Estimation of Population and Food Grain Production in Bangladesh by 2020: A Simple Moving Average Approach to a Time Series Analysis

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Abstract
The study used a time series dataset for a period of 23 years to estimate and analyse the size of population, food grain production and requirements for next ten years in Bangladesh with a view to providing policy makers and government with information for policy formulation and analysis. Using a simple moving average (SMA) method, a five-year average technique is applied for smoothing observed data series to generate a linear trend for the estimation of projected values of population, food grain requirements, net food grain production and food grain balance. The results indicate that the growth of population over next ten years will be very similar to the observed period. Increase in domestic food grain production shows a higher trend than food grain requirements leading to a food grain surplus over the same period. However, the size of population is growing too large to accommodate in a small country with a very low per capita income. The growing population will put enormous pressure on available resources thereby making future development unsustainable. The study suggests that the government should formulate policies to significantly reduce population growth.

Introduction

Appropriate policy formulation, planning and programme implementation are keys to socio-economic development of a country. Accurate projection of data plays an important role in providing policy makers with information and analysis that are required for policy formulation, planning, programme design and implementation for maintaining a sustainable socio-economic development in future. Projections of population and food grain production are intended to be useful for farmers, governments, agribusiness industries and policy makers. This sort of projection is crucial for developing countries like Bangladesh with a large size of population, small size of land area, low per capita income, high level of poverty, persistent food shortage, prolonged dependency on foreign aid, and low productivity in food grain sector.

Since its independence in 1971, Bangladesh has been considering high population growth as a number one problem for the economy. Although it strived to reduce population growth; the size of population became almost double over last three decade from 72 million in 1972 to 140 million in 2005 with an average increase by over 2 million per year (MoA 2007: Table 101). This enormous size of population living in a land of 145567 sq kilometre (with a density of over 1000 people per sq km) has posed a serious challenge for future development of the economy in following ways: putting huge pressure on environment and available resources; limiting agricultural growth and food grain production through reducing arable land for housing and non-agricultural purposes;

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raising requirement for food grain; and raising the number of poor population thus slowing down the rate of poverty reduction (Ali 1995: 95; Baffes and Gautam 2001:528; Rahman 2010: 957). Therefore, projection of population and proper population polices are crucial for sustainable development in Bangladesh (CPD 2003: 1).

Similarly, the food grain requirement also increased to double over the same period. Although, the domestic net food grain production increased by three times during this period; there are growing concerns that future food grain production will be constrained by reduction of arable land due to acquisition for housing, rapid urbanisation, infrastructure development etc., and lack of technical progress and modernisation in agriculture (Baffes and Gautam 2001:534). The increase in net food grain production might be attributed to a shift from local varieties to modern high yielding varieties (Bayes et al 1985: 225; Baffes and Gautam 2001:529). Most countries including Bangladesh consider domestic food grain production as an important factor for food price stabilisation and food security, and thereby pursue food self-sufficiency policies, in large part to avoid macroeconomic and political instability from food price shocks (Byerlee, Diao *et al.*, 2005): 8; Deb et al 2009: 1).

The projection of population and food grain production has increasingly become an important tool for development planning in many developing countries like Bangladesh, with the primary purposes: to (i) help policy makers develop appropriate population and food policies, (ii) help decide future investments and decisions on food grain production to improve food security, (iii) aid in addressing population and environmental issues, and (iv) allow for planning of future food requirement, as well as to identify national infrastructure and research and development requirements (Li *et al.* 2010: 16). Understanding the size of population, their demand for food grain and net domestic food grain production are keys to the development of policies on population and food to ensure sustainable development in Bangladesh. Although the debate over the value and effectiveness of the technical analysis of projection of population and food grain production still remains substantial along with consideration of costs, seasonal variation, uncertainty, risk involved etc.; technical analysis is based on the argument that the movements of population and food grain production are not random rather they move in trends, which are somewhat predictable (Ming-Ming and Siok-Hwa 2006: 146). Therefore, the main objective of this study is to estimate and analyse population size, their food grain requirement and food grain production in Bangladesh by 2020 with a view to providing policymakers and government with information for policy formulation and planning.

Many studies attempted to shed light on issues of projection of population and food grain production. Tarrant (1982) found that food policies in Bangladesh were conflicting- focusing on the interests of producers and consumers. He argued that these conflicting policies affected food grain production and estimation. Clay (1986) found that projections of food grain production, requirements and consumption would be crucial for policy analysis. He argued that World Food Programme (WFP) and International Food Research Institute (IFPRI) estimates were based on an extrapolation of trends in production. The models of Food and Agricultural Organisation (FAO) explored the implications of normative moderate or high growth scenarios for the agricultural sector. There were two general results from the two gap models: (1) food requirements were typically estimated as substantially in excess of current levels and expanding; (2) estimates were based on World Health Organisation (WHO)/FAO nutritional guidelines produced far higher requirements and projections reflected a demand, either based on past trend or improved growth scenarios. Allen (1994) extensively reviewed literature on economic forecasting in food grain and agricultural production. He argued that because of the special position of food production in a nation's food security, governments became both major suppliers and main users of agricultural forecasts. He found that for short-term forecasting, composite methods led to more accurate forecasts, better than those produced by single method. Also surprising was that econometric models and univariate methods both did badly as compared to naive models such as simple averaging methods. Baffes and Gautam (2001) found that in short run the current level of per capita food grain production could be sustained only through increased yields of modern rice varieties in Bangladesh. In long run, population control was found to have significant benefits in the economy. Koning *et al* (2008: 275) argued that the world's technical potential for food production seemed sufficient for feeding a significantly larger population than was expected by mid-century. Nevertheless, the productivity of land was being depleted, so that decreasing returns, rising energy prices and the underutilisation of potentials in some regions might cause a new change in the secular trend in food prices. This entailed transition risks, not least by the interaction of a trend change with endogenous price fluctuations in world food markets. This study will contribute to the literature by projecting population and food grain production in Bangladesh. It has applied a simple moving average (SMA) method to estimate the projected values of population, food grain requirements, net food grain production and food grain balance of the economy.

Simple moving averages (SMA) are frequently used in forecasting system when data changes over time but exhibits negligible growth and seasonality (Johnson et al 1999: 1199). They are useful in smoothing a time series data towards linearisation. Karen *et al* (2009:251) argued that SMA is perhaps the simplest of the smoothing algorithms but one of the most powerful techniques in prediction. If the duration of the cycle is short and data exhibits low seasonal effects then SMA can produce significant accuracy in predicting projected values of parameters.

Methodology

This study used a steady state model (SSM) of Johnson *et al.* (1999) for application of a SMA method to prediction of population and food grain production in Bangladesh. The SSM can be defined by two equations- (a) the observation equation that defines how the data points result from a random disturbance about a true but unknown level, and (b) the system equation that represents the movement of this level through time as a random walk process. This model provides a realistic characterisation of data generation. In this formulation observations are treated as stochastic disturbances about the unknown mean which itself undergoes a random walk. It can be represented by the following two equations as written in Johnson *et al* (1999: 1262) and Johnson *et al* (1999a: 1199).

Observation equation:

$$y_t = O_t + v_t; \qquad v_t \sim [O, V] \qquad (1)$$

System Equation:

$$O_t = O_{t-1} + w_{t;} \qquad w_t \sim [o, W] \qquad (2)$$

Where y_t is the observation at time t; O_t is the underlying level at time t; v_t and w_t are stochastic terms from distribution with zero means and fixed variance, V and W respectively. The optimal length of the average is related to the ratio of two variances V/W, often denoted by r. The optimal length of average can be presented by the following equation.

$$N^2 = 3\,(V/W) + {}^1/_2 \qquad or$$

$$N^2 = 3r + {}^1/_2 \qquad (3)$$

The model argues that for the time series under examination, the optimal average length may be unknown. As a broad generalisation, simple averages are often chosen on the basis of the characteristics of time series data such as monthly, fortnightly, weekly etc. Therefore, in practice, a single arbitrary or compromised value $\acute{N}$ has to be selected that may or may not be ideal for any individual series but satisfactory over all the series.

This study examines Bangladesh's annual data for a period of 23 years (Appendix: A1) to estimate and forecast the population and food grain production, requirement and balance. Bangladesh practices 5-year plans system. Each 5-year plan consists of 5 consecutive annual plans. Therefore, it is rationale to select 5-year as an arbitrary length of moving average ($\acute{N}$). Bangladesh Bureau of Statistics (BBS) used this length for time series analysis (MoA 2007: Table

1.01). Thus, this study arbitrarily selects 5-year as the length of average ($\acute{N}$) for calculation of simple moving average.

The simple moving average *m* of $\acute{N}$ values (number of periods), made after the information of the observation y_t, can be defined as

$$m = (1/\acute{N}) \sum_{i=0}^{\acute{N}-1} y_{t-i} \qquad (i = 0, 1, \ldots, \acute{N}-1) \qquad (4)$$

In this study, $\acute{N} = n$ = 5-year length. So, equation (4) can be rewritten as

$$m = (1/n) \sum_{i=0}^{n-1} y_{t-i} \qquad (i = 0, 1, \ldots, n-1)$$

Where y_t is independent and identically distributed observation at time t.

Application of a SMA computation to a time series data generates a moving group of data with a new mean calculated as the group steps along one data point at a time. Each time a new data point is added at the leading end, another is dropped off at the trailing end in order to maintain the selected length (*n*) of average. Each data point is therefore included in a sequence of *n* successive SMA calculations before it drops off the trailing end (Hay and Bull 2009: 251). This process continues until all data points are covered at the leading end.

The data used in this study comprises population, food grain requirement and net total food grain production in Bangladesh from 1985-86 to 2007-08. The characteristics of the data set are presented in Table 1. The value of mean, standard deviation, skewness and kurtosis of population, food grain requirement (FR) and net total food grain production (NTFP) suggest that data are fairly dispersed and distributed around the mean. However the standard deviation of food grain balance (FB) is nearly three times greater than the mean indicating that the observations are scattered and far away from the centre or mean. This situation is reflected in Figure 1.

In 1985-86, net food grain production and food grain requirements were 14239.2 and 16605.8 thousand tonnes respectively indicating a food grain deficit by 2366.6 thousand tonnes. Net food grain production exceeded food grain requirement in 1999-00 and continued this trend by 2007-88 (Figure 1).

Table 1 : Descriptive statistics of data

		Population (million)	**FR** (000 tonnes)	**NTFP** (000 tonnes)	**FB** (000 tonnes)
Number of observations		23	23	23	23
Minimum		98.10	16605.78	14239.16	-3691.74
Maximum		142.40	23576.31	26942.25	3365.94
Mean	Statistic	121.13	20319.04	19513.87	-805.16
	Std. Error	2.87	451.63	857.91	454.56
Std. Deviation		13.78	2165.95	4114.42	2179.99
Variance		190.02	4691363.51	1.693E7	4752398.84
Skewness	Statistic	-.102	-.208	.360	.51
	Std. Error	.48	.48	.481	.48
Kurtosis	Statistic	-1.24	-1.27	-1.414	-1.25
	Std. Error	.935	.935	.935	.935

Note: FR, NTFR and FB are Food Grain Requirement, Net Total Food Grain Requirement and Food Grain Balance Respectively.
Source: Authors' calculation

Result Analysis

A 5-year SMA technique has generated two new data sets: one for population in column 3 (SMA-population) and another for NTFP in column 5 (SMA-NTFP) as shown in Table 2. Interestingly, the observations in SMA-population show a trend very similar to the original data set of population as may be observed from the table. Even, some observations in SMA-population are same as their original counterparts suggesting that the rate of population growth follows almost a linear trend. This result indicates that both data sets for population are merged with each other and follow almost the same trend line as seen in Figure 2.

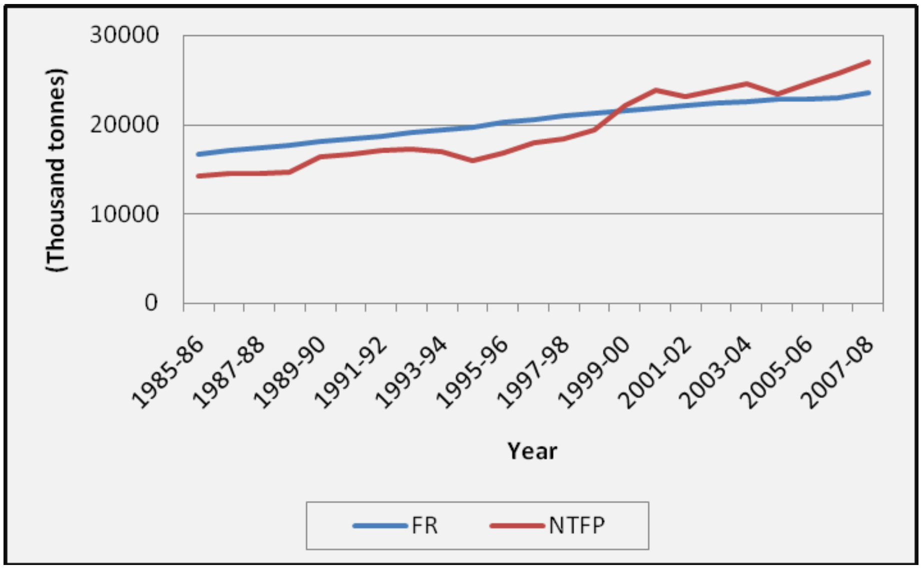

Figure 1: Net Total Food Grain Production (NTFP) and Food Grain Requirement (FR) in Bangladesh

Source: Authors' calculation from Table 1.01 (MoA 2007)

Table 2: Computations for the 5-year Simple Moving Average (SMA)

Year 1	Population (million) 2	SMA-Population 3	NTFP 4	SMA -NTFP 5
1985-86	98.1		14239.2	
1986-87	100.3		14591.1	
1987-88	102.5	102.5	14558.3	14897.6
1988-89	104.7	104.6	14650.5	15373.0
1989-90	106.8	106.8	16449.0	15871.8
1990-91	108.9	108.9	16615.9	16412.8
1991-92	111.0	110.9	17085.4	16875.8
1992-93	113.0	113.0	17263.1	16788.0
1993-94	115.0	115.0	16965.7	16840.4
1994-95	117.0	117.2	16010.0	17026.4
1995-96	119.0	119.5	16877.6	17239.6
1996-97	122.1	121.8	18015.3	17718.8
1997-98	124.3	124.0	18329.3	18942.7
1998-99	126.5	126.2	19361.8	20325.4
1999-00	128.1	128.0	22129.5	21334.1
2000-01	129.8	129.9	23791.4	22425.9
2001-02	131.5	131.6	23058.5	23449.1
2002-03	133.5	133.4	23788.4	23707.4

2003-04	135.2	135.2	24477.9	23863.0
2004-05	137.0	137.0	23420.7	24377.1
2005-06	138.8	138.8	24569.3	25007.8
2006-07	140.6		25629.1	
2007-08	142.4		26942.3	

Source: Authors' calculation

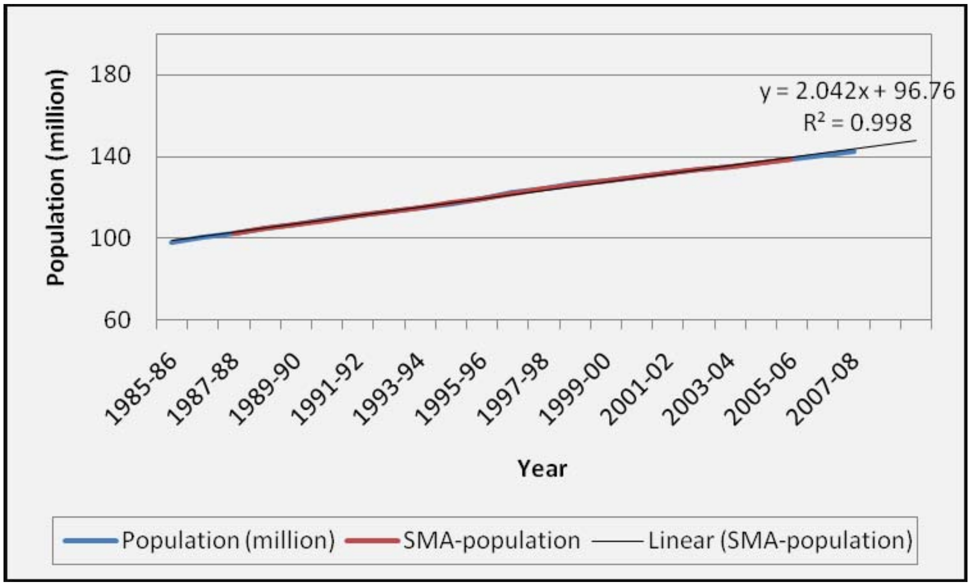

Figure 2: Population Size and 5-Year Simple Moving Average (SMA)
Source: Authors' calculation

On the other hand the SMA-NTFP data set varies from original NTFP observations. This variation is apparent from column 4 (NFTP) and 5 (SMA-NTFP) in the Table 2. For instance, in 1993-94, the figures for actual food grain production (NTFP) and randomly estimated food grain production (SMA-NTFP) are very similar- 16965.7 and 16840.7 thousand tonnes respectively but in 1994-95, the value of NTFP (16010) is much smaller than estimated SMA-NTFP value (17026); whereas in 1999-00, this value of NTFP (22129.5) is much greater than the value of SMA-NTFP (21334.1). This result suggests that the food grain production in Bangladesh has got seasonal and cyclical trends, and it is subject to some risks and uncertainty that might be caused by natural calamities such as floods, cyclone, drought, over-rainfalls etc and/or originated from market forces such as demand, supply, prices etc. This trend of fluctuation in estimated food grain production is presented in Figure 3.

As mentioned earlier the trends of true observations and randomly generated (through SMA) stochastic observations of the size of population are similar as shown in Figure 2. This result is expected and realistic in terms of the nature of the data (population). It suggests that the growth

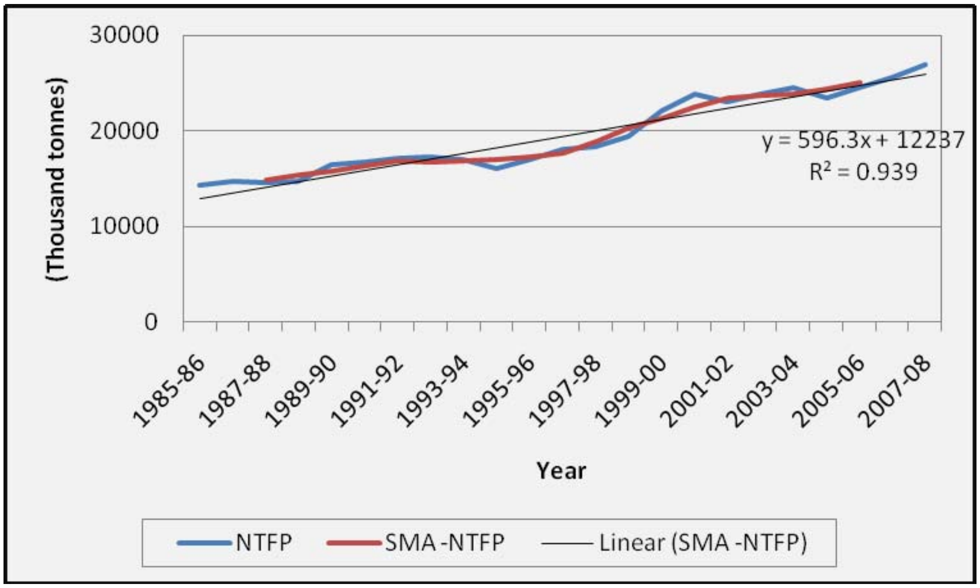

Figure 3: Net Total Food grain Production (NTFP) and 5-Year Simple Moving Average (SMA)
Source: Authors' calculation

of population is almost in a linear trend and free from seasonal and cyclical bias. The regression line (trend line) of stochastic observations is represented by the equation

$$y = 2.0425x + 96.767 \qquad or$$
$$y = 96.767 + 2.0425x, \qquad (x = 0, 1, 2, \dots\dots N).$$

Where *y* is the size of population and *x* is the reference year of that population. The coefficient of determination, R^2 is a statistical measure of how well a regression line approximates real data. In this model $R^2 = 0.998$ suggests that 99 percent of the estimated observations are likely to be predicted by this model.

Figure 3 presents the values of observed (NTFP) and estimated (SMA-NTFP) food grain production. There is a seasonal and cyclical variation in the trend of food grain production as mentioned earlier. The SMA method generated a linear trend in future food grain production as shown by the linear (SMA-NTFP) line.

This line is represented by the equation

$$y = 596.37x + 12237 \qquad or$$
$$y = 12237 + 596.37x, \qquad (x = 0, 1, 2, \dots\dots N).$$

Where *y* is the value of estimated NTFP and *x* is the reference year of that food grain production. In this model $R^2 = 0.9395$ suggests that this model is likely to have the capability of predicting 93 percent of the estimated observations. On the basis of the above two trend lines and models the study suggests that prediction of population growth will more likely be precise than the projection of food grain production.

Using the above estimated linear equations (trend lines) the study has projected the size of population, NTFP, food grain requirement and food grain balance in Bangladesh for a period from 2010 to 2020. These projected values are presented in Figure 4 and Figure 5. The size of population will grow from 147.8 million in 2010 to 168.3 million in 2020. This projection suggests that the size of population will increase over 2 million per year indicating a similar trend of growth to the observed period between 1985-86 and 2007-08. Therefore, the study predicts that the size of population in Bangladesh will grow by 20.5 million over next decade.

The food grain requirement is estimated on the basis of necessity of 453.66 gm per day per head as estimated by Bangladesh Bureau of Statistics (MoA 2007: Table 1.01). Therefore, FR estimation is based on estimated size of population and their food grain requirements. In 2010, the estimated FR is 24480.6 thousand tonnes. This figure is estimated to increase to 27862.9 thousand tonnes in 2020. The study forecasts that there will be an increase in FR by an average of 338.2 thousand tonnes per annum over next decade.

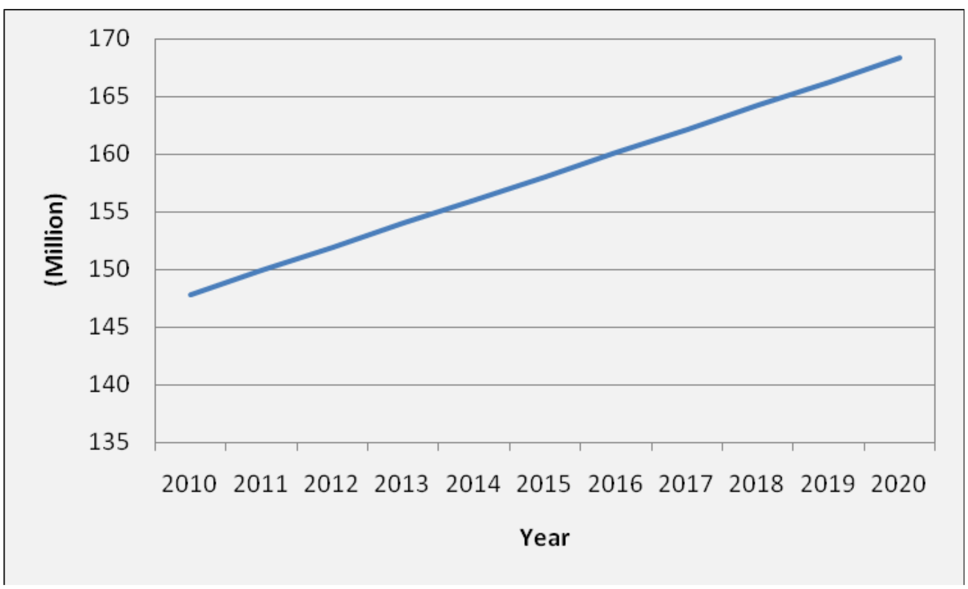

Figure 4: Projected Population in Bangladesh by 2020
Source: Authors' calculation

In Bangladesh net food grain production is calculated by deducting 11.58 percent from total food grain production for seeds, wastage as per study on *'Seed, Feed and Post Harvest Losses'* conducted by Ministry of Food (MoA 2007: note (ii) for Table 1.01). The projected values of NTFP in 2010 and 2020 are likely to be 27142.8 and 33105.1 thousand tonnes respectively. It is expected that the NTFP will increase by an average of 596.37 thousand tonnes per year over next decade exceeding annual FR over the same period resulting in a positive balance of food grain.

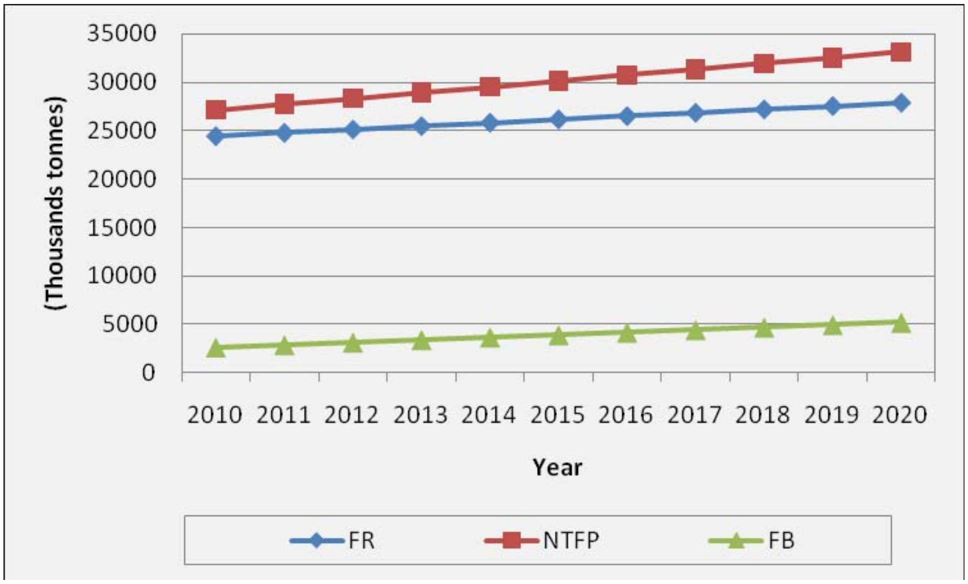

Figure 5: Projected food grain requirement (FR), net total food grain production (NTFP) and food grain balance (FB) in Bangladesh by 2020
Source: Authors' calculation

The estimated balance of food grain of a particular year is estimated by the difference between NTFP and FR of that year. Therefore, the study projects that food grain balance will be positive and will increase by an average of 258.17 thousand tonnes. The food grain balances in 2010 and 2020 are expected to be 2662.2 and 5242.1 thousand tonnes respectively.

Conclusion

The projections of this study suggest that the NTFP in Bangladesh will be likely to increase by a faster rate than the rate of population growth by 2020. So, Bangladesh is expected to continue to experience food surplus over next decade. However, the size of population is too large to live in a small country posing a big challenge to the government and policy makers in ensuring future sustainable development. On the other hand, food grain production in Bangladesh is much dependent of natural calamities such as floods - mixed with risks and uncertainty. The uncertainty elements of natural conditions may hamper future food grain production leading to food grain shortage of the economy. The study suggests that the trend of population growth will likely be more predictable and accurate than the movement of food grain production indicating an important policy implication for population reduction. The government should adopt population policies to reduce the rate of population growth to ensure sustainable development in future. These policies may include incentives for late marriage and small family size, increasing awareness of population problems and policies to improve child mortality rate so that couples are not indented to expect more children in their family because of uncertainty of lives of existing children due to high rate of child mortality. These policy measures may reduce the growth of population and help the government solve population problem and reduce food grain requirement in future.

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Appendix

A1: Population, Food grain Requirement (FR), Net Total Food grain Production (NTFP) and Net Food grain Balance (NFB) in Bangladesh: 1985-86 to 2007-2008

Year	Population (million)	FR (000 tonnes)	NTFP (000 tonnes)	NFB (000 tonnes)
1985-86	98.1	16605.8	14239.2	-2366.6
1986-87	100.3	16970.0	14591.1	-2378.9
1987-88	102.5	17334.3	14558.3	-2776.0
1988-89	104.7	17681.9	14650.5	-3031.4
1989-90	106.8	18029.6	16449.0	-1580.6
1990-91	108.9	18377.3	16615.9	-1761.4
1991-92	111.0	18708.4	17085.4	-1623.0
1992-93	113.0	19039.5	17263.1	-1776.4
1993-94	115.0	19370.7	16965.7	-2405.0
1994-95	117.0	19701.8	16010.0	-3691.7
1995-96	119.0	20215.0	16877.6	-3337.4
1996-97	122.1	20579.2	18015.3	-2563.9
1997-98	124.3	20943.5	18329.3	-2614.2
1998-99	126.5	21208.4	19361.8	-1846.6
1999-00	128.1	21489.8	22129.5	639.7
2000-01	129.8	21771.3	23791.4	2020.1
2001-02	131.5	22094.1	23058.5	964.4
2002-03	133.5	22350.8	23788.4	1437.6
2003-04	135.2	22549.4	24477.9	1928.5
2004-05	137.0	22855.7	23420.7	565.0
2005-06	138.8	22855.7	24569.3	1713.6
2006-07	140.6	23029.6	25629.1	2599.6
2007-08	142.4	23576.3	26942.3	3365.9

Source: MoA 2007: Table 1.01; MoF 2008: 241