Review Article

Generation Change of Cropping Intensity in Bangladesh: A Systematic Review

ABSTRACT

The cropping intensity in Bangladesh remained stagnant until the late 18th century, then surged notably between 1987–88 and 2010–11. In the first half of 50 years of Bangladesh's independence, cropping intensity has increased from 143% to 173.06% with an increasing rate of 1.20%, at that time net cropped area decreased by 8248.16 thousand hectares to 7806.07 thousand hectares but grossed cropped area increased 11785.55 thousand hectares to 13518.64 thousand hectares. In the second half of 50 years, cropping intensity has increased from 173.06 to 198.00 with an increasing rate of 0.99% per year, in this time both net and gross cropped area increased. Overall, within the 50 years of Bangladesh's independence, cropping intensity has increased from 143% (1971-72) to 198% (2019-20) with an increasing rate of 1.10% per year and will be 211.03 % (projected) by 2030. At that time net cropped area decreased from 8248.16 thousand hectares to 8126.00 thousand hectares but grossed cropped area increased from 11785.55 thousand hectares to 16057.00 thousand hectares. This overall change in cropping intensity is due to an increase in double (17.11%) and tripled cropped area (18.37%) and a decline in single cropped area (-35.76%). Shifting from single to multiple cropping attributed to this change. New short-duration cultivars tailored to fallow time drove intensity. However, limited climate-smart solutions and management practices posed hindrances. Examining rice yield extension, this study used historical and projected trends to forecast 2030 cropping intensity. New four cropped-based CP has also been introduced which occupied 0.28% of the net cropped area and definitely will play a vital role to increase cropping intensity in the future.

Keywords: Cropping intensity, Cropping patterns, generation change

INTRODUCTION

Bangladesh is a densely populated country with lower per capita arable land (15 decimal head^{-1}) usage annual loss of agricultural land is about 0.30% per annum due to the construction of houses, roads and industrial infrastructure (Hasan et al., 2013). Thus the increase in cropping intensity in rice-based cropping systems is becoming important for food security and poverty alleviation. Shortly, the main challenge is to increase 50% yield per unit of land by manipulating limited land resources (Hossain et al., 2018). Cropping intensity plays a major role in the agricultural progress of any region. Higher cropping intensity shows intensive use of land for agricultural purposes (Deshmukh & Tanaji, 2017). The scope for expanding net sown area has already reached a saturation level and the potential for raising yield is nearly exhausted in many crops and regions, stepping up of incidence multiple cropping will be necessary to augment crop production. The agricultural growth that

Bangladesh has experienced since independence is an outcome of efforts to ensure the availability and use of high-quality seeds of high-yielding varieties, fertilizers, irrigation, pesticides, farm machinery and equipment; and agricultural credit. The major sources of agricultural growth during this period were the spread of modern crop varieties, intensification of input use and investments leading to expansion in the irrigated area (Mainuddin, 2021). The contribution of increased cultivable area under agricultural production has declined over time and increases in production in the past two and half decades have been almost entirely due to increased productivity (Choudhary, 2013).

Sustainable crop production in Bangladesh through the improvement of cropping patterns in a rice-based cropping system is regarded as increasingly important in national issues such as food security, land degradation, pollution control, poverty alleviation and the creation of job opportunities (Rahman et al., 2018). To produce maximum crop within a finite area, two most important options to be adopted are i) to increase the cropping intensity by producing three or more crops over the same piece of field within a year and ii) to increase the productivity of the individual crop depending on how well it utilizes the basic resources especially, the limiting ones, like water and nutrients (Mondal et al., 2015). With the development of short-duration high yielding varieties key crops such as rice, potato, mustard, pulse, jute, vegetables opportunities have been created to accommodate three or four crops in the same piece of land in a year (Hossain et al., 2018).

The present cropping intensity is 198% (Yearbook of Agri Stats, 2022) and that can be increased to some extent by improving the current cropping patterns such as incorporating short-duration crops and through management of cultivation practices (BARI, 2019). Most of the major cropping patterns practiced around the country are comprised of single, two to three crops a year. Recently four crop-based cropping patterns has been introduced by BARI in many AEZs.

A lot of information on location specific suitable cropping patterns is available in Bangladesh but little information is available on cropping intensity change trends and impacts on agriculture in Bangladesh. The purpose of this research is to analyze the generational change of cropping patterns in Bangladesh through a systematic review of the literature for the period 1971-2022. So, this study plays an important role in planning and policy making both at micro and macro levels.

METHODOLOGY

Source of data

For accomplishing the objectives of the study secondary data were collected. The necessary secondary data related to making documents of cropping intensity were collected from different published sources including the statistical yearbook of Bangladesh (BBS), the Yearbook of Agriculture Statistics (Yearbook of Agri Stats, 2022), Food and Agriculture data (FAO, 2022), world bank open data 2022, annual report of Bangladesh agricultural research council (BARC, 2012), annual report of soil resource development institute (SRDI, 2019) and others related records, books, journals, articles, government reports, websites, newspapers, daily archives, socio-economic survey report of Bangladesh. The future trend of various data until 2030 was projected based on BBS and historical data.

Predict a future value

The FORECAST function under excel statistics was used to calculate or predict a future value using existing values. In financial modeling, the FORECAST function can be useful in calculating the statistical value of a forecast made. The estimation of projected food requirement by the year 2030 is made by considering the population and minimum per-head requirement. The estimation of projected production capacity in 2030 is prepared by analyzing the previous twelve years (2009-2021) of production data collected from the Agricultural Research Vision 2030 report, (BARC, 2012).

The FORECAST function uses the following arguments:

FORECAST (x, known_y's, known_x's)

Where,

x = this is a numeric x-value (year 2030) for which we want to forecast a new y-value.

Known_y's = the dependent array or range of data (production data of individual crop).

Known_x's = this is the independent array or range of data that is known to us (years from 2009 to 2021).

The FORECAST function was calculated a new y-value using the simple straight-line equation: $y = a + bx$,

Where, $a = \bar{y} - b\bar{x}$ and

$$b = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sum(x - \bar{x})^2}$$

The values of x and y are the sample means (the averages) of the known_x and known_y values.

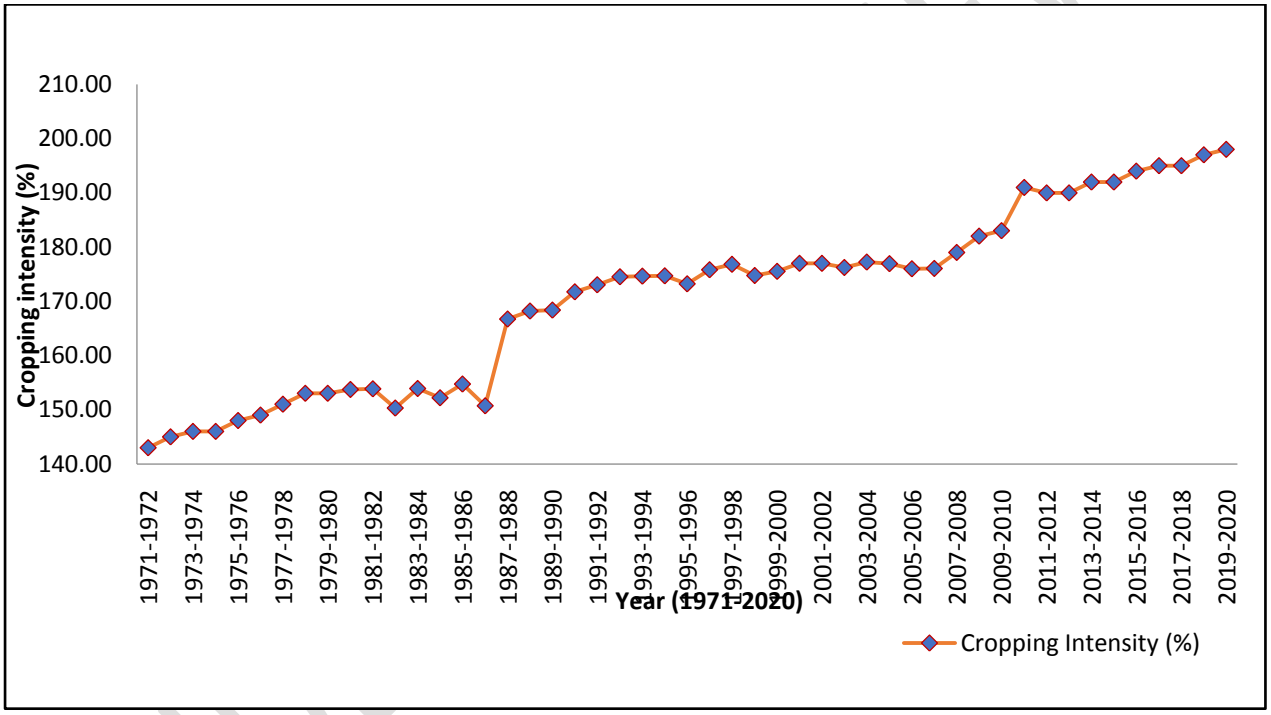
RESULT AND DISCUSSION

Document of cropping intensity in Bangladesh

Cropping intensity is expressed as the number of crops a farmer grows in a given agricultural year on the same field (Raut et al., 2011). Agricultural production can be increased either by bringing more and more land under cultivation or by increasing the cropping intensity and productivity of land or a combination of both. As the availability of land is fixed, intensive cultivation is more suitable to increase production. Adoption of improved seeds, fertilizers and mechanization are the important factors responsible for increasing cropping intensity (Deshmukh & Tanaji, 2017). In Bangladesh, cropping intensity did not increase much until the late 1980s. There was a sharp rise in the years between 1987-88 and 2010-11 (Figure 1). In the first half of 50 years of Bangladesh's independence, cropping intensity has increased from 143% to 173.06% with an increasing rate of 1.20% per year, at that time net cropped area decreased from 8248.16 thousand hectares to 7806.07 thousand hectares but the total cropped area increased 11785.55 thousand hectares to 13518.64 thousand hectares (Figure 2), that's mean single cropped area converted to double and triple cropped area. Cultivation of modern crop varieties, improvising cultural operations, and crop protection measures collectively contributed to such achievement.

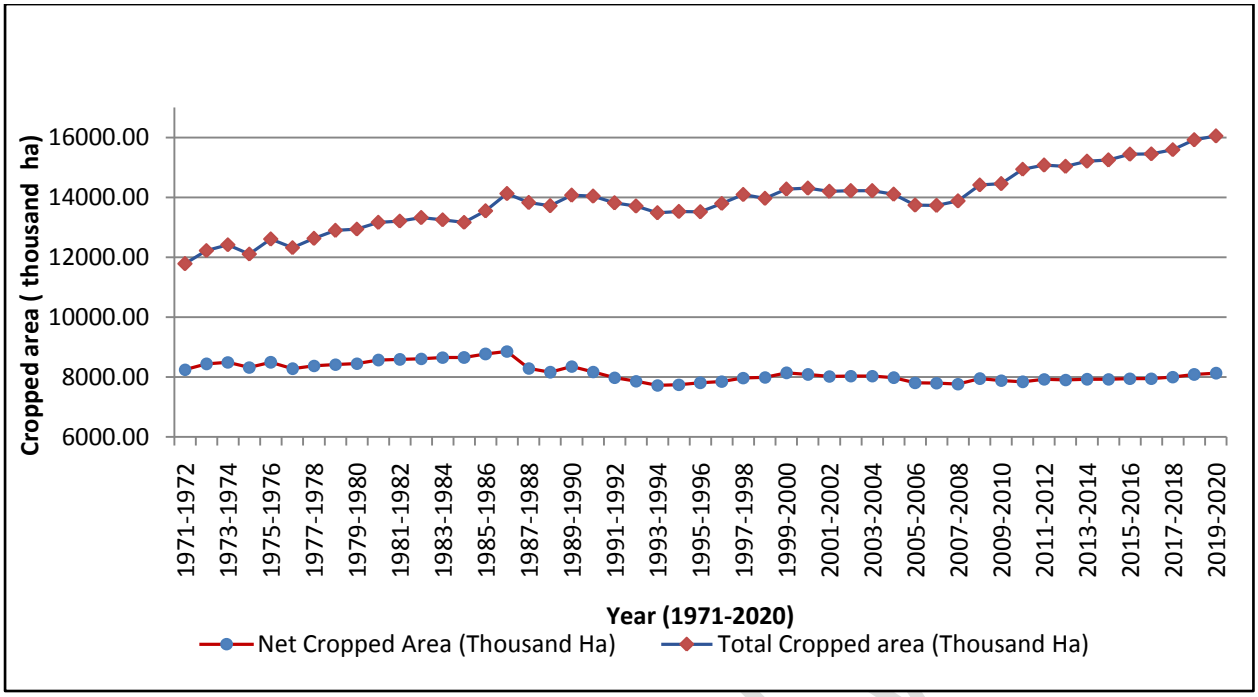
In the second half of 50 years, cropping intensity increased from 173.06 to 198.00 with an increasing rate of 0.99% per year (Figure 1), in this time both net and gross cropped areas increased. In the year 2019-20, the net area was 8126.00 thousand hectares and the total cropped area increased by 16057.00 thousand hectares (Figure 2). Modern agricultural

mechanization, irrigation facilities, year-round & short-duration varieties and overall farmer's friendly policy help to increase net and gross cropped area. But, it has not increased much in the last 25 years. In overall the 50 years of Bangladesh's independence, cropping intensity has increased from 143% to 198% with an increasing rate of 1.10% per year, at that time net cropped area decreased from 8248.16 thousand hectares to 8126.00 thousand hectares but the total cropped area increased 11785.55 thousand hectares to 16057.00 thousand hectares. This overall increase in cropping intensity is due to an increase in tripled cropped areas and a decline in single-cropped areas. The double-cropped area has not changed much over the last two decades, though it increased in the 1990s. In the meantime, four crops were successfully cultivated in a calendar year. In the year 2019-20, four cropped area was about 23000 hectares (BBS, 2020). It should be noted here that the population of Bangladesh in 1971-72 was 65.53 million, but at this time the population of the country is 2.5 times higher.



(Source: BBS, FAOSTAT, World Bank open-source data)

Figure 1. Trend of changing cropping intensity (%) in Bangladesh from 1971-72 to 2019-20



(Source: BBS, FAOSTAT, World Bank open source data)

Figure 2. Trend of changing net and gross cropped area in Bangladesh from 1971-72 to 2019-20.

Changes have been taking place in the crop sector in terms of area allocation to different crops. Cropping pattern is dependent on physical, social, historical, institutional and economic factors as well as government policies (Agrawal and Kassam, 1976). The crop sector has experienced accelerated growth for almost a half-century (1971-72 to 2020-21) after the emergence of Bangladesh. A change in the quantity of output reflects growth performance in crop agriculture. The increase in crop output is the result of changes in several contributing factors like changes in the area allocated to a particular crop and yield rates. Area allocation to a particular crop is being influenced by expected output prices relative to input prices, expected yield (based on the art of technology available), rainfall during the pre-sowing period, price and yield risk. Yield is postulated as being influenced by the technology of production, input costs and rainfall/water availability during the growing period (Hasan et al., 2019). Table 1 reveals that the trend of changing cropping intensity in Bangladesh from 1970-71 to 2019-20. It shows that continuously increasing cropping intensity in Bangladesh. In the year 1970-71, the net cropped area was 8248.16 thousand hectares and the gross cropped area was 11794.87 thousand hectares and 2019-20 year the net cropped area is 8126.00 thousand hectares and the gross cropped area is 16057.00 thousand hectares increasing trend year by year. In the year 1970-71, the cropping intensity is 143% become increasing continuously i.e. 198% in 2019-20. Table 1 indicates that the compound growth rate (CGR) of cropping intensity was 0.29 which shows that higher cropping intensity in Bangladesh. On the other hand, the Compound Growth Rate (CGR) of the net cropped area and grossed cropped area were -0.07 and 0.22 respectively. That means the trend of net cropped area gradually decreasing but gross cropped area is increasing. The coefficient of variation for the net cropped area, grossed cropped area and cropping intensity were 3.98%, 8.89% and 11.09 respectively. It indicates that, during 1971-2020 times, the trend of

changing of cropping intensity and gross cropped areas showed higher variation but net cropped areas showed lower variation in Bangladesh.

Table 1. Change of net cropped area (NCA), gross cropped area (GCA) and cropping intensity every 5 years interval in Bangladesh

Year	Net Cropped Area (NCA) ('000 Hectares)	Gross Cropped Area (GCA) ('000 Hectares)	Cropping Intensity (%)
1971-72	8248.16	11794.87	143.00
1975-76	8489.14	12563.93	148.00
1980-81	8565.93	13169.26	153.74
1985-86	8769.74	13570.30	154.74
1990-91	8177.33	14034.24	171.62
1995-96	7806.07	13512.61	173.10
2000-01	8085.02	14299.30	176.86
2005-06	7809.31	13736.39	175.90
2010-11	7838.00	14943.00	190.65
2015-16	7947.00	15438.00	194.26
2019-20	8126.00	16057.00	198.00
Mean	**8169.25**	**13919.90**	**170.90**
SD	**324.98**	**1237.55**	**18.96**
CGR	**-0.07**	**0.22**	**0.29**
CV(%)	**3.98**	**8.89**	**11.09**

Source: Yearbook of Agricultural Statistics (1980-81 to 2020-2021), Alam and Abedien (1996), World Bank open source data

SD = Standard deviation, CGR= Compound Growth Rate, CV= Co-efficient of Variance

Table 2 indicates the division-wise cropping intensity in Bangladesh in the last twelve years from 2008-09 to 2019-20. The cropping intensity shows great spatial variation in Bangladesh within twelve years, with higher levels in the northern plains. In the 2019-20 year, the highest cropping intensity was found in the Rangpur region (222%) followed by Rajshahi (216%) and Mymensingh region (206%). The difference between the two areas in terms of cropping patterns as well as cropping intensity is mainly caused by the timely availability of water for irrigation. The irrigation facilitated area under Rangpur, Rajshahi and Mymensingh regions were 52.77%, 62.02% and 49.45% respectively (Yearbook of Agri Stats, 2021). At the same time, the last 5 years average rainfall in Rangpur, Rajshahi and Mymensingh regions was 2031.8 mm, 1290.0 mm and 2201.8 mm respectively (Agri stats, 2020). Although the average rainfall was low in Rajshahi, but irrigation facilitated area was highest in this region. With more irrigation facilities and rainfall, cropping intensity might be higher in this region compared to other region in Bangladesh. The cropping intensity in Chattagram and Dhaka region showed a little lower than the national average (198%). The irrigation facilitated areas under Chattagram and Dhaka regions were 35.16% and 50.97%, respectively (Yearbook of Agri Stats, 2021). The last 5 years average rainfall in Chattagram and Dhaka regions were 3055.20 mm and 1998.40 mm respectively (Agri stats, 2020). Although the irrigation facilitated area was low compared to other region in Chattagram but the average rainfall in Chattagram was highest. The lowest cropping intensity found in the Khulna region (147%) followed by Sylhet and Barishal region. The irrigation facilitated area under Khulna, Sylhet and Barishal region was 64.02%, 34.152% and 15.96% respectively (Agri stats, 2020). The last 5 years average rainfall in Khulna, Sylhet and Barishal region was 1964.60 mm, 4401.00

mm and 2163.20 mm respectively (Agri stats, 2020). Although the average rainfall was high in this region but most of the areas are climatically vulnerable, that's why cropping intensity might be low in this area. The Compound Growth Rate (CGR) of cropping intensity was positive for all regions except Barishal and Mymensingh region which was -0.47 and -0.22 respectively. That means last 11 years cropping intensity was not increased in this area. In the case of the Barishal region, cropping intensity decreased from 169% to 164%, it might occur several natural calamities occurs the last few years in this region. On the other hand, the highest CGR was found in Rajshahi (2.30) followed by Khulna (1.53), Rangpur (1.21) and Dhaka (1.17), which means cropping intensity rapidly increased in this area. The highest Coefficient of Variation was found in Rajshahi regions (8.29%) followed by Khulna (6.03%) and Dhaka (5.07) respectively. It indicates that, during 2009-2020 times, the trend of changing cropping intensity of these regions showed higher variation in Bangladesh.

Table 2. Division wise cropping intensity of Bangladesh during 2008-2020

Division	Barishal	Chattagram	Dhaka	Khulna	Mymensingh	Rajshahi	Rangpur	Sylhet
2008-09	169	183	167	128	206	173	199	148
2009-10	171	184	174	127	207	173	200	147
2010-11	176	199	172	134	215	180	202	154
2011-12	177	191	168	132	211	190	204	150
2012-13	175	190	168	132	209	190	188	151
2013-14	178	191	164	134	206	198	212	150
2014-15	173	193	181	147	205	199	214	153
2015-16	187	187	184	148	205	202	216	152
2016-17	165	187	184	145	205	215	220	152
2017-18	165	188	185	146	205	215	219	152
2018-19	164	193	188	147	205	216	220	163
2019-20	164	193	188	147	206	216	222	163
Mean	**172.00**	**189.92**	**176.92**	**138.92**	**207.08**	**197.25**	**209.67**	**152.92**
SD	**7.06**	**4.44**	**8.97**	**8.37**	**3.12**	**16.34**	**10.81**	**5.11**
CGR	**-0.47**	**0.17**	**1.17**	**1.53**	**-0.22**	**2.30**	**1.21**	**0.70**
CV(%)	**4.10**	**2.34**	**5.07**	**6.03**	**1.51**	**8.29**	**5.15**	**3.34**

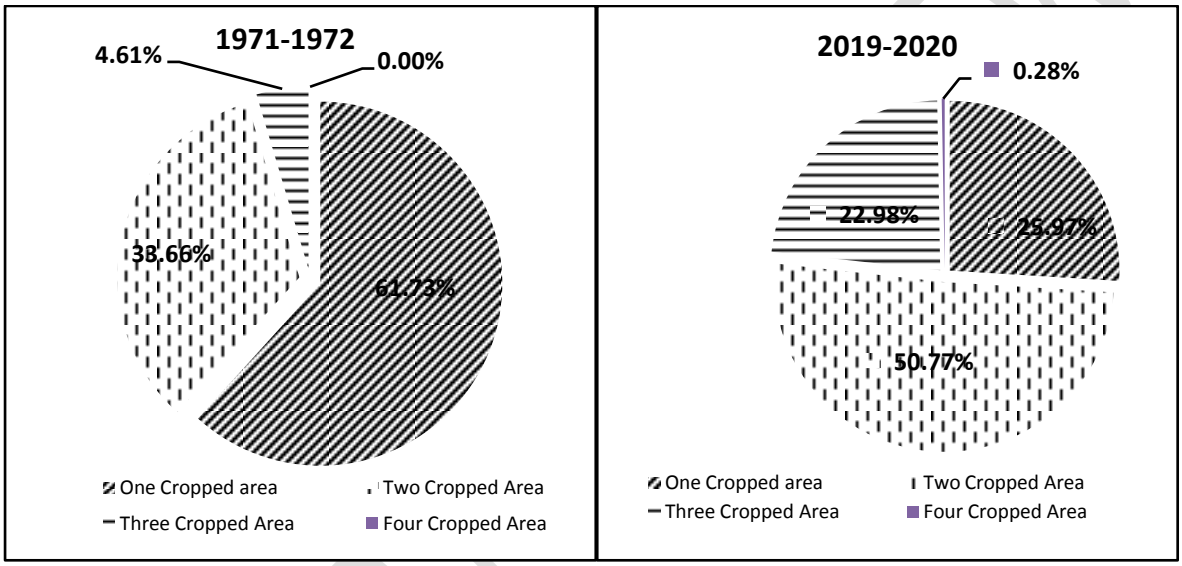
Source: Yearbook of Agricultural Statistics (2008-09 to 2019-20)

SD = Standard deviation, CGR= Compound Growth Rate, CV= Co-efficient of Variance

The trend of changing cropped areas in Bangladesh

The country experiences a lot of environmental variations, as is the case for land use patterns. The land use in croplands involves single-crop, double-crop, triple-crop, quadruple-crop, current fallow etc. Agricultural land use is highly dynamic in Bangladesh. Among the cultivated crops, rice and other cereals crops occupy about 77.31% of total cropped areas (Yearbook of Agri Stats, 2021). So, all the other crops together, occupy the rest of the crop. Generally, there are three crop seasons in Bangladesh. Due to the elevation of land and some other problems all the cultivable land is not suitable to use all three seasons for crop

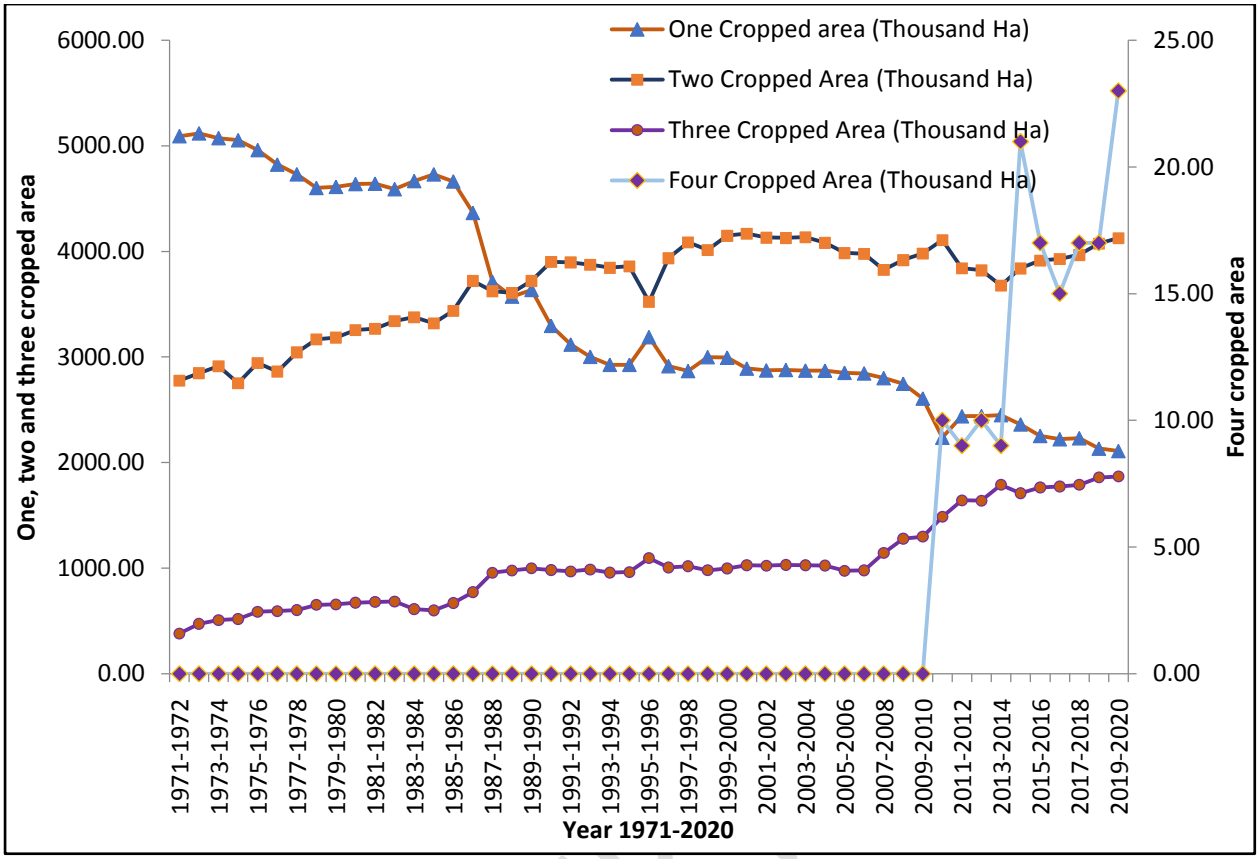
production. Figure 3 presents the trends in agricultural land use change in Bangladesh over the 50 years under consideration (1971-2020). In 1971-72, most of the cultivated land (61.73% of net cultivable land) produces crops once in a cropping calendar year but within 50 years the scenario is changed. At present, almost 50% of net cultivable land produces a crop more than once in a cropping calendar year. It indicates there are high cropping intensity prevails during this time. This overall increase in cropping intensity is due to an increase in double (17.11%) and tripled cropped area (18.37%) and a decline in single cropped area (35.76%). Now a day, four cropped-based cropping patterns also introduce in Bangladesh which occupied 0.28% of the total cultivable area (Figure 3), which definitely will play a vital role to increase cropping intensity in the future. Similarly, the more multiple crop area, the more options for practicing crop diversification in the cultivable land.



(Source: BBS, FAOSTAT, World Bank)

Figure 3. Changing of cropped area in Bangladesh last 50 years

The overall land area has increased by 4% from 14.28 million ha in 1971 to 14.84 million ha in 2020 owing to the reclamation of new lands rising from the river beds (known as char lands) (SRDI, 2019). The net sown area available for agriculture practices recorded an overall decline of 0.1% perhaps due to diversion of land for non-agricultural land uses (e.g., road, housing and industrial infrastructures) (Rahman, 2010). However, due to improvements in irrigation, the gross cropped area (GCA), which takes into account land area sown twice or three times in a year, has steadily increased during the early and take-off stages of Green Revolution (1971- 1995), as expected, but then stagnated during the mature stage of GR (1996-2020) finally reaching 16.05 million ha in 2020 (Figure 2). The main reason for such an increase is the development of irrigation which enabled farmers to grow three or four crops in a year. In figure 4, it is visible that one cropped area is gradually declining over time but at the same time, two and three cropped area is increasing. Due to improvement mechanization and modern short-duration varieties four cropped-based cropping patterns were also introduced in Bangladesh and increase its area gradually.



(Source: BBS, FAOSTAT, World Bank)

Figure 4. Trend of changing of cropped area in Bangladesh

Things to do to increase cropping intensity

As per the Bangladesh Bureau of Statistics (BBS, 2020), around 4125 thousand hectare and 1867 thousand hectare of land remain under double and triple-cropped areas respectively, which means that 50.77% and 20.98% of the net cropped area in Bangladesh has avenues partly or a greater part to be brought under quadruple cropping system. The area of cropland is declining, that's why there is no alternate option of horizontal extension but intensifying land use system through by growing more crops or multiple cropping on the same piece of land in a calendar year (Islam et al., 2018). However, agriculture is heading towards a new example to address the country's food security a concerned issue of Bangladesh (Daily star, 2022). In Sustainable Development Goals (SDG-2030) goal no. 2.3, it mentions that, "By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment". That means food production must double by 2030 to meet the demand of our growing population. Cultivation of short-duration modern crop varieties, improvising crop protection measures and cultural operations as well as increasing crop intensity collectively contributed to such achievement (Islam et al., 2018).

The estimation of food crops requirement by the year 2030 is made by considering the population and minimum per head requirement. The estimation of production capacity in

2030 is prepared by analyzing previous twelve-year production data (Table 3). All food crops except rice will be in deficit as per projected requirements for the year 2030. However, horizontal expansion of crop area as well as vertical increase of crop productivity is to be explored and ensured through the adoption of modern technologies. In addition, exploration of new areasespecially in unfavorable ecosystems and technological interventions through reducing knowledge-gap of farmers are some of the important areas to overcome the problem.

Table 3. Projections of food demand by 2030 in Bangladesh

Crop	The projected requirement in 2030 (million tons)	Current production in 2020 (million tons)	Additional requirement (million tons)	Production capacity in 2030 (million tons)
Rice	37.50	36.60	0.9	40.25
Wheat	4.20	1.25	2.95	1.01
Maize	8.30	4.70	3.60	7.24
Pulses	3.50	0.39	3.11	0.69
Oilseeds	1.70	0.97	0.73	1.13
Potato	12.30	9.60	2.7	11.39
Vegetables	6.40	4.58	1.82	6.33
Cropping intensity	-	198%	-	211.03%

Source: Author's estimation by using forecast formula and yearbook of agricultural statistics 2010-2020

A sum of 1.13 lakh ha of agricultural land has been lost during the past 34 years from 1976 to 2010. The rate of cropland shifting to non-agricultural land (housing, industry, etc.) is alarming as it is associated with the food security of the country. Total cropland was estimated to be 9.76 million ha, 9.44 million ha and 8.75 ha in 1976, 2000, and 2010 with an average decrease of 0.14% from 1976 to 2000 and 0.73% during 2000 - 2010, respectively (SRDI, 2013). Hasan et al., 2013 reported the rate of change in cropland over the 34 years is 0.30% which is still declining. Despite that total gross cropped area has been increasing and will be increased in the future because of increasing cropping intensity. It was observed that cropping intensity increased from 143% (1971-72) to 198% (2019-20) at the rate of 1.15% and will be 211.03 % (projected) by 2030. It indicates that some single-cropped areas transformed into a double-cropped areas, some double-cropped areas to the triple-cropped areas, and some triple-cropped areas to quadruple-cropped areas by accommodating rice or non-rice crops in the cropping patterns. It can be noted that cropping intensity in Bangladesh substantially changed because of the development and dissemination of new generation short-duration cultivars to fit into the fallow period in the existing single, two or three crops-based cropping patterns (Nasim et al., 2021). Additionally, the availability of other green revolution technologies including chemical fertilizers, pesticides, irrigation facilities and modern farm mechanization also contributed to increasing cropping intensity. Therefore, it can be claimed

that it is possible to increase total crop production through the adoption of higher yield potential better genotype and improved cropping pattern through agronomic practices.

CONCLUSION

The findings of the study related to the document of cropping intensity indicated that within the 50 years after Bangladesh's independence cropping intensity is gradually increased. Proper timeliness of operations, reduction in drudgery, incentives for farmers and farm workers to adopt modern agricultural technology were responsible to Increase in cropping intensity. Moreover, net cropped area is decreasing at an alarming rate because of high population pressure. Higher cropping intensity means that a greater part of the net area is being cultivated more than once or two during one agricultural year. This also hints that, higher productivity per unit of arable land during one calendar year. Extension of agricultural land is not possible in Bangladesh. To explore the potential of gradually increasing cropping intensity, it is necessary to integrate the available technologies to increase total productivity. Cropping intensity, and hence, the total annual system productivity and profitability, can be increased through the practice of three and four crops-based cropping patterns. Increasing production through utilizing the fallow period can create scope for improvement of the agricultural production system. The use of short-duration, high-yielding and climate-smart varieties can bring more area under three or four-crops based cropping patterns as well as increase cropping intensity in the near future.

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