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Research Article

Growth and Instability Analysis of Minor Pulses in Bangladesh

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Abstract: Providing a balanced diet to ensure food and nutritional security is the primary worldwide challenge. Food production efficiency and sustainability must be enhanced to address hunger and malnutrition, while food quantity and quality must grow. Pulses are an important food for the people of Bangladesh. Besides major pulses, we have to look at minor pulses as well. On the other hand, growth and instability are the two crucial aspects of agriculture. Since agriculture depends on weather conditions, the crop area, production, and yield are subject to significant variations over time. This study examined growth and instability in the area, production and yield of minor pulses using secondary data for the past 40 years (1981-2020). The entire period was divided into four sub-periods: 1981-1990, 1991-2000, 2001-2010 & 2011-2020 for analysis through different statistical tools. A suitable exponential growth function was used to calculate growth rates, and the Cuddy-Della Valle Index (CDI) was created to examine instability. The investigation showed that over the time period, both the area and production of minor pulses significantly decreased. However, the yield growth rate was modest and fell short of the demand in our nation. The investigation also revealed that there was no stability in the area, production, or yield of minor pulses during the course of the study.

***Keywords*: **Bangladesh, CDI, growth decomposition, instability, minor pulses

1. Introduction

Pulses are one of the best sources of high-quality proteins, minerals, and energy in the human diet. Through the addition of nitrogen, carbon, and organic matter, pulses support agricultural and environmental sustainability [1]. Pulses are a major and inexpensive source of vegetable proteins, maintaining their affordability compared to other protein sources. Pulses are therefore often regarded as the poor's main source of protein in Bangladesh and are essential for giving the underprivileged access to a balanced diet. Bangladesh's sizable population is malnourished [2]. Pulses have been recognized as having outstanding promise for reducing human malnutrition among the poorest population of the nation.

A favorable climatic condition exists in Bangladesh for growing different types of pulses all over the country. Even so, Bangladesh had to import a huge quantity of pulses to meet the demand. Food and Agriculture Organization (FAO) showed that Bangladesh imported 1,363.39 thousand tons of pulses valued at 707.172 million USD in 2021 [3]. According to Bangladesh Bank's statistics, Bangladesh spent Tk. 6,185 crore to import pulses in the last fiscal year of 2021-22, an increase of 11% year-on-year. The "Pulses and Oil Crops Research and Development Vision: 2030" is

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a plan developed by the Ministry of Agriculture and the Department of Agricultural Extension (DAE) to increase the output of pulses and oilseeds by the year 2030. To fulfill the country's increasing demand, it is also necessary to increase the production of minor pulses like chickpea, grass pea, field pea, and other pulses (Arhar, Fallon, and Garikalai).

Chickpea cultivation covers approximately 4.584 thousand hectares of land, resulting in an annual production of 5.01 thousand tons with an average yield of 1.093 t/ha. Over the past two decades, chickpea production has declined significantly, dropping from 59,900 tons in 1997/98 to 5,009 tons in 2020/21, despite a notable increase in yield from 0.712 to 1.093 t/ha during this period [4]. In the year 2020/21, field pea was cultivated on around 7.493 thousand hectares of land, generating a total production of 8.052 thousand tons with an average yield of 1.075 t/ha [4]. Similarly, grass pea was grown on 115.97 ha in 2020/21, resulting in a total production of 130.63 tons and an average yield of 1.126 t/ha, both in dry areas and flooded rice fields. For Arhar cultivation in the same period, the total national area covered was 447.77 ha, yielding a total of 474.34 mt with an average yield of 1.06 t/ha [5]. Additionally, in 2020/21, the total area devoted to Fallon cultivation in Bangladesh was 12,239.68 ha, leading to a total production of 16,083 mt with a mean yield of 1.314 t/ha [5]. Lastly, the country's Garikalai cultivation covered 575.34 ha in 2020/21, resulting in a total production of 433.2 mt with an average yield of 753 t/ha [5].

Sustaining agricultural productivity requires both a rapid growth rate and low instability in production. Balancing these two aspects is essential for building resilient and productive agricultural systems that can contribute to the well-being of societies and economies. Considering the importance of pulses, the present study was carried out to examine the growth and instability in the area, production, and yield of minor pulses in Bangladesh. Researchers, politicians, and planners in the country can utilize the study's conclusions as a starting point. The specific objectives of this research are delineated in the subsequent sections. This study aims to:

(i) To estimate the growth rates of area, production, and yield of minor pulses in Bangladesh;

(ii) To quantify the change and instability in area, production, and yield of minor pulses;

(iii) To derive some policy implications from the above objectives.

2. Materials and methods

2.1 *Data and its sources*

Secondary data was gathered from numerous published sources for this investigation. From 1981 until 2020, we compiled a time series of data from the Yearbook of Agricultural Statistics of Bangladesh on the acreage, production, and yield of various pulse crops in Bangladesh.

2.2 *Analytical procedures*

Different statistical measures were employed to assess the data and shed light on the rate of change, the degree of instability, and the degree of link between the area, production, and yield of different pulse crops in Bangladesh.

2.2.1 *Index number*

The relative changes in pulse crop acreage, production, and yield within a certain time frame can be measured using an index number. At first, the entire study period is divided into four sub-periods: 1981 to 1990, 1991-2000, 2001-2010, and 2011-2020. The reason for the division was to know the changes that occurred in the area, production, and yield of pulses after a 10 years' period. The 10 years (e.g. 1981-1990) average area, production, and yield value were considered the base year.

2.2.2 *Annual growth rates*

Growth rates are the percent change of a variable over time. It is important because it can help researchers and policymakers to predict future growth. The compound growth rates of area, production, yield, and price of pulses were calculated by fitting an exponential function of the following type (equation 1), which was done for simplicity and was frequently employed even in the recent past [6-7].

$$Y = ae^{bt} \text{ or } \ln Y = \ln a + bt \quad (1)$$

Where, Y is the area/production/yield of minor pulses, ‘t’ is the time in a year, and ‘a’ is the constant, $e^b - 1$ is the compound growth rate which is expressed in percentage.

The relative importance of area and yield in explaining the fluctuation in crop output has been calculated using the component analysis method. This model (equation 2) has been used to examine the impact of crop growth performance on agricultural yields by a number of writers [8-11].

$$\Delta P = A \circ \Delta Y + Y \circ \Delta A + \Delta A \Delta Y \quad (2)$$

where P, A, and Y represent production, area, and yield respectively.

Change in production = Yield effect + Area effect + Interaction effect

As a result, we can break down the total production change into three effects viz., yield, area and interaction effects.

2.2.3 *Instability index*

The instability index measures the degree to which a given situation is unstable. Agricultural instability can be quantified using a number of various indices and statistics, including the coefficient of variation (CV), dispersion, Cuddy-Della Valle Index (CDI), Coppock Instability Index, and others. In order to investigate the nature and degree of instability in Bangladesh’s pulse area, production, and yield, the current study used the Cuddy and Valle Index [12]. There are caveats to using a CV to demonstrate instability in any time series data. The trending element of the time series data is not adequately explained. Variation evaluated by CV might be overstated if the time series data display any trend; for example, if the CV is used to measure instability in production, the region with consistently increasing production will receive a high score. Contrarily, CDI initially endeavors to remove the trend from the CV by employing the coefficient of determination (R^2). That’s why it’s a more accurate gauge of agricultural production volatility. When this index’s value is low, agricultural production is stable, and vice versa. The estimable form of equation (3) is as follows:

$$CV_t = (\text{CV}) \times \sqrt{1 - R^2} \quad (3)$$

Where CV_t is the coefficient of variation around the trend; CV is the coefficient of variation around the mean in percent; and adjusted for degrees of freedom, R^2 is the coefficient of determination from time trend regression.

$$\text{CV} = \frac{\text{Standard deviation}}{\text{Mean}} \times 100 \quad (4)$$

$$R^2 = 1 - \frac{\text{Unexplained variation}}{\text{Total variation}} \quad (5)$$

3. Results and discussion

Table 1’s comprehensive indices reveal a consistent decline in both the area and production of chickpeas and other minor pulses from 1991 to 2020, compared to their respective base periods. Similarly, field pea and grass pea also demonstrate a decreasing trend from 2001 to 2020, relative to their base periods. Conversely, the productivity indices for all minor pulses exhibit an upward trajectory from 1991 to 2020 when contrasted with their base periods. The only exception is a downturn observed solely in the 1991-2000 period for chickpeas and other minor pulses, as indicated in Table 1. Despite the decrease in area and production, the yield of minor pulses has increased during those periods, primarily due to the adoption of improved varieties along with management technologies for pulses.

Table 1. Index of area, production and yield of minor pulses during 1981-2020

Minor pulses		Time period			
		1981-1990	1991-2000	2001-2010	2011-2020
Chickpea	Area (ha %)	100 (76,582)	85.7	15.1	7.9
	Production (mt %)	100 (55,401)	85.7	15.9	10.8
	Yield ((t/ha) %)	100 (0.73)	99.5	104.9	137.5
Field pea	Area (ha %)	100 (14,929)	122.2	70.0	48.4
	Production (mt %)	100 (10,059)	138.0	85.5	72.8
	Yield ((t/ha) %)	100 (0.665)	114.3	125.9	152.0
Grass pea	Area (ha %)	100 (158,417)	143.7	78.8	68.4
	Production (mt %)	100 (115,491)	152.7	94.4	99.2
	Yield ((t/ha) %)	100 (0.73)	105.9	120.4	143.7
Other minor pulses	Area (ha %)	100 (25,014)	98.3	31.2	37.1
	Production (mt %)	100 (15,896)	83.8	36.9	69.6
	Yield ((t/ha) %)	100 (0.64)	85.2	119.4	185.2

Note: Figures within parentheses indicate a 10-year average value in the base year of the indices
Other pulses include Arhar, Fallon, and Garikalai
Source: Various issues of BBS

The overall analysis spanning from 1981 to 2020 reveals significantly negative growth rates in both the cultivation area and production of different minor pulses, as illustrated in Table 2. However, fluctuations in these growth rates stem from factors such as changing agricultural methods, climate fluctuations, challenges in competing with other cereal crops, and shifts in market demand. On the other hand, the growth rates in yield have been relatively consistent across pulses and time periods.

According to the overall analysis for the entire time period (from 1981 to 2020), all minor pulses have shown significantly positive growth rates in yield, indicating productivity improvements (Table 2). This suggests that efforts to enhance yield have succeeded even when the area under cultivation or total production may have faced challenges. This is due to the widespread adoption of improved varieties and management technologies. Among pulses, grass pea has recorded the highest growth in area and production, while chickpea has the least (Table 2). Because, the reduction in chickpea yield can fluctuate significantly, ranging from 30% to 60%, influenced by factors such as genotype, timing of sowing, geographical location, and prevailing climatic conditions during the sowing period [13].

The overall analysis also revealed that yield was higher than the contribution in the area for field pea and grass pea in the mean production of them at the national level, while chickpea and other pulses were opposite (Table 3). Again, over four distinct periods: 1981-1990, 1991-2000, 2001-2010, and 2011-2020, we see that the 2011-2020-time period showed relatively positive growth across all pulses in terms of area, production, and yield except for the slide difference in chickpea (Table 3).

Table 2. Growth rates of area, production and yield of minor pulses during 1981-2020

Minor pulses		Time period				
		1981-1990	1991-2000	2001-2010	2011-2020	1981-2020 (overall)
Chickpea	Area (ha)	9.86***	-21.67***	-8.78***	-6.60***	-8.91***
	Production (mt)	9.25***	-21.53***	-7.56***	-4.28***	-7.92***
	Yield (t/ha)	-0.60	0.14	1.21***	2.32***	0.99***
Field pea	Area (ha)	8.42***	-0.48	-12.19***	1.80*	-2.54***
	Production (mt)	10.09***	0.12	-10.32***	3.64***	-1.12**
	Yield (t/ha)	1.67***	0.36	1.86***	1.84***	1.35***
Grass pea	Area (ha)	15.50***	-2.95***	-10.05***	0.99	-1.24**
	Production (mt)	15.15***	-1.57**	-8.06***	2.83***	-0.03
	Yield (t/ha)	-0.34	1.37***	1.98***	1.84***	1.21***
Other minor pulses	Area (ha)	13.00***	-14.41***	-1.70	5.40***	-3.52***
	Production (mt)	13.05***	-15.23***	5.02***	9.52***	-1.36*
	Yield (t/ha)	0.049	-0.822	6.72***	4.12***	2.16***

Note: '***' '**' & '*' represent 1%, 5% and 10% level of significance

Table 3. Growth decomposition in the production of minor pulses during 1981-2020

Minor pulses		Time period				
		1981-1990	1991-2000	2001-2010	2011-2020	1981-2020 (overall)
Chickpea	Area	99.79	99.64	116.70	226.20	108.82
	Yield	4.76	2.63	-16.63	-121.94	-9.36
	Interaction	4.54	2.27	0.07	4.25	-0.55
Field pea	Area	74.34	-1,632.04	114.50	51.68	-470.00
	Yield	29.73	1,671.32	-14.72	44.71	591.18
	Interaction	4.11	-60.73	-0.22	-3.61	21.19

Table 3. (cont.)

Minor pulses		Time period				
		1981-1990	1991-2000	2001-2010	2011-2020	1981-2020 (overall)
Grass pea	Area	99.10	201.40	137.50	69.35	17.94
	Yield	0.98	-101.04	-39.73	31.04	84.19
	Interaction	0.09	0.36	-2.26	0.39	2.13
Other minor pulses	Area	102.77	79.2	-20.56	72.39	76.06
	Yield	-4.98	21.03	118.7	16.38	4.79
	Interaction	-2.21	0.22	-1.86	-11.23	-18.62

Source: Author's calculation using BBS data of different years

The overall instability of the production was a little bit higher than the area instability except for the grass pea, but this difference is too low (Table 4). On the other side, the instability related to productivity for all pulse was negative during 1981-2020 meaning that all pulse productivity was almost stable over the stipulated period (Table 4).

Table 4. Instability indices for area, production and yield of minor pulses during 1981-2020

Minor pulses		Time period				
		1981-1990	1991-2000	2001-2010	2011-2020	1981-2020 (overall)
Chickpea	Area	1.87	4.25	1.00	0.48	4.87
	Production	1.89	4.34	1.04	0.72	4.94
	Yield	-20.06	-4.98	-4.36	-48.25	-38.37
Field pea	Area	2.19	0.17	1.01	0.79	3.42
	Production	2.40	0.23	1.28	0.73	3.53
	Yield	-8.23	-8.05	-23.73	406.50	-20.21
Grass pea	Area	2.60	0.29	1.04	0.48	3.41
	Production	2.59	0.37	1.41	0.58	3.23
	Yield	-15.78	-9.51	-39.24	-53.79	-34.84
Other minor pulses	Area	2.58	2.78	1.32	1.28	4.78
	Production	2.68	2.48	1.49	1.24	5.32
	Yield	-6.06	-10.56	-21.61	68.81	-64.45

Source: Author's calculation using BBS data of different years

4. Conclusions

This study reflects that the indices for area and production of all minor pulses decreased from their base period in the last decade while the indices for yield increased. Furthermore, in the context of Bangladesh, this study has explored the growth of minor pulses production in Bangladesh and found positive and significant growth rates in yield for all the minor pulses. Still, this growth is deficient, while significantly negative growth rates are observed in the area for all the minor pulses (it suggests that either arable land is being lost or farmers are losing interest in growing pulse crops) and negative growth rates in production for all the minor pulses. Natural disasters are a constant source of instability for Bangladesh's agriculture sector. Our analyses also support this claim. However, the instability in the area, production, and yield of pulses are low at the national level.

Recommendations

Several suggestions for fostering long-term growth in Bangladesh's minor pulse output might be made in light of the study's findings:

Firstly, agricultural researchers should focus on developing minor pulse varieties that exhibit climate-friendly characteristics, high-yielding traits, and resistance to major diseases. This will address the growing demand for minor pulses efficiently. Secondly, established improved minor pulse varieties and agricultural technologies developed by institutions like Bangladesh Agricultural Research Institute (BARI) should be widely disseminated among farmers. Creating better linkages between research and extension and pilot projects can be instrumental in achieving this goal, ensuring that these advancements reach farmers effectively. Thirdly, it is imperative to channel research endeavors and policy backing towards augmenting both the cultivated area and yield of minor pulses. This can be achieved through strategies such as expanding cultivation areas (utilizing fallow lands through new cropping patterns), enhancing management practices, introducing pulse cultivation in nontraditional areas, and establishing robust marketing systems and credit facilities. This expansion will contribute to increase per capita availability, reduced reliance on imports, and a degree of stability in pulse prices. Finally, emphasizing collaborative efforts among government agencies, non-governmental organizations (NGOs), and private sector stakeholders is crucial for promoting growth and stability in Bangladesh's minor pulse sector. Through such collaboration, comprehensive strategies and initiatives can be developed to benefit all involved stakeholders. Special attention should be given to improving postharvest handling, storage, and processing of pulses to minimize losses and maintain quality.

Conflict of interest

The authors declare no competing financial interest.

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