Trends of Major Cereal Productivity in South Asia

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Abstract:
The trend analysis in the time series of crop production is an important tool to make future plans and to take the appropriate decisions for sustainability in food production and future food security. The objective of this study was to assess the trend analysis of the yield of five different major kinds of cereal (paddy, maize, millet, wheat, and barley) from 1985 to 2016 in six South Asian countries (Nepal, India, Pakistan, Bhutan, Afghanistan, and Bangladesh). The average annual yields of cereals in five quadrennial drought years (1985, 1989, 1993, 1997, and 2002) were estimated. The results revealed that the yield of major cereals had an increasing trend over the study period. The reasons for the fluctuations in the production were due to the changing climates, increasing global warming, the development of new hybrids and cultivars, the adoption of new practices by the farmers, economic constraints, and agronomic constraints. For improving the production of cereal crops, the use of modern technology should be increased, and the agricultural organizations should provide full support at the country level.

Keywords: Cereals, Drought years, South Asia, Yield

1.0. Introduction
Cereal crops have played major roles in addressing food security issues. These are the most dominant staple foods to the world’s population, which are produced extensively in the countries of South Asia, India and Bangladesh are top producers. A great fluctuation in the yield of different major cereals (viz. paddy, maize, millet, wheat, and barley) have been observed in different countries when retrospect to the historical agricultural productions. South Asia occupies approximately 3% of the world’s total land area; the region is home to more than 24% of the world’s population [1]. It is the world’s second poorest region with over 500 million people living on less than US$1.25 per day [2]. With about 60% of the region’s population engaged in agriculture, 57% area of South Asia is arable or agricultural land [3]. Paddy (Oryzae sativa L.) is one of the chief staple foods for more than 60 percent of the global population [4]. The Green Revolution assisted in transforming the South Asian region from one of food scarcity to surpluses and latterly moved millions of people out of poverty. Presently, there is the convenience to build on that success by releasing the untapped potential in the rice agro-food sector [5]. CSR36 (Naina), BRRI dhan47, Basmati 198, Pokkali, CH-45, Parwanipur-1 are some of the varieties of paddy that are grown in South Asia. Maize (Zea mays L.) is one of the topmost producing cereal crops in the world. The overwhelming progress of maize in the SAARC is an outcome of increased demand in poultry and other feed industries rather than an increase in demand for food [6].

The International Maize and Wheat Improvement Center (CIMMYT) is offering an advanced set of improved maize hybrids to partners in South and South East Asia and related agro-ecological zones, to enhance production for farmers in these regions [7]. Rampur-1, Makalu-2, P-3501, African tall, Kashmir gold, CH-124 are some of the maize varieties in South Asia. Wheat (Triticum aestivum L.) consumption has been gradually rising since the green revolution in the 1960s now oscillating around 20 kg per capita per year in Bangladesh, 50-60 kg in Nepal and India; meanwhile, it has long been around 100 kg in Pakistan [8]. Wheat is the second major staple crop, next to the rice. A joint collaboration of National Agricultural Research Centers (NARC) and CIMMYT has made remarkable progress due to which significant increment in wheat production has been observed for the last few years (Chatrath et al., 2007). NL-30, Lumbini, Annapurna, VL-832, WH-896, Sehar-06, Lalma-13, Bajoka 2 BL, Bijoy are some of the wheat varieties grown throughout the region. Millet (Eleusine coracana L.) has consistently been a valuable and nutritious part of the diets of small-scale farmers and indigenous groups in the region. Dalé-1, Okhle-1, Barnyard, Bari fox Tail, Bari Koun-3 are the millet varieties cultivated in different South Asian countries. Barley (Hordeum vulgare L.) is cultivated in a very small area in South Asia. The majority of the world’s barley is produced in regions where cereals such as maize and rice cannot be grown well [9]. This paper aims at finding out the drought years within the year of 1985-2018 and the total yield of cereals in the respective major drought years. Also, the ways of increasing the production of cereals in south Asia were described in brief. This will obviously help in projecting the future yield of the major cereals in South Asia.

2.0. Methodology
2.1. Socio-demographic and economic characteristics of the study area
The study was carried out in South Asia which is the association of eight countries. But the production of cereals was analyzed merely of the six countries (Nepal, India, Pakistan, Bhutan, Afghanistan, and Bangladesh). Two countries; Maldives and Sri Lanka, were excluded due to very low agricultural production compared to total production.
Figure 1. Map showing SAARC countries

South Asia comprises 1.9 billion populations within the area of 5.1 million km². India is the largest contributor to the economy through GDP by the agricultural sector. The majority of the people are educated as the literacy rate of South Asia is 71%. Despite the constant advancement in the scope of occupations other than farming, agriculture is followed by most people as their primary profession. The socio-demographic characteristic of the different countries of South Asia is described below.

Table 1. Socio-demographic and economic characteristics of the study area

| Characteristics          | Nepal    | India    | Pakistan | Afghanistan | Bhutan    | Bangladesh |
|--------------------------|----------|----------|----------|-------------|-----------|------------|
| Total area (1000 ha)     | 14718    | 328725.9 | 79610    | 65286       | 3839.4    | 14763      |
| Total Population (millions) | 28.1     | 1353     | 212.2    | 37.17       | 0.754     | 161.4      |
| Agricultural area (1000 ha) | 3636     | 179721   | 36794    | 37910       | 23        | 9194.21    |
| GDP (Billion USD)        | 29.81    | 2719     | 314.6    | 23          | 2.447     | 49         |
| GDP by agriculture (%)   | 27       | 15.4     | 18.5     | 23          | 16.2      | 14.23      |
| Unemployment rate (%)    | 3        | 6.1      | 5.7      | 23.9        | 3.2       | 4.2        |
| Literacy rate (%)        | 67.9     | 74.4     | 58       | 43          | 59.5      | 73.9       |
| Occupation               |          |          |          |             |           |            |
| Agriculture (%)          | 69       | 44       | 37.4     | 44.3        | 58        | 40.6       |
| Industry (%)             | 12       | 25       | 24       | 18.1        | 20        | 20.4       |
| Services (%)             | 19       | 31       | 38.6     | 37.6        | 22        | 39.6       |
| Religion                 |          |          |          |             |           |            |
| Hinduism (%)             | 81.3     | 80.5     | 1.85     | 0.01        | 22.6      | 10.1       |
| Buddhism (%)             | 9        | 0.7      | 0.4      | 0.03        | 75.1      | 0.6        |
| Christianity (%)         | 4.4      | 2.3      | 1.59     | 0.2         | 0.5       | 0.4        |
| Islam (%)                | 1.4      | 13.4     | 95.3     | 99.6        | 0.2       | 88.63      |
| Others                   | 3.9      | 3.1      | 0.86     | 0.16        | 1.6       | 0.27       |

(Worldometer, 2019)

2.2. Data Analysis

Time series agricultural data in South Asia is collected from the data recorded by FAO from 1985 to 2018. The total yield (TY) of five cereal crops (viz. Paddy, Maize, Millet, Wheat, and Barley) is computed as in equation (i). The quantity of total yield is calculated for 34 years, the period from 1985 to 2018 which is used to determine the agricultural drought years in South Asia as in equation (i).

$$TY_n = \frac{(TP_{paddy} + TP_{maize} + TP_{millet} + TP_{wheat} + TP_{barley})}{(TA_{paddy} + TA_{maize} + TA_{wheat} + TA_{millet} + TA_{barley})} \times 10,000$$

(i)

Where $TY_n$ = total yield for 'n' no. of years expressed in hq ha⁻¹ (Hundred grams per hectare); TP= Total production; TA= Total area
Annual average yield (AAY) is computed to determine the years of individual crops which have production below average as in equation (ii)

\[
\text{AAY} = \frac{(\text{Total yield 1985} + \text{Total yield 1986} \ldots \ldots + \text{Total yield 2018})}{\text{No. of years}}
\]  

(iii)

Data analysis for yield was performed by using Excel ver.2020.

3.0. Results and Discussion

3.1. Annual average yield of cereals in South Asian countries

The annual average total yields of major cereals for 34 years period from 1985 to 2018 were 25291 hg ha⁻¹. The total yields were above average in the years 2001, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, and 2018 (FAO, 1985-2018).

Table 2. Annual average yield of cereals production in South Asia from 1985-2018

| Years | Total cereal production (tons) | Total area (ha) | Total Yield (Hg ha⁻¹) |
|-------|-------------------------------|----------------|----------------------|
| 1985* | 218304677                     | 124731711      | 17502                |
| 1986* | 22244208                       | 125119992      | 17778                |
| 1987* | 209126335                     | 120126952      | 17409                |
| 1988* | 240169222                     | 126422830      | 18997                |
| 1989* | 256637246                     | 127309244      | 20159                |
| 1990* | 255629529                     | 126488005      | 20210                |
| 1991* | 259455429                     | 125376066      | 20694                |
| 1992* | 264931574                     | 124023261      | 21361                |
| 1993* | 277305799                     | 125972241      | 22013                |
| 1994* | 279433854                     | 127002578      | 22002                |
| 1995* | 282675277                     | 126523715      | 22342                |
| 1996* | 290589266                     | 127391875      | 22811                |
| 1997* | 298659456                     | 127634403      | 23400                |
| 1998* | 309938067                     | 130205857      | 23804                |
| 1999* | 318541620                     | 129427819      | 24612                |
| 2000* | 322077746                     | 130222615      | 24733                |
| 2001  | 327271389                     | 127696417      | 25629                |
| 2002* | 299680427                     | 123649847      | 24236                |
| 2003  | 334217968                     | 129021801      | 25904                |
| 2004  | 327160998                     | 127518914      | 25656                |
| 2005  | 345639715                     | 131087726      | 26832                |
| 2006  | 34838668                      | 131154326      | 26653                |
| 2007  | 374384949                     | 133362634      | 28073                |
| 2008  | 371626376                     | 13283706       | 27976                |
| 2009  | 367773730                     | 131636037      | 27939                |
| 2010  | 385599042                     | 134026150      | 28770                |
| 2011  | 405171351                     | 134688258      | 30082                |
| 2012  | 412305199                     | 134122630      | 30741                |
| 2013  | 420486866                     | 135029257      | 31140                |
| 2014  | 425130031                     | 136500946      | 31145                |
| 2015  | 412756952                     | 134614957      | 30662                |
| 2016  | 431688436                     | 134368605      | 32127                |
| 2017  | 449467332                     | 135504001      | 33170                |
| 2018  | 456033666                     | 134665060      | 33864                |

| Annual Average | 329438133 | 129572513 | 25291 |

Year* with shaded portion = Drought years in cereals production and the yield is in hq per hectare (hq ha⁻¹). (FAO, 1985-2019)

The total yields were below average in the years 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, and 2002 which were 17502 hq ha⁻¹, 17778 hq ha⁻¹, 17409 hq ha⁻¹, 18997 hq ha⁻¹, 20159 hq ha⁻¹, 20210 hq ha⁻¹, 20694 hq ha⁻¹, 21361 hq ha⁻¹, 22013 hq ha⁻¹, 22002 hq ha⁻¹, 22342 hq ha⁻¹, 22811 hq ha⁻¹, 23400 hq ha⁻¹, 23804 hq ha⁻¹, 24612 hq ha⁻¹, 24733 hq ha⁻¹, and 24236 hq ha⁻¹ respectively (FAO, 1985-2018).

The yield of cereals was found to be increasing at the rate of 466.08 hq per year. The different varieties of cereals cultivated in South Asia are listed in Table 3.
Table 3. Crop varieties grown in South Asia

| Cereals   | Different cereals varieties grown in South Asia                                                                 |
|-----------|-----------------------------------------------------------------------------------------------------------------|
| Paddy     | CSR 36 (Nain), BRRI dhan 47, NDRK 5088, CR dhan 405 (Luna Sankh), BINA dhan 10, Gosaba-5, CSR 43, KSK-28, Nona-borka, Basmati 198, Sathra 278, BRRI dhan 61, Fl. 378,                                           |
| Maize     | Barnali, Shuvra, Khaibutta, Mohar, Bari Maize 5, Bari sweet corn-1, Kulani, BH-660, BH-540, Bari Hybrid bhutta 1, Bari Hybrid bhutta 2 |
| Millet    | PRM 1, Bharathi (VR 762), KOPN 235, VL 352, KMR 340, GN-8, CO 15, Dapoli-2 (SCN-6), MB-87, 18-BY, FB-822, Sargodha Bajra 2011                                       |
| Wheat     | Koshan 09, Muqawin 09, Baghlan 09, Super 152, Ufan, Danpe, Hoggana, NARC-2011, Karim, C 306, Raj 3077                                                                    |
| Barley    | Baudin, Buloke, Dash, Yagan, Fleet, Mundah, Grout, Shepherd, Merit 57, AAC Synergy, Pinnacle, Flagship, Stirling                                                        |

3.2. Individual cereal yield of cereals in South Asian countries

Data on cereal production may be influenced by a variety of reporting and timing differences. The total yield of different cereals from 1985-2018 in different countries of South Asia was presented in the Table 4.

Table 4. Analysis of individual cereal yield from 1985-2018 in South Asian countries

| Total Yield (hg ha⁻¹) | Paddy | Maize | Millet | Wheat | Barley |
|-----------------------|-------|-------|--------|-------|--------|
| Nepal                 | 26567 | 19170 | 10888  | 18534 | 10417  |
| India                 | 30407 | 19675 | 8752   | 26249 | 19729  |
| Pakistan              | 30266 | 25753 | 5304   | 23095 | 9122   |
| Afghanistan           | 24746 | 18135 | 15077  | 14476 | 12401  |
| Bhutan                | 24879 | 20342 | 10680  | 14177 | 12601  |
| Bangladesh            | 34486 | 36268 | 6813   | 22036 | 7443   |
| Average Yield         | 28559 | 23224 | 9586   | 19761 | 11952  |

(FAO, 1985-2019)

Nepal: The total yield of paddy, maize, millet, wheat, and barley from 1985-2018 in Nepal were 26567 hg ha⁻¹, 19170 hg ha⁻¹, 10888 hg ha⁻¹, 18534 hg ha⁻¹, and 10417 hg ha⁻¹ respectively. Among these five cereals, millet was the only one which was above average yield of south Asia. In 1985, the total yield of cereals in Nepal was 16591 hg ha⁻¹ which increased to 29013 hg ha⁻¹ in 2018. The highest yield of paddy, maize, millet, and wheat were observed in the year 2018 which were 35058 hg ha⁻¹, 25921 hg ha⁻¹, 11916 hg ha⁻¹, and 27573 hg ha⁻¹ respectively (FAO, 1985-2018).

India: The total yield of paddy, maize, millet, wheat, and barley from 1985-2018 in India were 30407 hg ha⁻¹, 19675 hg ha⁻¹, 8752 hg ha⁻¹, 26249 hg ha⁻¹, and 19729 hg ha⁻¹ respectively. Maize and millet were the two cereal crops that yield below average in India. However, Paddy, wheat, and barley contributed heavily to the total cereal production in India. Also, the yields of wheat and barley were the highest in India. The total yield of cereals increased from 17677 hg ha⁻¹ to 33694 hg ha⁻¹ in the period of 1985-2018. The highest yield of paddy, millet, wheat and barley were observed in the year 2018 which was 38782 hg ha⁻¹, 12781 hg ha⁻¹, 33705 hg ha⁻¹, and 26929 hg ha⁻¹ respectively. However, the highest yield of maize was in 2017, which was 31182 hg ha⁻¹ (FAO, 1985-2018).

Pakistan: The total yield of paddy, maize, millet, wheat, and barley from 1985-2018 in Pakistan were 30266 hg ha⁻¹, 25753 hg ha⁻¹, 5304 hg ha⁻¹, 23095 hg ha⁻¹, and 9122 hg ha⁻¹ respectively. Millet and barley were two crops with a yield less than the average yield in Pakistan. The total yield of cereals increased from 16373 hg ha⁻¹ to 31694 hg ha⁻¹ in the period of 1985-2018. The highest yields of paddy and wheat were observed in 2017 which were 38526 hg ha⁻¹ and 29729 hg ha⁻¹ respectively and maize and millet were observed maximum in 2018 which were 47863 hg ha⁻¹ and 7679 hg ha⁻¹ respectively. The yield of barley was observed maximum in 1998, which was 10701 hg ha⁻¹ (FAO, 1985-2018).

Afghanistan: The total yield of paddy, maize, millet, wheat, and barley from 1985-2018 in Afghanistan were 24746 hg ha⁻¹, 18135 hg ha⁻¹, 15077 hg ha⁻¹, 14476 hg ha⁻¹, and 12401 hg ha⁻¹ respectively. The country was dominated by millet and barley cultivation which was higher than the average yield in south Asia. The yields of paddy, maize, and wheat were below average yield. The total yield of cereals increased from 1337 hg ha⁻¹ to 21649 hg ha⁻¹ in the period of 1985-2018. The highest yield of paddy was attained in 2006 which was 33375 hg ha⁻¹, maize in 2002, which was 29800 hg ha⁻¹, millet in 2017 which was 34703 hg ha⁻¹, wheat in 2018 which was 22100 hg ha⁻¹, and barley in 2010 which was 20613 hg ha⁻¹ (FAO, 1985-2018).

Bhutan: The total yields of paddy, maize, wheat, and barley from 1985-2018 in Bhutan were 24879 hg ha⁻¹, 20342 hg ha⁻¹, 10680 hg ha⁻¹, 14177 hg ha⁻¹, and 12601 hg ha⁻¹ respectively. Paddy, maize, and wheat were observed to have below average yield in Bhutan. The total yield of cereals increased from 14329 hg ha⁻¹ to 36001 hg ha⁻¹ in the period of 1985-2018. The highest yield of paddy was attained in 2018 which was 42888 hg ha⁻¹, millet in 2004 which was 40949 hg ha⁻¹, millet in 2014 which was 28706 hg ha⁻¹, wheat and barley in 2011 which was 26686 hg ha⁻¹ and 19569 hg ha⁻¹ respectively (FAO, 1985-2018).

Bangladesh: The total yields of paddy, maize, wheat, and barley from 1985-2018 in Bangladesh were 34486 hg ha⁻¹, 36268 hg ha⁻¹, 6813 hg ha⁻¹, 22036 hg ha⁻¹, and 7443 hg ha⁻¹ respectively. Only millet and barley were the cereals with below average yield. Bangladesh was one of the highest producers of cereals in Asia. The highest yields of paddy and maize were observed in 2018 which was 47368 hg ha⁻¹ and 82104 hg ha⁻¹ respectively, millet in 2016 which was 12137 hg ha⁻¹, wheat in 2017 which was 31576 hg ha⁻¹ and barley in 2014 which was 10726 hg ha⁻¹. The total yield of cereals increased substantially from 21488 hg ha⁻¹ to 47907 hg ha⁻¹ in the period of 1985-2018 (FAO, 1985-2018).
3.3. Average yield of cereals during drought years in South Asian countries

Paddy: The average yields of paddy from 1985 to 2018 were 31198 hg ha⁻¹. The yields were below average in the years 1985 to 2000 and in 2002 and 2004. However, in 2003 the yield was higher than the average which was 32032 hg ha⁻¹. The total yield of paddy in 1985, 1989, 1993, 1997, and 2002 was far less than the average yield which was 23154 hg ha⁻¹, 25796 hg ha⁻¹, 28080 hg ha⁻¹, 28302 hg ha⁻¹, and 28332 hg ha⁻¹ respectively. The maximum yield of paddy was observed in 2018 which was 40243 hg ha⁻¹ and minimum in 1986 which was 22281 hg ha⁻¹ (FAO, 1985-2018).

Maize: The average yield of maize from 1985 to 2018 was 21295 hg ha⁻¹. The yield was below average in the years 1985-2003. The yield has been reduced sharply and was below average in the years 1985, 1989, 1993, 1997, and 2002 which is 12041 hg ha⁻¹, 15970 hg ha⁻¹, 16427 hg ha⁻¹, 17688 hg ha⁻¹, and 18557 hg ha⁻¹ respectively. The maximum yield of maize in South Asia was observed in 2017 which was 34288 hg ha⁻¹ and minimum in 1987 which was 11214 hg ha⁻¹ (FAO, 1985-2018).

Wheat: The average yield of wheat from 1985 to 2018 was 23625 hg ha⁻¹. The yield was below average in the years 1985-1999. The total yield of wheat in South Asia in the years 1985, 1989, 1993, 1997, and 2002 were 16685 hg ha⁻¹, 19132 hg ha⁻¹, 20532 hg ha⁻¹, 23125 hg ha⁻¹, and 24886 hg ha⁻¹ respectively. The maximum yield was obtained in 2018 which was 30549 hg ha⁻¹ and minimum in 1985 which was 16685 hg ha⁻¹ (FAO, 1985-2018).

Millet: The average yield of Millet from 1985 to 2018 was 8662 hg ha⁻¹. The yield was below average in the years 1985-2000, 2002, 2005, and 2009. The total yield of millet in the years 1985, 1989, 1993, 1997, and 2002 were 4648 hg ha⁻¹, 6708 hg ha⁻¹, 6436 hg ha⁻¹, 8005 hg ha⁻¹, and 6361 hg ha⁻¹ respectively. The maximum yield was obtained in 2018 which was 12507 hg ha⁻¹ and minimum in 1985 which was 4648 hg ha⁻¹ (FAO, 1985-2018).

Barley: The average yield of Barley from 1985 to 2018 was 16607 hg ha⁻¹. The yields were below average in the years 1985-1997, 1999, 2000, 2001, and 2008. In the drought years, 1985, 1989, 1993, 1997, and 2002 the total yield of Barley was 11218 hg ha⁻¹, 11953 hg ha⁻¹, 15065 hg ha⁻¹, 16577 hg ha⁻¹, and 18413 hg ha⁻¹ respectively. The maximum yield was attained in 2016 which was 20872 hg ha⁻¹ and minimum in 1985 which was 11218 hg ha⁻¹ (FAO, 1985-2018).

Table 5. Yield analysis (hg/ha) for individual crops

| Years | Paddy   | Maize   | Millet  | Wheat   | Barley   |
|-------|---------|---------|---------|---------|----------|
| 1985  | 23154   | 12041   | 4648    | 16685   | 11218    |
| 1986  | 22281   | 13196   | 5093    | 18320   | 12828    |
| 1987  | 22371   | 11214   | 5035    | 16863   | 12271    |
| 1988  | 24947   | 14096   | 6612    | 17563   | 13667    |
| 1989  | 25976   | 15970   | 6708    | 19132   | 11953    |
| 1990  | 26028   | 15299   | 6885    | 18708   | 13458    |
| 1991  | 26301   | 14294   | 5777    | 19938   | 14542    |
| 1992  | 26195   | 16730   | 8369    | 20980   | 14750    |
| 1993  | 28080   | 16427   | 6436    | 20532   | 15065    |
| 1994  | 27839   | 15260   | 7428    | 20837   | 15933    |
| 1995  | 27024   | 16712   | 6770    | 22514   | 15076    |
| 1996  | 28216   | 17455   | 8161    | 21728   | 15946    |
| 1997  | 28302   | 17688   | 8005    | 23125   | 16577    |
| 1998  | 29023   | 18594   | 8082    | 22872   | 17575    |
| 1999  | 30217   | 18993   | 7312    | 23455   | 15370    |
| 2000  | 29792   | 18806   | 7722    | 24684   | 15260    |
| 2001  | 31530   | 20361   | 8910    | 24048   | 16303    |
| 2002  | 28332   | 18557   | 6361    | 24886   | 18413    |
| 2003  | 32032   | 21133   | 10640   | 24163   | 17899    |
| 2004  | 30913   | 21538   | 9062    | 24938   | 17228    |
| 2005  | 32731   | 22022   | 8562    | 24572   | 17149    |
| 2006  | 33005   | 22310   | 8728    | 24398   | 18252    |
| 2007  | 34326   | 26285   | 10646   | 25699   | 18611    |
| 2008  | 34244   | 26602   | 10166   | 24755   | 15772    |
| 2009  | 34532   | 22983   | 7983    | 26334   | 17487    |
| 2010  | 35415   | 27442   | 11046   | 25853   | 20475    |
| 2011  | 37221   | 27567   | 11626   | 26587   | 17783    |
| 2012  | 38152   | 28482   | 9908    | 27742   | 18858    |
| 2013  | 37825   | 28826   | 11596   | 27910   | 19096    |
| 2014  | 37506   | 29618   | 11530   | 28438   | 19118    |
| 2015  | 37912   | 29639   | 12408   | 26376   | 18674    |
| 2016  | 39316   | 29916   | 11389   | 28566   | 20872    |
| 2017  | 39751   | 34288   | 12410   | 29497   | 20860    |
| 2018  | 40243   | 34079   | 12507   | 30549   | 20286    |

Source: FAO (1985-2018)
3.4. National level total yield of cereals during drought years in South Asian countries

The total yield of cereals in Bhutan and Afghanistan was below average in all the years viz. 1985, 1989, 1993, 1997, and 2002 respectively. The average yield of Nepal, India, Pakistan, Afghanistan, Bhutan, and Bangladesh in five quadrennial drought years was presented in Table 6.

Table 6. National level total yield of cereals of the five drought years of South Asia and the average yield in respective years

| Country     | 1985    | 1989    | 1993    | 1997    | 2002    |
|-------------|---------|---------|---------|---------|---------|
| Nepal       | 16597   | 18869   | 18588   | 19466   | 21708   |
| India       | 17677   | 20906   | 22576   | 24158   | 23431   |
| Pakistan    | 16373   | 18255   | 20020   | 20916   | 23083   |
| Afghanistan | 13317   | 12376   | 11329   | 13488   | 16698   |
| Bhutan      | 14329   | 10341   | 11940   | 15998   | 16139   |
| Bangladesh  | 21488   | 25005   | 26478   | 26825   | 33951   |
| Average Yield | 16629   | 17625   | 18489   | 20125   | 22502   |

FAO (1985-2018)

Where, “+” sign means the yield of cereals above average yield in different years and the “-” sign means the yield of cereals below average yield in the respective years.

3.5. Average yield of individual crops during drought years in South Asian countries

Paddy: The average yield of paddy was 21750 kg ha⁻¹ in 1985. The yield in 1985 was below average in Nepal and Bhutan. The average yield of paddy was 22278 kg ha⁻¹ in 1989 and 23087 kg ha⁻¹ in 1993. The yields in 1989 and 1993 were below average in Bhutan and Afghanistan. The average yield of paddy was 24592 kg ha⁻¹ in 1997. The yield in 1997 was below average in Nepal, Bhutan, and Afghanistan. The average yield of paddy was 27790 kg ha⁻¹ in 2002. The yield in 2002 was below average in Bhutan, India, and Nepal (FAO, 1985-2018).

Maize: The average yield of Maize was 12854 kg ha⁻¹ in 1985, 13296 kg ha⁻¹ in 1989, and 13782 kg ha⁻¹ in 1993. The yield in 1985 was below average in India, Pakistan, Bhutan, and Bangladesh. The yield in 1989 and 1993 was below average in Bhutan and Bangladesh. The average yield of maize was 15494 kg ha⁻¹ in 1997. The yield in 1997 was below average in Bangladesh and Afghanistan. The average yield of maize was 23259 kg ha⁻¹ in 2002. The yield in 2002 was below average in Bhutan, India, Pakistan, and Nepal (FAO, 1985-2018).

Wheat: The average yields of wheat were 15093 kg ha⁻¹ in 1985, 15127 kg ha⁻¹ in 1989, 15921 kg ha⁻¹ in 1993, 18681 kg ha⁻¹ in 1997, and 19572 kg ha⁻¹ in 2002. In all the years, the yield in Nepal, Bhutan, and Afghanistan was below average. These three countries highly lag back in wheat production. India was the highest wheat-producing country among South Asian nations (FAO, 1985-2018).

Millet: The average yield of Millet was 7015 kg ha⁻¹ in 1985, 7767 kg ha⁻¹ in 1989, 7679 kg ha⁻¹ in 1993. The yields in 1985 and 1989 were below average in India and Pakistan. The yield in 1993 was below average in India, Pakistan, and Bangladesh. The average yield of Millet was 7751 kg ha⁻¹ in 1997. The yield in 1997 was below average in Pakistan, Bhutan, and Bangladesh. The average yield of Millet was 7064 kg ha⁻¹ in 2002. The yield in 2002 was below average in Bhutan, India, Pakistan, and Bangladesh (FAO, 1985-2018).

Barley: The average yields of Barley were 9397 kg ha⁻¹ in 1985 and 9989 kg ha⁻¹ in 1989. The yield in 1985 and 1989 was below average in Nepal, Pakistan, and Bangladesh. The average yield of Barley was 10369 kg ha⁻¹ in 1993. The yield in 1993 was below average in Nepal, Pakistan, Afghanistan, Bhutan, and Bangladesh. The average yields in 1997 and 2002 were 11512 kg ha⁻¹ and 12450 kg ha⁻¹ respectively. The yield in 1997 and 2002 was below average in Nepal, Pakistan, Bhutan, and Bangladesh (FAO, 1985-2018).

1985
Analysis of individual cereal yield in 1985

1989
Analysis of individual cereal yield in 1989

1993

Analysis of individual cereal yield in 1993
Analysis of individual cereal yield in 1997

2002
Analysis of individual cereal yield in 2002

3.6. Suggestions of the ways for increasing the cereal production

Intensive cereal cultivation systems that include paddy, wheat, maize, millet, and barley are widespread throughout South Asia. These systems hold the major economic activity in many rural areas and provide staple food for millions of people. Following strategies are suggested to implement in order to increase the production of cereal in South Asia:

a. Encourage resource-conserving exercises, technologies, and services that enhance yield with less water, labor, and input costs.

b. Convey the farmers with new ideas on cropping management practices from applied research in the field.

c. Promote approach to market information and enterprise development.

d. Embolden policy analysis to remove drawbacks to the adoption of modern technologies.

e. Set up strategic partnerships to help sustain and enhance the scale of benefits of improved cereal growth

f. Cope with climate extremes in cereal cropping systems.

g. Enhance the foundations of agro-advisory and precision management through knowledge organization and data integration at scale.

h. Development and promotion of high yielding, stress-tolerant, and better grain quality crop varieties.

i. Integrated crop and resource management for sustainable rice production of cereal crops.

j. Promotion of small-scale mechanization and post-harvest technologies.

k. Productivity enhancement with the help of NARS (National Agricultural Research System) of each country likes NARC (Nepal Agricultural Research Council), ICAR (Indian Council of Agricultural Research), and BARC (Bangladesh Agricultural Research Council) and so on.

4.0. Conclusion

South Asia is a major production home of different cereals. The production of major cereals has had an increasing trend over 34 years (from 1985 to 2018) in south Asian countries. Because of the global climatic changes, every year there were fluctuations in cereals production. The yields of cereals in Nepal, Pakistan, Afghanistan, and Bhutan were below average in 1985. It was below average in Afghanistan and Bhutan in 1989 and 1993. The yield was below average in Nepal, Afghanistan, and Bhutan in 1997 and 2002. The development of high-yielding stress-tolerant varieties, adoption of modern technologies, economic use of scarce resources, and promotion of post-harvest storage facilities can enhance cereal productivity in South Asia.

5.0. References

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