanistan. We conduct our analysis in two stages. In the first stage, we check for non-stationary or existence of unit root in the time series data. Due to the argument Zakari et al. [37], for the test to be accurate, the time series analysis must have the same order of integration. Augmented Dickey-Fuller (ADF) tests of unit root were used.

In the second stage, we used the BOX-jenkins (1970) technique of the ARIMA (p d p) approach to predict production and consumption [38]. The ARIMA (p d q) model a mixture of the autoregressive (AR) and moving average (MA) models, which demonstrate that there is an association between present and past values. The AR is one of the ARIMA model elements indicating the variable under concern is regressed on its initial values. MA aspect of the ARIMA approach indicates that the regression error is a linear combination of values of the error occurring at different time intervals in the previous, and I aspect of ARIMA indicates how many periods differencing has been achieved.

The enter aim of investigation an appropriate AR, I, and MR terms is to adjust to get the approach to be in the greatest way possible. However, the ARIMA approach has its own limitation when it comes to relying on past values; nevertheless, it works greatest for long time series. It doesn't clarify the original data mechanism's structure; instead, it approximates historical trends [39,40].

AR (p) approach can be defined as:

Y_t = c + $\alpha_1 Y_{t-1}$ + $\alpha_2 Y_{t-2}$ + ………………..+ $\alpha_p Y_{t-p}$ + ε_t (1)

Where ε_t = (0,σ^2), c is an unknown constant, and it is measure to one for the constraints of the AR approach.

MA (q) approach cone specified as:

Y_t = c + ε_t + $\alpha_1 \varepsilon_{t-1}$ + ……… +α_q+ ε_{t-q} (2)

Where ε_t = (0, σ^2), c is a constant term of unknown and α_1 , α_2 are the MA model's parameters of the MA approach.

A time series stationary Y_t It is named order of autoregressive moving average (p), ARIMA (p), if for every t:

Y_t - $\alpha_1 Y_{t-1}$ + $\alpha_2 Y_{t-2}$ + ……….. + $\alpha_p Y_{t-p}$ = c + ε_t + α_1 ε_{t-1} + ………… +α_q ε_{t-q} (3)
ε = (0, σ^2).

The polynomials generation (ε) = 1 – θε - …….. - $\theta_p \varepsilon^p$ And (ε) = 1 + α_1ε + ……….$\alpha_q \varepsilon^q$, they have not common roots.

After association the differencing with the ARIMA approach, the autoregressive integrated moving average method was obtained, in this approaches, i.e., the ARIMA (p, d, q), where d is the differencing order; therefore, an ARIMA approach corresponds to an ARIMA after differencing Y_t d periods. However, the autoregressive model of the common form of ARIMA model (p, d, q) is expressed as:

Y_t = c + $\alpha_1 Y_{t-1}$ + α_2 Y_{t-2} + ………… + α_p Y_{1-p} + $\alpha_t \varepsilon_{t-1}$ + $\alpha_2 \varepsilon_{t-2}$ ………+ $\alpha_q \varepsilon_{t-q}$ + ε_t (4)

2.2.3 Food balance projections

Food security is a global issue and regional with fast-growing implications [41]. Continued population growth and consumption growth would rise food demand globally for at least the next 40 years [42]. Hence, the global political agenda has taken an essential role in decreasing malnutrition and hunger and increasing food security [35]. 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 [43,44]. Thus, with respect to the methodology of previous research by Funk et al. [35]. We will estimate food availability by using 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= (a/n) y (5)

This equation is a coarse metric that visibly ignores several substantial cereal consumptions related to nourishment, trade, vulnerability, and livelihoods of pastoral, etc [45,46,47]. However, grain production per capita is a vital indicator availability of food, particularly in a large region of landlocked with huge agricultural inhabitants and high food insecurity regions [35]. 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 over time over climate factors. We describe "theoretical population without food" to well understand the human consequences of changing population and grain production interactions.

P= [(ay) – (ng)] g^{-1} (6)

In this model, **P** is the hypothetical population's foodless, estimated in the unit of persons. **(ay)** is the production of cereal annually (area times yield) (kg per year), **n** represents the quantity of people, and **g** represents the necessity of annual cereal (kg per person per year); in practice, the amount of g significantly different among cultures and livelihood groups. This research adopts the requirement of caloric 1900 calories/day with a standard caloric content of 3600 calories per Kg per cereal grain [46]. 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 [48]. This study also ignores imports and other sources of nutrition, although just an estimate of the food availability. Eq. 5 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 persons 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 Data and Context

Due to the nature of time-series data, since we are researching with time-series analysis, it is important that we first determine the stationary of individual time series before prediction. However, we examined the time series structures of production and consumption individually by using the ADF test [37]. The result of our analysis indicated that the null hypothesis of the existence of unit root is rejected after the first differencing for production and consumption. This administrates that time series of production and consumption are stationary and integrated of one unit.

After differencing has been used to stationeries, in the second stage, the series of time needs to look whether any AR or MA terms are needed to correct the autocorrelation that remains in the differenced time to fit an ARIMA model. Therefore we used autocorrelation methods (ACF), and partial autocorrelation function (PACF) plots are used to accomplish this. However, finally, we obtained ARIMA (1, 1, 2) model to forecast major cereal production and consumption over time. The result of our analysis is present in Table 3 to further interpretation in self-sufficiency.

3.2 Cereal Production and Consumption

Afghanistan remains one of the countries with the lowest level of food security globally [27]. 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. Fig. 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 [4,16,49,50] Table (2).

Our result demonstrates that the ratio of production and consumption (p/c) =1 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) continuing decrease to the level of 0.55 to 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.

3.3 Food Balance Analysis

Food availability is a primary element and has a vital role in increasing Afghanistan's food security [51]. 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

Table 2. 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)

Table 3. Forecasted production, consumption of cereals, and self-sufficiency (2019 – 2030)

Year	Production(000 tons)	Consumption (000 tons)	Self -sufficiency (%)
2019	4562.76	8231.8	55.43
2020	4631.87	8335.7	55.57
2021	4696.68	8439.6	55.65
2022	4757.82	8543.8	55.69
2023	4815.83	8648.0	55.69
2024	4871.17	8752.3	55.66
2025	4924.24	8856.7	55.60
2026	4975.35	8961.15	55.52
2027	5024.82	9065.65	55.43
2028	5072..87	9170.15	55.32
2029	5119.72	9274.65	55.20
2030	5165.55	9379.25	55.07

Source: Authors (2020)

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).

Table 4. Cereal production per capita 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 assessments for 1979- 2018*
[b] *the total FAO yield of cereal for 1979-2018*
[c] *the proportion of total harvested area of cereals and population for 1979- 2018*
[d] *production per capita, or the ratio of the total grain production and population*
[e] *the theoretical food balance defined by Eq 6. This is a number of unfed people assuming a caloric cereal requirement of 190kg per person per year.*

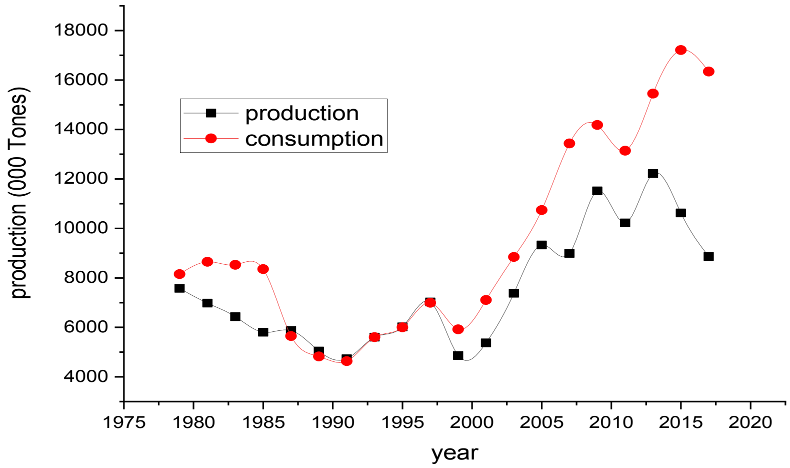

Fig. 3. Time-series of cereal Production and consumption for 19790 – 2018 in Afghanistan

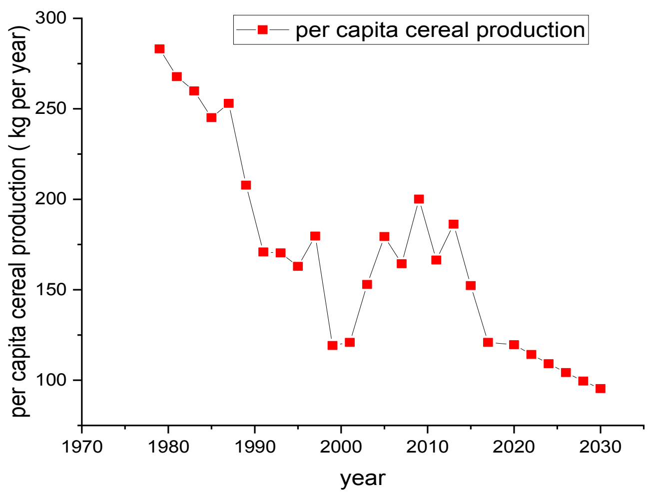

Fig. 4 Per capita production of major cereal crop in Kilogram per person per the year 1979 – 2030

Table 5. Projection of cereal per capita production and theoretical food balance statistics. These values were based on2018- 2030 estimates of yields and per capita

Year	Per capita cereal production (kg person)	Change annual per capita production (2018 - 2030) (kg person)	(%)	food balance (million)
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 cereal production per capita (Eq.5).

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

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

d. Theoretical food balance (Eq.6), expressed in millions of people, based on annual food grain need of 190 kg per $person^{-1}$ *per* $year^{-1}$ *.*

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 in 2030; this may not be theoretically possible according to the current agricultural situation in Afghanistan.

4. CONCLUSION

Afghanistan remains a major stronghold of hunger in the world. However, in recent decades, one of the Afghanistan government's food policies is to achieve self-sufficiency in cereal food crops due to their importance in terms of consumption and production quantity. Thus, in the present study, grain self-sufficiency and theoretical food balance projection in Afghanistan, with particular reference to wheat, rice, and maize, were investigated by examining trends in production, consumption, yield, aria, and overall population. ARIMA model and cross metric were selected as the best-fitted models for forecasting and predicting theatrical food balance projection.

Afghanistan is very far from self-sufficiency in major food crops due to the poor performance of Agriculture. The production is less than demand and appears likely to continue to be insufficient by 2030. Thus, our statistical analysis demonstrated that the self-sufficiency of Afghanistan as a whole has decreased from 0.9 to 0.54 in the past four decades, and it has been volatile over this period, and it has become more unstable recently. Furthermore, the forecasting result demonstrated that the self-sufficiency change rate would gradually decline.

More importantly, our results assume that cereal 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. 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.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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