Asian Australas. J. Biosci. Biotechnol. 2016, 1 (3), 539-546

Asian-Australasian Journal of Bioscience and Biotechnology
ISSN 2414-1283 (Print) 2414-6293 (Online)
www.ebupress.com/journal/aajbb

Article

Impact of temperature raising on crop production in Tangail, Bangladesh: A case study in Tangail district, Bangladesh

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Received: 15 November 2016/Accepted: 18 December 2016/ Published: 28 December 2016

Abstract: A case study in Tangail district, Bangladesh was carried out from September, 2013 to February 2014 to observe the trend of temperature with time series plot and the impact of temperature crop production. Questionnaire survey, field observation and FGD methods were used to collect primary data while a long duration (1990-2010) secondary data were collected from concerned institutes (DAE, BBS, BMD). Annual average of maximum temperature (T_{max}) data were collected by using environmental multimeter from all upazillas (Sub-district level) including Madhupur Forest which was in line with the secondary data. During the year 1990 to 2011 the T_{max} exhibits an increasing trend which is statistically insignificant (R^2= 0.0044). The highest value in 1995 was 40.5 and the lowest 35.5^{0}C in 1990. A decreasing trend line also was discovered for relative humidity (RH), rainfall and sunshine hours (SH) from 1990 to 2011. However negative insignificant correlation was observed between all three parameters with temperature i.e. Rainfall, RH and SH. The field data were collected from 195 people (male and female) respondents. Negative correlation was observed in rice (R^2= 0.071), wheat (R^2= 0.049) and potato (R^2= 0.010) while total vegetable production showed positive correlation (R^2= 0.068). Nevertheless Maximum Production rate for rice (3.38 m.ton/acre), wheat (3.12m.ton/acre), potato (2.26m.ton/acre) and vegetables (18.55 m.ton/acre) was observed while T_{max} ranged between 37.2-38.5 °C and dropped down after that in all four crops. Enforcement of environmental laws and policies, regular monitoring and mass awareness should be ensured for the proper management of our environment.

Keywords: climate change; Bangladesh; agriculture; global warming; rice; wheat

1. Introduction

Climate change and global warming has become an earth threatening issue. Research shows in the last century, linear trend of average earth's surface temperature has amplified by 0.7 ^{0}C. (IPCC, 2007a).After 1850, among the 12 warmest years 11 lies between last two decades (IPCC, 2007). Unfortunately both direct and indirect impact of climate change on human life has hampered the pace of sustainable development (UNFCCC, 2007). Climate also plays a key role in agriculture through defining productivity potential (Olesen and Bindi, 2002), yield quality (through heat and water stress) or by diseases and pest infestation status (Kassam *et al*., 1991), especially in the South Asian subtropical condition (Ghini *et al*., 2008). As a South Asian nation Bangladesh is considered as one of the most vulnerable country to climate change (Pouliotte *et al*., 2009). More than 70% of its total land are being used for Agriculture (FAOSTAT, 2009) and climate change along with global warming plays significant role for sustainable development (Hossain *et al*, 2013). There is always an urge in Bangladesh to feed its huge growing population through overcoming all obstacles related to the crop productivity and agricultural land management (Ahmed, 2000). Like the other South Asian nation Bangladesh is also facing an upsurge in temperature over the last three decades (Gow, 2012). Recently some studies in developing countries have been performed to investigate economic effect on agriculture due to climate change (Kurukulasuriya and Ajwad, 2007; Haim *et al*., 2008; Deressa and Hassan, 2009; Wang *et al*., 2009). All these studies claimed high susceptibility of crop production caused by climate change. In Bangladesh limited empirical investigation have been done to understand the impact of temperature rise in crop production. Furthermore these researches are only focused rice and wheat (Mahmood *et al*, 1998; Ruane *et al*., 2013; Amin *et al*., 2015). Hence, there is an urge to study the impact of climate change especially temperature rising on other major crops. Tangail is a district of Bangladesh with diverse groupings of soil, landform and climatic features which lead it to take place in four different Agro ecological zones (AEZ) i.e. AEZ 7, 8, 9 and 28 (Huq, 2013). Only this single district is surrounded by 10 rivers and had a blast in population in last 4 decades (BBS, 2011a, 2012b); a clear indication of its vulnerability to climate change. Therefore, the objective of the study is to identify the trends of temperature rising district and identify the adverse impacts of the rising temperature on major crop production in Tangail District.

2. Materials and Methods

A case study was carried out at Tangail District, Dhaka division, Bangladesh. Study area is located between latitude 24.30^{0}N and 89.92^{0}E. Its surface area is 3,375 km² and annual average temperature: Maximum 38.33^{0}C, minimum 7.13^{0}C and annual rainfall 136.33 mm (BBS, 2014c). Active Brahmaputra-Jamuna Floodplain (AEZ 7), Young Brahmaputra and Jamuna Floodplain (AEZ 8), Old Brahmaputra Floodplain (AEZ 9) and Madhupur Tract (AEZ 28) are the 4 AEZs of the study area (Huq, 2013). The research was based on both primary and secondary data collection alone with literature review. The study was developed during six month (September-February) under six phases (Figure 1) and in each phase respective out puts have contributed towards overall composition of the impact assessment of temperature rising.

2.1. Primary data collection

Primary data were collected through field observation, questionnaire survey and FGD. In this study mainly data of temperature, relative humidity were collected through environmental multi-meter, thermometer. Survey questionnaire contained questions related to causes and sources of temperature rising, impact of temperature rising crop productivity etc.

2.2. Secondary data collection

Secondary data were collected from authentic and related authorities and institution, national and international journals, available books, related reports, thesis and newsletters, research papers, internet website, census and National encyclopedia of Bangladesh. Meteorological data were collected from Bangladesh Meteorological Department (BMD, 2014). Previous temperature data were collected to see the temperature trend. Crops production from data were collected Department of Agriculture Extension (DAE, 2014), data on population from Bangladesh Bureau of Statistics (BBS, 2011a, 2012b, 2014). The web based information was collected from Google Scholar.

2.3. Data processing and analysis

After collecting data those were processed and analyzed through MS Excel-2007 and line graph represented crop production, change of rivers and relationship between change of climatic parameters and crop production. In this research different methodologies like- interview with local people, questionnaire survey applied for the data collection.

3. Results and Discussion

3.1. Trend of annual maximum temperature, relative humidity, rainfall and sunshine hours

A wide variation in Annual average of maximum temperature (T_{max}) was witnessed during the Study period (1990-2010). The Trend reached its peak in 1995 (40.5^{0}C) and however dropped down in earlier year i.e. 1990 (35.5^{0}C). Although the trend line along with values are not statistically significant but an upward trend (R^2=0.004) was observer in last 2 decades (Figure 2). Relative humidity (RH) has also fluctuated time to time. Maximum RH was observed in 1992 (82%) and minimum was in 2009 (78%). The Co-efficient of determination for RH is 0.055 and p value shows statistically insignificance. Total average of RH for the study area was 80%. Statistically insignificant data was also experienced for rainfall and Sunshine hours (SH) in relation to years. Maximum rainfall was observed in 1993 (305mm) whereas minimum value was found in 2009

(62mm). Co-efficient of determination is 0.022 for Sunshine hours with an average of 6.35 hrs. However our field observation matched with secondary data source (Table 1).

3.2. Correlation among climatic variable

Figure 3 indicates correlation among different climatic parameters. Rainfall and temperature showed a negative correlation. Rainfall peaked in cool temperature and it gradually dropped down in hot weather. Zhao *et al.*, 1991 studied 80 years climate data at 1000 weather station in USA and claimed similar negative correlation between rainfall and temperature. The result is also in line with Crutcher, 1978 who observed the similar negative trend. However in our study area Temperature expresses similar behavior with RH and SH. Overall study shows sunny weather (higher SH) lead to larger responses of daytime temperatures ($T_{max)}$ in almost all cases. Makowski *et al.* (2009) and Besselaar *et al*., 2015 both claimed similar trend for T_{max} and SH relationship.

3.3. Causes of temperature rising

Target groups in study area shared their views about the reasons behind temperature rising. These are increasing urbanization, industrialization, deforestation, population growth, transport etc. After analyzing questionnaire survey response it was found that 24.10% people thought it was urbanization while 20% industrialization, 21.02% deforestation, 14.35% over population, 16.92% transport and 3.58% others reasons (Figure 4).

3.4. Production of major Crops in Tangail district and correlation with T_{max}

3.4.1. Rice

Result shows a downward trend of correlation between rice productions with T_{max} from 1991 to 2011. The trend indicated that the negative insignificant relationship between them. In 2011, rice production was 765355 M.ton (3.08 M.ton/acre) with a yearly average temperature of 37^0C and the land involvement was 248460 acre. In the year of 2011 and 1991 the yearly average temperatures were 37.2 and 37.5^0C and the production of rice were 967551 (maximum) and 579042 M.ton(Figure 5) respectively. However this production rate of rice (3.48 M.ton/acre) did not increased in comparison with the production rate (4.52 M.ton/acre) of 2006. The highest land involvement (277995 acre)was in the year of 1996 and the highest land involvement rate 120.77% was observed in 1996 in comparison with other years. In the year of 2006 and 1996 the temperatures were 38.4 and 38.5^0C respectively. The production of rice was 659217 M.ton in 1996 and the land involvement was 277995 acre i.e. the production rate was 2.37 M.ton/acre. The land involvement rate was increased 120.77% in 1996 in comparison with 1991. In 2011 the land involvement was 277623 acre and the land involvement rate 39.00% was increased in comparison with in 2006 (Figure 5). The above discussion clearly indicates adverse effect of temperature after a certain level which is in line with Sarker *et al.*, 2012 who discovered negative effect of T_{max} in Boro rice. Our study shows rice production rate dropped down tremendously after T_{max} reached 38.5^0C in 1996 which is supported by Kim *et al.*, 1996 who claimed that production ceased afterT_{max} reached 40^0C. Still In some cases irregular seasonal changing, flood, drought, smog, heavy rainfall also causes the depletion of certain crop production (according to survey response).

3.4.2. Wheat

In the years of 1990, 1995, 2000, 2005 and 2010 the temperature was 35.55, 40.54, 37.44, 38.05 and 37.55^0C respectively (Figure 6). The production of wheat was 37329 M.ton (1.88 M.ton/acre) in the yearly average temperature 35.55^0C and the land involvement was 19838 acre in 1990. In the year of 2000 and 2010 the yearly average temperatures were 37.44 and 37.55^0C and the production of wheat were 42000 and 10661 M.ton respectively. In the years of 1995 and 2000 the temperatures were increased comparatively and these were 40.54 and 37.44^0C respectively. The production of wheat was 39179 M.ton in 1995 and the production rate was 1.78 M.ton/acre. The land area involvement was increased in 10.89% in 1995 in comparison with 1990. The highest decreasing rate (59.18%) of land involvement (4720 acre) in wheat production was observed in 2010 in comparison with 2005 while the production rate 2.25 M.ton/acre was the highest. The highest land involvement 22000 acre in 1995 but the highest production was 42000 M. ton (Figure 6) in 2000. In the year of 2000 the land involvement was 19850 acre and the land involvement rate was 9.77% and the production rate of wheat was 2.11M.ton/acre. In 2005, the land involvement was 11565 acre, production was 18498 M. ton and the production rate was 1.59 M. ton/acre. These clearly indicates the negative correlation between wheat production and T_{max} which clearly supports the result of Sarker *et al.*, 2012 who described similar decreasing trend.

Table 1. The practical scenario of climatic variable in Tangail district comparative with the BMD, 2014.

Upazila of Tangail District	Temperature (^{0}C)	Relative humidity (%)	Secondary data	
			Temperature (^{0}C)	Relative humidity (%)
Tangail sadar	25.6	69	26.6	67
Basail	28.3	71	27.6	75
Kalihati	26.8	67	27	71
Ghatail	27.5	74	27	71
Nagorpur	26.3	65	26.6	67
Mirzapur	19.4	80	18	87
Madhupur	25.5	78	28.6	79
Bhuiapur	27.4	69	27	71
Gopalpur	25.6	75	28.6	79
Sakhipur	29.8	70	27.6	75
Deldoar	21.4	77	25.5	79
Dhanbari	24.9	78	28.6	79
Madhupur forest	22.2	85	28.6	79

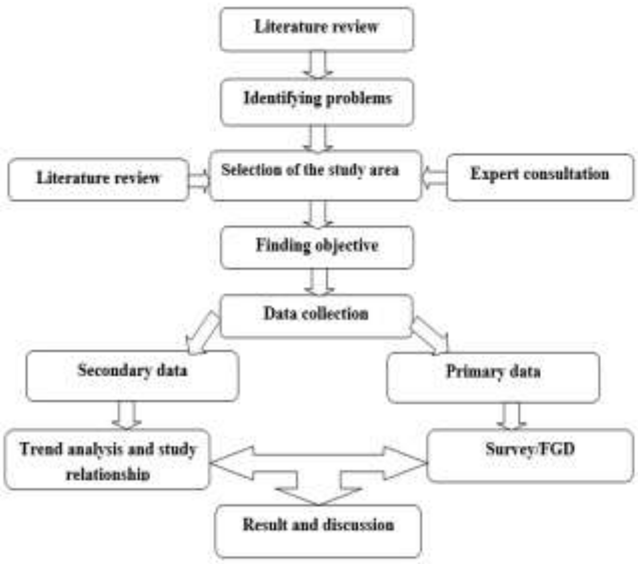

Figure 1. Flow diagram of methodology.

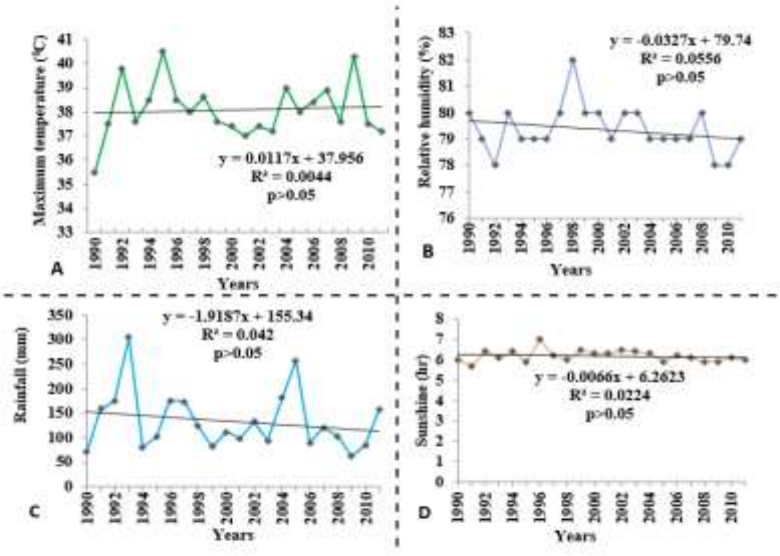

Figure 2. (A) Trend of annual maximum temperature; (B) Trend of annual average relative humidity; (C) Trend of maximum annual rainfall; (D) Trend of maximum annual rainfall.

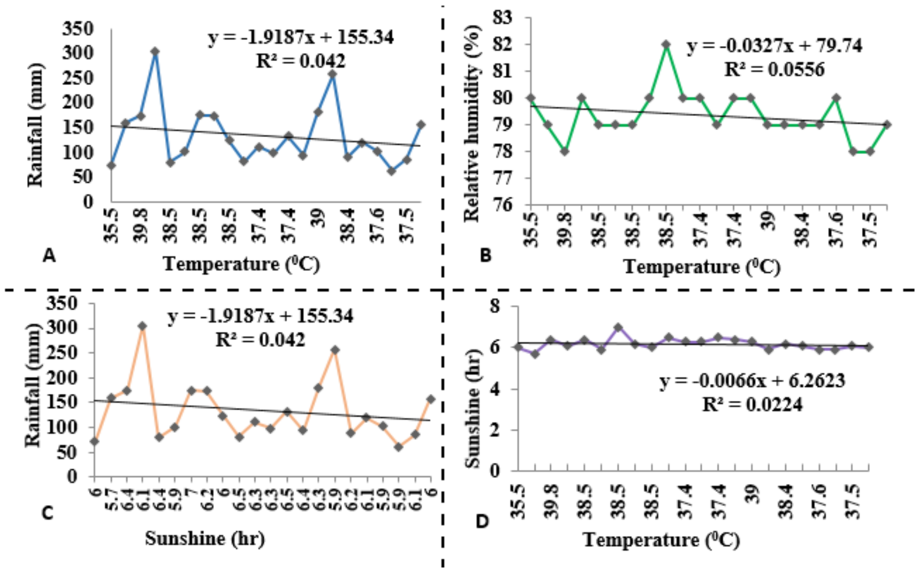

Figure 3. (A) Correlation between rainfall and temperature (1990-2011); (B) Correlation between relative humidity and temperature (1990-2011); (C) Correlation between sunshine and temperature (1990-2011); (D)Correlation between rainfall and sunshine (1990-2011).

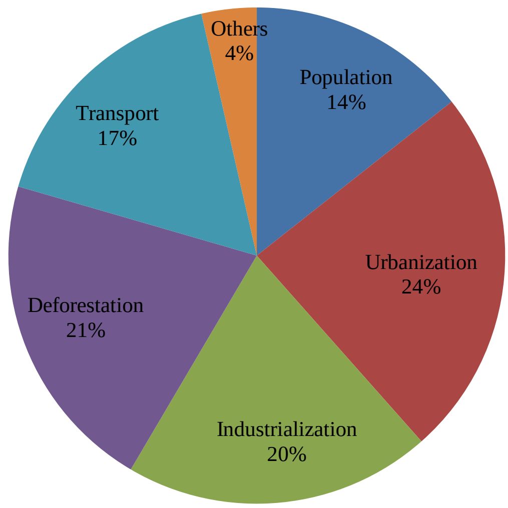

Figure 4. Causes of temperature rising (survey response).

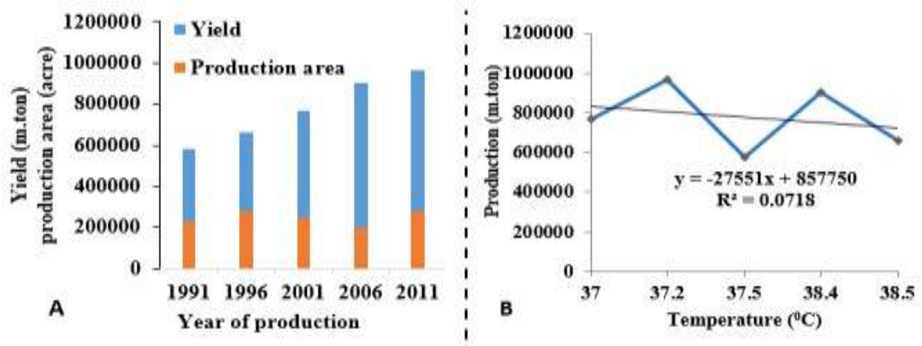

Figure 5. (A) Total rice yield with area of production in Tangail district in 1991-2011 period (Source DAE, 2014); (B) Correlation between rice production and temperature.

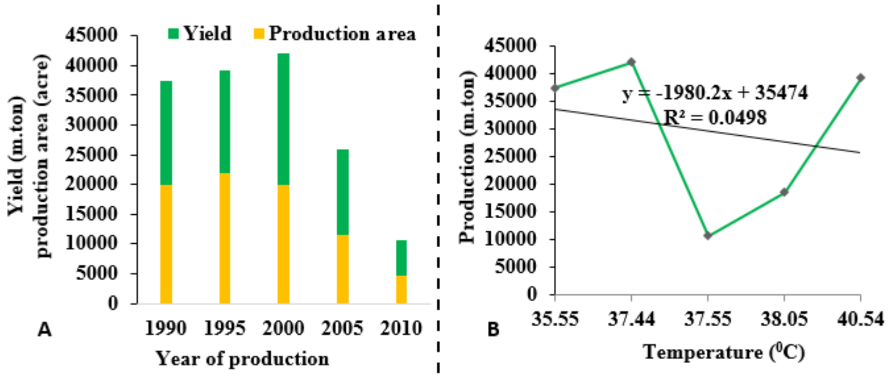

Figure 6. (A) Total wheat yield with area of production in Tangail district in 1990-2010 period (Source DAE, 2014); (B) Correlation between wheat production and temperature.

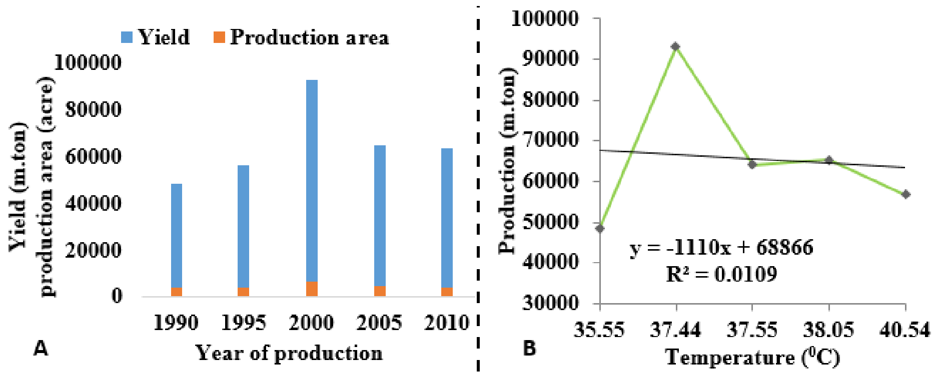

Figure 7. (A) Total potato yield with area of production in Tangail district in 1990-2010 period (Source DAE, 2014); (B) Correlation between potato production and temperature.

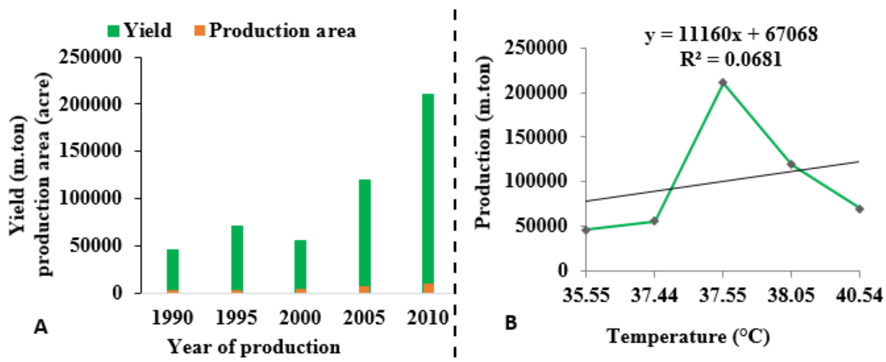

Figure 8. (A) Total Vegetable yield with area of production in Tangail district in 1990-2010 period (Source DAE, 2014); (B) Correlation between vegetable production and temperature.

3.4.3. Potato

The temperature was 35.55, 40.54, 37.44, 38.05 and 37.55^{0}C in the years of 1990, 1995, 2000, 2005 and 2010 respectively. The trend line indicated the negative correlation between production and T_{max} (Figure 7). The production of potato was 48436 M. ton (12.51M.ton/acre) with a yearly average temperature 35.55^{0}C and the land involvement was 3869 acre in 1990. In the year of 2000 and 2010 the yearly average temperatures were 37.44 and 37.55^{0}C and the production of potato were 93096 and 64066 M.ton respectively. In 2010 the production rate of potato 14.96 M. ton/acre was highest in comparison with other years (Figure 7). The highest land involvement was 6315 acre while the highest production 93096 M.ton and the highest land involvement rate 43.19 % were observed in 2000 in comparison with other years. In 2010 the land involvement was 4282 acre and the decreasing land involvement rate for 2010 was 17.07% in comparison with 2005. In the year of

1995 and 2000 the temperatures were increased comparatively and these were 40.54 and 37.44^{0}C respectively. The production of potato was 56787 M. ton and the production rate was 12.87 M. ton/acre in 1995. The land area involvement rate was increased in 13.98% in 1995 in comparison with 1990. The highest decreasing rate (17.07%) of land involvement i.e. 4282 acre in potato production was observed in 2010 in comparison with 2005 and the production was 64066 M. ton but the production rate (14.96 M.ton/acre) was the highest. From the above discussion we can say that the temperature influenced the potato production in different years. But not only can't this single factor be responsible for the whole production. Some other climatic factors (relative humidity, sunshine and rainfall) correlate with the temperature to ensure the favorable environment for crop production. In some cases irregular seasonal changing, flood, drought, smog, heavy rainfall cause the depletion of certain crop production.

3.4.4. Vegetables

The trend line indicated the positive correlation between vegetable production andT_{max} (Figure 8). In the years of 1990, 1995, 2000, 2005 and 2010 the temperature was 35.55, 40.54, 37.44, 38.05 and 37.55^{0}C respectively. The production of vegetable was 46262 M.ton (13.81 M.ton/acre) in the yearly average temperature 35.55^{0}C and the land involvement was 3348 acre in 1990. The production of vegetable was 70357 and 56081 M. ton and the production rate was 18.55 and 14.55 M.ton/acre in 1995 and 2000 respectively. The land area involvement rate was increased in 13.26% in 1995 in comparison with 1990. The highest increasing rate (95.19%) of land involvement 7523 acre in vegetable production was observed in 2005 in comparison with 2000 and the production was 119492 M.ton but the production rate was1588 M.ton/acre. In the year of 2000 and 2010 the yearly average temperatures were 37.44 and 37.55^{0}C and the production of vegetable were 56081 and 210549 M.ton respectively. In 2010, the production rate of vegetable 20.88 M.ton/acre was the highest in comparison with the production rate of vegetable was 15.88 M.ton/acre of 2005. The highest land involvement 10082 acre, the highest production 210549 M.ton and the land involvement rate 34.01 % were observed in 2010 sin comparison 2005. The land involvement was 3854 acre and land involvement rate was 1.63M.ton/acre in 2000. From the above discussion we can say that the temperature influences the vegetable production in different years. But not only can't this single factor be responsible for the whole production. Some other climatic factors (relative humidity, sunshine and rainfall) correlate with the temperature to ensure the favorable environment for crop production.

4. Conclusions

Temperature seems to have become an indispensable part of the climatic variable. From the study it was found that extreme temperature becomes a problem the production of crops. Production of some vegetables was increased in high temperature but most of the crop production was decreased. Alone with temperature other causes such as unfavorable weather condition, seasonal variation and natural calamities etc. which influence the production of crops. Because temperature correlates with these natural hazards adaptive capabilities of the crops, without proper attempt food security will be disrupted. Crops which can withstand adverse climate may ensure food security. Increased public awareness and multidisciplinary approach from the government for sustainable development in needed.

Conflict of interest

None to declare.

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