Variation of Carbon Dioxide over SAARC Countries during the 1971-2010

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ABSTRACT
Several factors responsible for climate change according to IPCC report factor mainly include burning fossil fuel, change land use and, deforestation, industrial activity, volcanic eruption, agriculture. The carbon dioxide and other green house gases are cause the climate change. In the present the variations of the Carbon dioxide (CO_2) emission over South Asian Association for Regional Cooperation (SAARC) countries during the period of 1971-2010 has been carried out. Out of eight developing SAARC countries emits more amount of CO_2. The Maldives have higher emission of CO_2 whereas Afghanistan is lowest.

Keywords
SAARC, CO_2, IPCC, Climate Change.

1. INTRODUCTION
The earth atmosphere system has been changed during last century due to the increase in anthropogenic activity. After the industrial revolution, the most significantly changes by anthropogenic activity is increase in the Carbon dioxide (CO_2) and other green house gases concentration in atmosphere. The industrial revolution marks of a strong increasing use of fossil fuels and emission of CO_2. Carbon dioxide emissions depend on the type and amount of energy consumed, and energy consumption is directly or indirectly linked to the socio-economic development of a country. So the projection of CO_2 emissions from the energy sector is based mainly on projections of the population and economic growth of a country over a specific period in the future. Besides, other greenhouse gases are also emitted from a number of activities that uses energy such as residential and commercial cooking, space heating, industrial processes, transportation and, so on.

According to IPCC reports defined equilibrium climate sensitivity refers to the equilibrium change in the annual mean global surface temperature following a doubling of the atmospheric equivalent carbon dioxide concentration. In last twelve years (1995-2006) record the instrumental record of global surface temperature (since 1850) among the twelve warmest years. According to the Third Assessment Report (TAR) the temperature increase is widespread over the globe and is greater at higher northern latitudes in the 100-years linear trend (1906-2005) of 0.74 [0.56 to 0.92]°C1 is larger than the corresponding trend of 0.6 [0.4 to 0.8]°C (1901-2000). Land regions have warmed faster than the oceans. The international convention of Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1997 in Kyoto, Japan, at the Third Session of the Conference of the Parties (COP) to the UNFCCC. This protocol agreed to reduce their anthropogenic greenhouse gas emissions (carbon dioxide, methane, nitrous oxide, hydro fluorocarbons, perfluorocarbons, and sulphur hexafluoride) by at least 5% below 1990 levels in the commitment period 2008 to 2012. The Kyoto Protocol entered into force on 16 February 2005. Rising sea level is consistent with warming. Global average sea level has risen since 1961 at an average rate of 1.8 [1.3 to 2.3] mm/yr and since 1993 at 3.1 [2.4 to 3.8] mm/yr, with contributions from thermal expansion, melting glaciers and ice caps, and the polar ice sheets. Whether the faster rate for 1993 to 2003 reflects decadal variation or an increase in the longer-term trend is unclear.

Marland et al [5] described as, global emission from burning of fossil fuel and cement production account 76.3% in 2007. Now, 4.5% global CO_2 release from fossil fuel burning and cement production. In present time atmospheric atmosphere CO_2 emission contribute 80%. Michael et al [6] described as the atmosphere CO_2 emission contribute 63% for climate change. The increase mean global atmospheric CO_2 concentration has increased from 280 ppm in the 1700s to 380 ppm in 2005, at a progressively faster rate each decade. This growth is governed by the global budget of atmospheric CO_2, which includes two major anthropogenic forcing fluxes: (a) CO_2 emissions from fossil fuel combustion and industrial processes, and (b) the CO_2 flux from land use change, mainly land clearing. Manable and Wetherald (1979) described as, Generally the increase CO_2 emission lead to warming and increasing of moisture content of air, contributes to the large reduction of meridional temperature gradient in the lower troposphere because of poleward highly reflective snow cover and increase transportation in poleward. In the CO_2 rich warm climate where moisture penetrates into higher latitudes is cause of greater increase of the rate of precipitation and runoff in high latitudes. The CO_2 emission increase they affects the many factor more Important on climate by increasing atmosphere CO_2 [Plass (1956), Kondrattev and Nilisk (1960), Kaplan (1960), Moller (1963), Hansen (1981)]. Kcholia and Reck (1997) described as, on doubling of CO_2 concentration quantitative impact on global climate change, global surface air temperature. The CO_2 emission shows that in develop country shows emissions have been higher as compared to developed nations since 2004, though developing countries release significantly lower levels of emissions per capita than developed countries [1].

The present study includes the variations of the CO_2 emission over SAARC countries during the period of 1971-2010. The variations of mean annual temperature over India and its relation with CO_2 emission has also been studied.

2. DATA AND METHODOLOGY
The CO_2 emission data for the period 1971-2010 was taken from the website (www.data.worldbank.org). The variations of CO_2 have been studied for SAARC countries viz. Maldives, India, Pakistan, Bhutan, Sri Lanka, Bangladesh, Afghanistan, and Nepal. Further, the CO_2 emission variation has also been analyzed for the four decades viz 1971-1980, 1981-1990, 1991-2000 and 2001-2010.

3. RESULTS AND ANALYSIS

The total and decade wise variation in CO_2 emission (in metric tons per capita) over SAARC countries is listed in Table 1. In recent decade 2001-10, the highest amount of CO_2 emission (859 metric tons per capita) is seen over Afghanistan and lowest amount of CO_2 emission is seen over Nepal (-4 metric tons per capita) and Bhutan (-0.6 metric tons per capita). Thus, there is decline in CO_2 emission over Nepal and Bhutan in recent decades. However, the results shows highest amount of CO_2 emission over Maldives (10485 metric tons per capita) and lowest amount of CO_2 emission over Afghanistan (73 metric tons per capita for the total period 1971-2010.

3.1. Variations of CO_2 emission over Maldives

Figure 1a shows the variation of the CO_2 emission (metric tons per capita) over Maldives during the period 1971-2010. The CO_2 emission during the period 1971-2010 shows the increasing trend with maximum increase in the year 2009. There is decline in CO_2 emission in recent year 2010. The minimum CO_2 emission is seen in the initial years 1971-78.Figure 1(b to e) shows the decadal variation in the CO_2 emission. The results suggest increase in CO_2 emission during all the four decades (*i.e*., 1971-1980, 1981-1990, 1991-2000 and 2001-2010). However, the recent decade 2001-10 shows highest variation and initial decade 1971-80 shows lowest variation of CO_2emission.The variance in CO_2 emission is least in recent decades and highest in initial decades 1971-80.

The growth rate of CO_2 emission is found to be 0.086 per year for the overall period 1971-2010. The growth rate of CO_2 emission is observed to be 0.026/year for the initial decades 1971-1980 (Figure 1b). The growth rate of CO_2 emissions found to be 0.042/year during 1981-90 and the growth rate of CO_2 emission is observed to be 0.104/year during 1991-2000. The growth rate of CO_2 emission is found to be 0.148/year during the period 2001-2010. Table 1 shows CO_2 emission over Maldives abruptly increases by 10485% for the total period1971-2010.The CO_2 emission shows maximum increase by 814.98% during the decade of 1971-80. The CO_2 emissions show increase by 138.66%, 64.66% and 59.19% during the decades 1981-1990, 1991-2000 and 2001-2010 respectively. The increase in CO_2 emission over Maldives is abrupt for the two decades 1971-80 and 1981-90. While, in last two decade show successively low emission as compared to the above two decades.

3.2. Variations of CO_2 emission over India

The variation in the CO_2 emission (metric tons per capita) over India for the period 1971-2010 (Figure 2a). The biggest absolute emission come from India after China and United states but in terms of CO_2 emission per capita, China is ranked 127^{th} at 1.7 metric tones per capita. During 1971-2010 three times increasing CO_2 emission. The CO_2 emission during the period 1971-2010 shows the increasing trend with maximum increase in the year 2009. There is decline in CO_2 emission in recent year 2010. Figure 2 (b to e) show the decadal variation in the CO_2 emission over India. The increase in CO_2 emission is evident during all the four decades. However, the increase in CO_2 emission is highest in the decade 2001-10 as compared to the CO_2 emission in the rest three decades. There is least CO_2 emission during the decade 1971-80. The rate of CO_2 emission is found to be 0.031/year during period of 1971-2010. There is almost no variance from the mean value of CO_2emission over India for the total period. The growth rate of CO_2 emission is observe to be 0.017/year during the decade 1971-80 and the growth rate of CO_2 emissions is found to be 0.031/year during the decade 1981-90. The growth rate of CO_2 emission is noted to be 0.035/year during the decade 1991-2000 and the growth rate of CO_2 emission is found to be 0.066/year during the recent decade 2001-10. Table 1 shows increase in CO_2 emission over India is found to be 359.55% for the period 1971-2010. The CO_2 emission show maximum increase by 51.63% during the decade 1981-90 and least increase in CO_2 emission by 36.77% during the decade 1991-2000. The CO_2 emission increase by 37.54%, 36.76% and 46.64% during the decades 1971-1980, 1991-2000 and 2001-2010 respectively.

3.3. Variations of CO_2 emission over Pakistan

Figure 3a shows the variation in the CO_2 emission (metric tons per capita) over Pakistan for the period 1971-2010. The CO_2 emission during the period 1971-2010 shows the increasing trend with maximum increase in the year2007. There is decline in CO_2 emission over Pakistan after the year 2007. Figure 3 (b to e) shows the decadal variation in the CO_2 emission over Pakistan. The increase in CO_2 emission is evident during all the four decades. The increase in CO_2 mission is highest in the recent decade 2001-10 but less as compared to increase in CO_2 emission over Maldives and India. The variance in CO_2 emission is least during the decade 1981-90 and the variance is maximum during the decade 1971-80. While, the variance in CO_2 emission during the decades 1991-2000 and 2001-10 is almost equal.

The CO_2 growth rate emission is found to be 0.017/year for the study period 1971-2010.The growth rate of CO_2 emission is observed to be 0.005/year for the decade 1971-80 and the growth rate of CO_2 emissions found to be 0.020/year for the decade 1981-90. The growth rate of CO_2 emission is noted to be 0.014 /year during 1991-2000 and the growth rate of CO_2 emission is found to be 0.025/year during the decade 2001-10. Table 1 shows increase of CO_2 emission by 146% during the study period. The CO_2 emission show maximum increase by 48.43% during the decade 1981-90 and least increase in CO_2 emission during the decade 1971-80. The CO_2 emission increases by 5.70%, 23.88% and 26.41% during the decade 1971-80, 1991-2000 and 2001-10 respectively.

3.4. Variations of CO_2 emission over Bhutan

Figure 4a depicts the variation in the CO_2 emission over Bhutan. The emission of CO_2 is fifty times more over Bhutan as compared to that over other SAARC countries for the study period 1971-2010. The CO_2 emission is highly variable over Bhutan as compared to rest SAARC countries. The CO_2 emission over Bhutan shows increasing trend with maximum increase in the year 1997. There is increase in CO_2 emission in the recent year 2010. The maximum decline in CO_2 emission is noticeable in the years 1989 and 2004. The CO_2 emission is constant for the initial years 1971-78. Figure 4(b to e) shows the decadal variation in the CO_2 emission over Bhutan. The increase in CO_2 emission is found during in the decade 1971-1980, 1981-1990 and 1991-2000. However, the increase in CO_2 emission is greater in the decade 1991-2000 as compared to the CO_2 emission in the decade. While the slow decrease in CO_2 emission during the decade 2001-2010.

The growth rate of CO_2 emission is found to be 0.021/year for the period 1971-2010. The growth rate of CO_2 emission is observed to be 0.005/year during the decade 1971-80 and the

growth rate of CO_2 emissions is found to be 0.017/year during the decade 1981-90. The growth rate of CO_2 emission is found to be 0.049/year during the decade 1991-2000 and the decay rate of CO_2 emission is found to be 0.005/year during the period 2001-10. The CO_2 emission abruptly increases over Bhutan by 5371.67% for the study period 1971-2010 (Table 1). However, a noticeable increase of 338.66, 295.79% and 102.57% is found during the decade 1971-80, 1981-90, and 1991-2000 respectively. The contrasting feature is seen in the recent decade 2001-10. There is decline in CO_2 emission by 0.63% in the recent decade.

3.5. Variations of CO_2 emission over Sri Lanka

The variation of CO_2 emission over Sri Lanka is shown in Figure 5a. The variance in CO_2 emission is more compared to above SAARC countries. The CO_2 emission over Sri Lanka increases for the period 1971-2010 with maximum increase in the year 2004. The turning point in CO_2 emission is seen in the year 1980 and 1998. Figure 5 (b to e) shows the decadal variation in the CO_2 emission over Sri Lanka. There is decrease in CO_2 emission during last two decades 1971-80 (Figure 5b) and 1981-90 (Figure 5c) and there is increase in CO_2 emission over Sri Lanka during recent two decades 1991-2000 (Figure 5d) and 2001-10 (Figure 5d). However, the increase is highest in the decade 1991-2000 and the decrease is highest in the decade 1981-90. The growth rate of CO_2 emission is found to be 0.011 metric ton per capita /year for the period of 1971-2010. The decay rate of CO_2 emission is observed to be 0.003 metric ton per capita /year for the decade 1971-80 and the decay rate of CO_2 emissions is found to be 0.009 metric ton per capita /year for the period 1981-90. The growth rate of CO_2 emission is noted to be 0.029 metric ton per capita/ year for the decade 1991-2000 and the growth rate of CO_2 emission is found to be 0.006 metric ton per capita /year for the decade 2001-10. Table 1 shows CO_2 emission is increased by 145.63% for the period 1971-2010. The CO_2 emission is maximum by 126.07% in the decade 1991-2000 and minimum by 17.17% in the decade 1981-90. However, a noticeable increase of 12.90% is found in the recent decade 1981-90.

3.6. Variations of CO_2 emission over Bangladesh

The variation in the CO_2 emission over Bangladesh during the study period 1971-2010 is shown in Figure 6a. The emission increase by six times over Bangladesh during 1971-2010. The CO_2 emission during the period 1971-2010 shows the increasing trend with maximum increase in the year 2010 and maximum decrease in the CO_2 emission in the year 1971. Figure 12 (b to e) shows the decadal variation in the CO_2 emission. The increase in CO_2 emission is found during four decade that is 1971-1980, 1981-1990, 1991-2000 and 2001-2010. While, the maximum increase in CO_2 emission is in the decade 2001-2010 as compared to the CO_2 emission in the decade 1971-1980, 1981-1990 and 1991-2000. However the slow increase in CO_2 emission during the decade 1971-1980.

The CO_2 growth rate emission is found to be 0.007 per year during period of 1971-2010. The growth rate of CO_2 emission is observed to be 0.004 per year during period 1971-1980. The growth rate of CO_2 emissions noted to be 0.005 per year during 1981-1990. The growth rate of CO_2 emission is found to be 0.007 per year during 1991-2000. The growth rate of CO_2 emission is noted to be 0.015per year during the period 2001-2010. It is also clear from Table 1that variation of CO_2 emission is increase by 629.34% during period 1971-2010. The CO_2 emission is maximum increase by 81.74% during period of 1971-1980. The CO_2 emission is increase 54.58%, 45.19% and 54.24% is found during 1981-1990, 1991-2000 and 2001-2010 respectively.

3.7. Variations of CO_2 emission over Afghanistan

Figure 7a represents the variation of CO_2 emission (metric tons per capita) during the period 1971-2010. The CO_2 emission during the period 1971-2010 shows the decreasing trend with maximum decrease in the year 2002 and maximum increase in the CO_2 emission in the year 2010. Figure 13 (b to e) shows the decadal variation in the CO_2 emission. The increase in CO_2 emission is found during the decade 1971-1980, 1981-1990 and 2001-2010. While, the increase in CO_2 emission is more in the decade 1991-2000 as compared to the CO_2 emission in the decade 1971-1980, 1981-1990. While the rapidly decrease in CO_2 emission during the decade 1971-1980.

The decay rate of CO_2 emission is found to be 0.002 per year during period of 1971-2010 over Afghanistan. The growth rate of CO_2 emission is observed to be 0.001 per decade during period 1971-1980. The growth rate of CO_2 emissions found to be 0.009 per year during 1981-1990. The decay rate of CO_2 emission is noted to be 0.012 per year during 1991-2000. The growth rate of CO_2 emission is found to be 0.028 per year during the period 2001-2010. Table 1 shows variation in emission of CO_2 is found to be 73% increases, these is very less emission among the SAARC country during 1971-2010. The CO_2 emission maximum increase by 859.32% is found during 2001-2010. While, noticeable increase in 49.11% during period 1981-1990. The CO_2emission is major decreases 80.81% .While noticeable decreases by 20.23% is found during 1971-1980.

3.8. Variations of CO_2 emission over Nepal

Figure 8a depicts the variation in the CO_2 emission (metric tons per capita) during the period 1971-2010. From 1971-2010 the emission of CO_2 is seven times increases. The CO_2 emission during the period 1971-2010 shows the increasing trend with maximum increase in the year 2010 and maximum decrease in the CO_2 emission in the year 1971. Figure 14 (b to e) shows the decadal variation in the CO_2 emission. The increase in CO_2 emission is found the decade 1971-1980, 1981-1990, 1991- 2000. However, the increase in CO_2 emission is greater in the decade 1991-2000 as compared to the CO_2 emission in the decade 1971-1980, 1981-1990. While, in decade 2001-2010 there is decrease of CO_2 emission. The growth rate of CO_2 emission is found to be 0.003 per year during period of 1971-2010 over Nepal. The growth rate of CO_2 emission is noted to be 0.001 per decade during period 1971-1980. The growth rate of CO_2 emissions found to be 0.009 per decade during 1981-1990. The growth rate of CO_2 emission is observed to be 0.009 per decade during 1991-2000. The decay rate of CO_2 emission is found to be in exponential form during the period 2001-2010.Table 1 shows variation in CO_2 emission increases by 733.95% are found during period 1971-2010.The CO_2 emission maximum increase by 169.63% is found during period 1991-2000. The CO_2 emission major decrease by 4.22% during decade 2001-2010. The CO_2 emission increase by 124.94% and 13.38% is found during period 1971-1980 and 1981-1990.

4. CONCLUSIONS

The following conclusions drawn from the study of CO_2 emission over different SAARC countries (Figure 9) are as follows:

- SAARC countries which include eight developing countries emit more amount of CO_2. The Maldives seems to be highest CO_2 emission in the SAARC countries whereas, Afghanistan is lowest.
- In India, increase in temperature is reinforced by increase in CO_2 emission during the period 1971-2007.
- In the decade 2001-2010, there is abrupt increase in CO_2 emission in the developing countries such as Maldives, India, Pakistan, Bangladesh and Afghanistan.
- The CO_2 emission over Bhutan, Sri Lanka and Nepal show increasing trend during the decade 1991-2000.
- On the basis of result the CO_2 emission (metric ton per capita) comparison of India with over different countries. The countries which are more emission of CO_2 such as Maldives than India.
- The countries those are less CO_2 emission such as Pakistan, Bhutan, Sri Lanka, Bangladesh, Afghanistan, and Nepal than India.

The world has experienced climate change on regional and global scale. The unpredicted rainfall event during April 2015 which was enough to destroy the harvesting of agricultural products and thereby has affected the life of a farmer. Also, the recent earthquake in Nepal is an indirect consequence of human efforts to disturb the natural cycle. In the present scenario of increase in extreme events due to global warming, there is an argent need to cut the CO2 emission by developed countries. The developing countries are heavily populated, so they are forced to increase their economy by increasing industrial production to overcome the demand. Therefore, developing countries cannot cut the CO_2 emission under certain limits. In future, if the developing countries can control their population growth then there can be a control over CO_2 emission.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

[1] Brussel's, 2009. Greenhouse Gas Emission Growing Faster since 2000, News release.

[2] J. Hansen, D. Jonson, A. Lasic, S. Lebedeff, P. Lee, D. Rind and G. Russell, 1981. Climate Impact of Increasing Atmospheric Carbon Dioxide, Science, Volume 213, pp. 957-966.

[3] L. D. Kaplan, 1960. The influence of carbon dioxide variation on the atmospheric heat balance, Tellus, Volume 12, pp. 204-208.

[4] K. Kondratiev, and H. I. Nilisk,1960. On the question of carbon dioxide variation in the atmosphere, GeofisPuraAppl, Volume 46, pp. 216-230.

[5] G. Marland, K. Hamal, 2009. How Uncertain Are Estimates of CO2 Emissions? Journal of Industrial Ecology Volume 13, pp. 4-7.

[6] Michael R. Raupach, Gregg Marland, Philippe Ciais, Corinne Le Quéré, Josep G. Canadell, GernotKlepper, and Christopher B. Field, 2007. Global and regional drivers of accelerating CO2 emissions, Proceedings of the National Academy of Sciences of United Statesof America (PNAS), Volume 104, Issue 24, pp. 10288–10293.

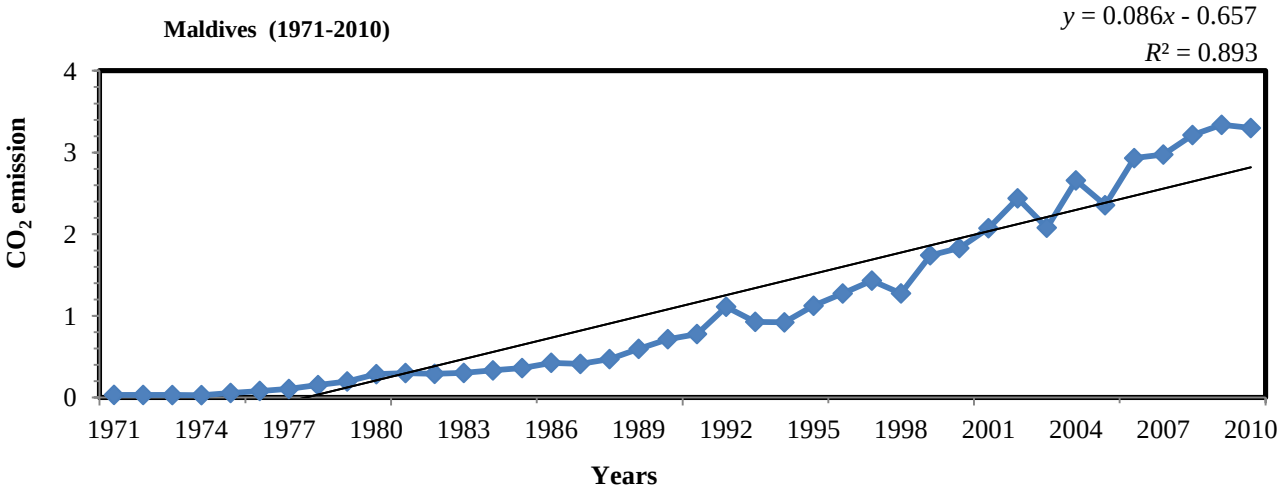
[7] F. Moller, 1963. On the influence of changes in air on the radiation balance of the earth's surface and on the climate, Journal Geophysic Research., Volume 68, pp. 3877-3886.

[8] G. N. Plass, 1956. The influence of 15-micron carcon dioxide band on the atmospheric infrared cooling rate, Quart Journal Roy Meteology, Volume 82, pp. 310-324.

7. APPENDIX

Table 1: Variation in CO_2 emission (in percent) over SAARC countries

Duration	Maldives	India	Pakistan	Bhutan	Sri Lanka	Bangladesh	Afghanistan	Nepal
1971-2010	**10485.26**	**359.5553**	**145.751**	**5371.671**	**145.6337**	**629.3432**	**73.22595**	**733.95**
1971-1980	814.9848	37.54873	5.703707	338.6602	-10.0778	81.74098	-20.2373	124.9448
1981-1990	138.6628	51.63211	48.43859	295.7923	-17.169	54.58401	49.11294	13.37902
1991-2000	64.6671	36.76853	23.8817	102.5743	126.0658	45.18616	-80.8183	169.6339
2001-2010	59.19504	46.64288	26.41726	-0.63174	12.90354	54.23856	859.3232	-4.2157



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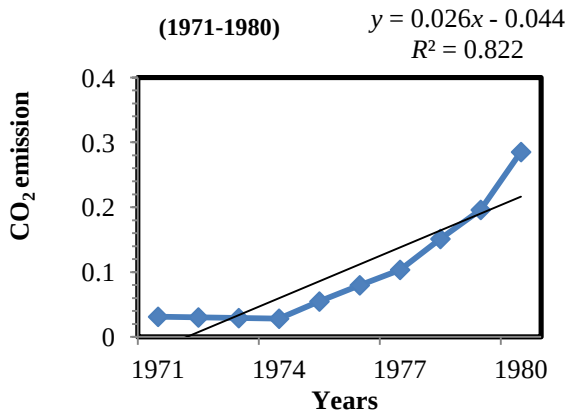

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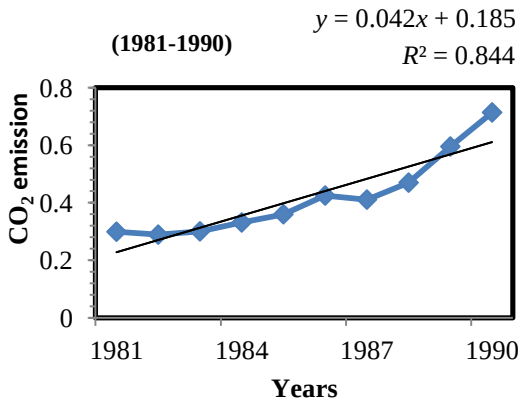

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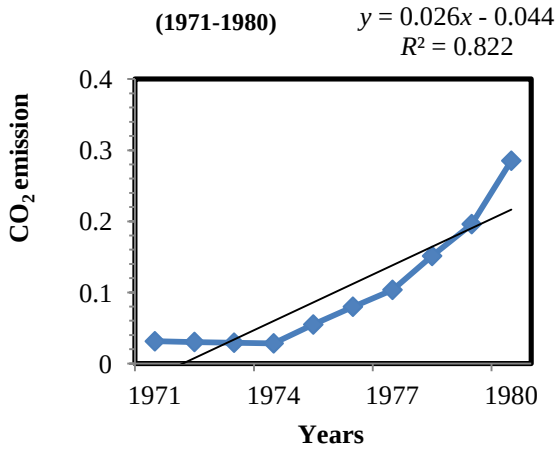

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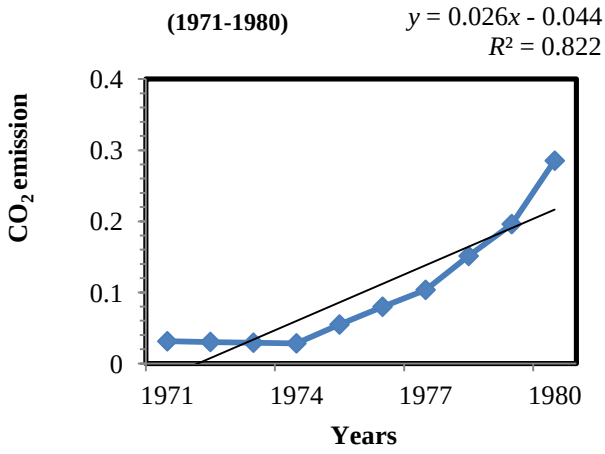


(e)

Fig 1: Variation of CO_2 emission (in metric ton per capita) over Maldives for the period (a) 1971-2010; (b) 1971-1980; (c) 1981- 1990 (d) 1991-2000 ; (e) 2001-2010.

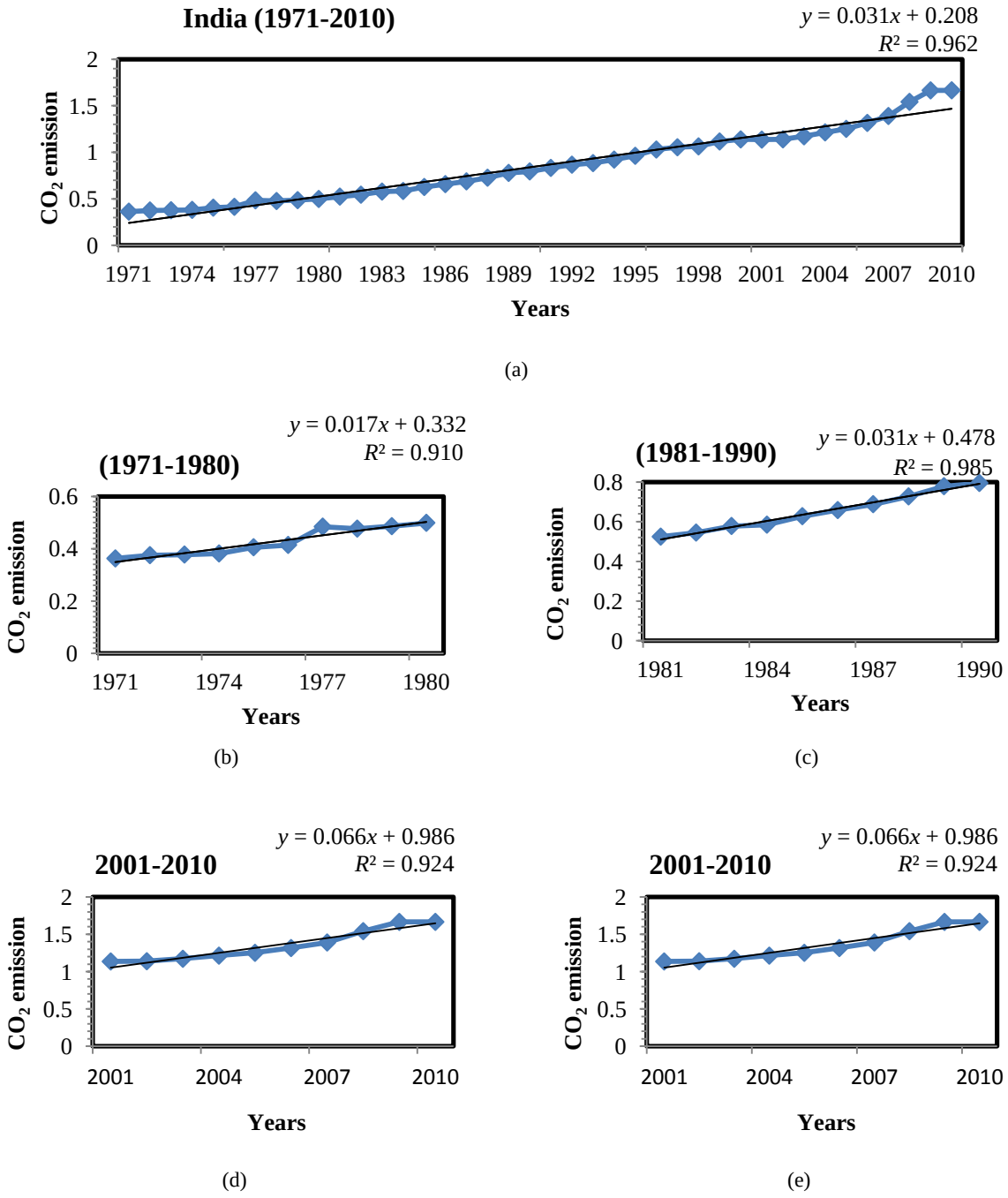
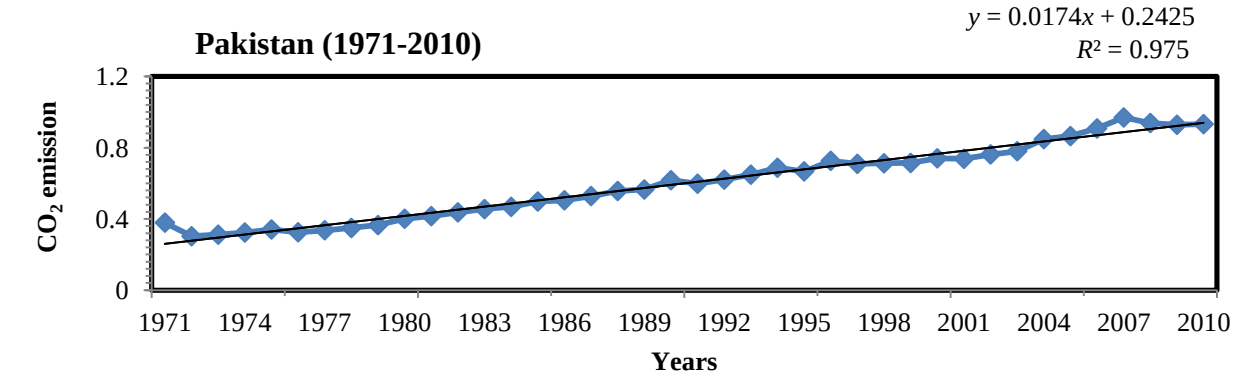


Fig. 2: Variation of CO_2emission (in metric ton per capita) over India for the period (a) 1971-2010; (b) 1971-1980; (c) 1981-1990 (d) 1991-2000 ; (e) 2001-2010.



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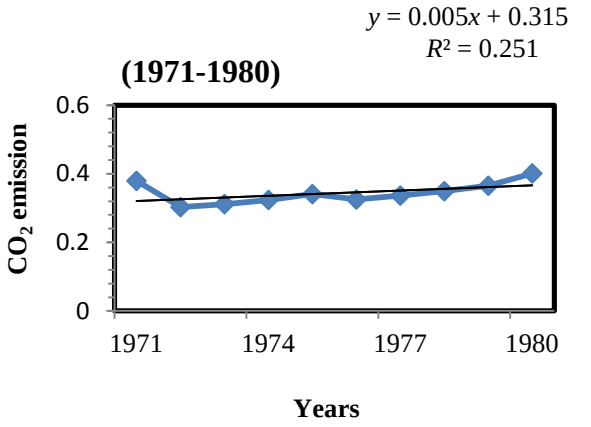

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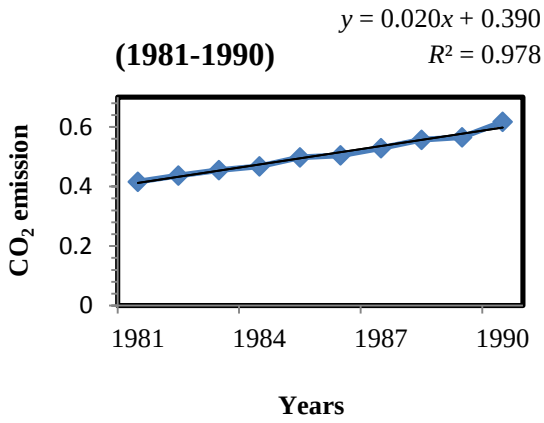

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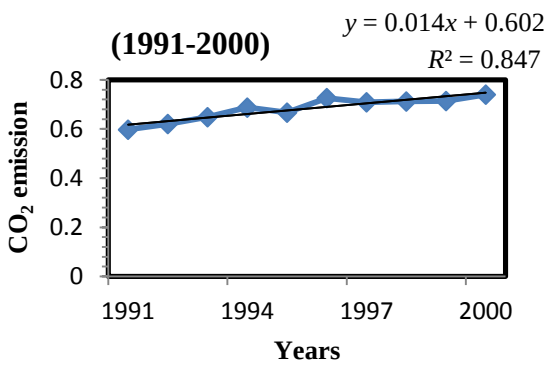

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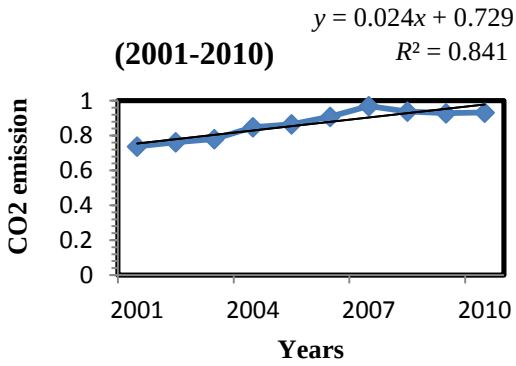
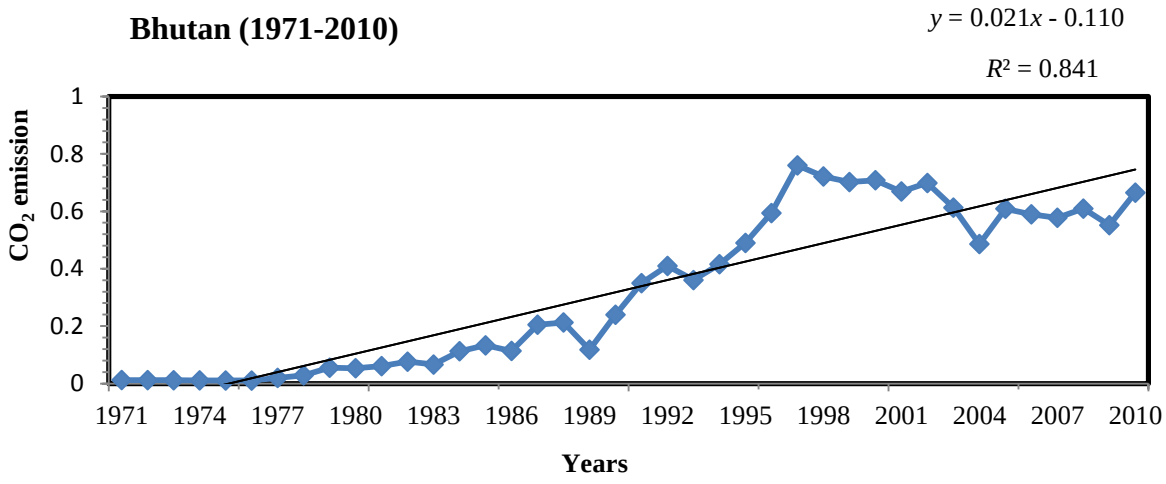


(e)

Fig 3: Variation of CO_2emission (in metric ton per capita) over Pakistan for (a) 1971-2010; (b) 1971-1980; (c) 1981-1990; (d) 1991-2000 ; (e) 2001-2010.



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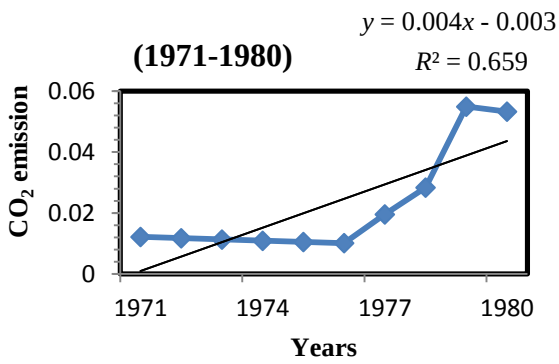

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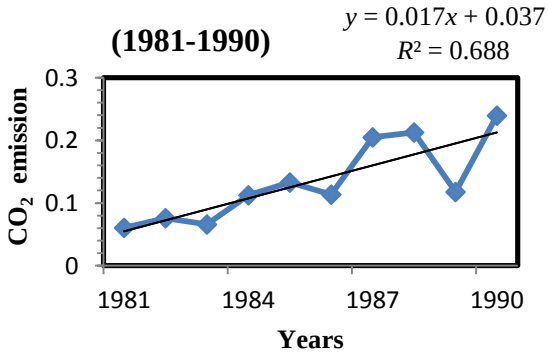
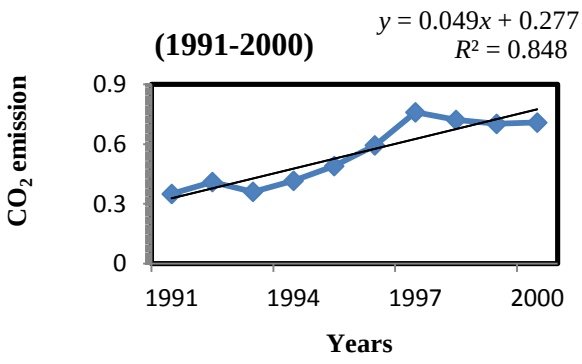
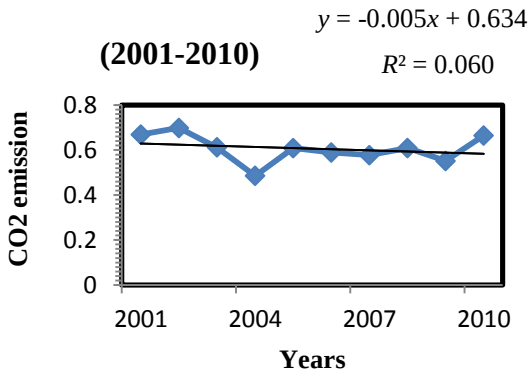


(c)

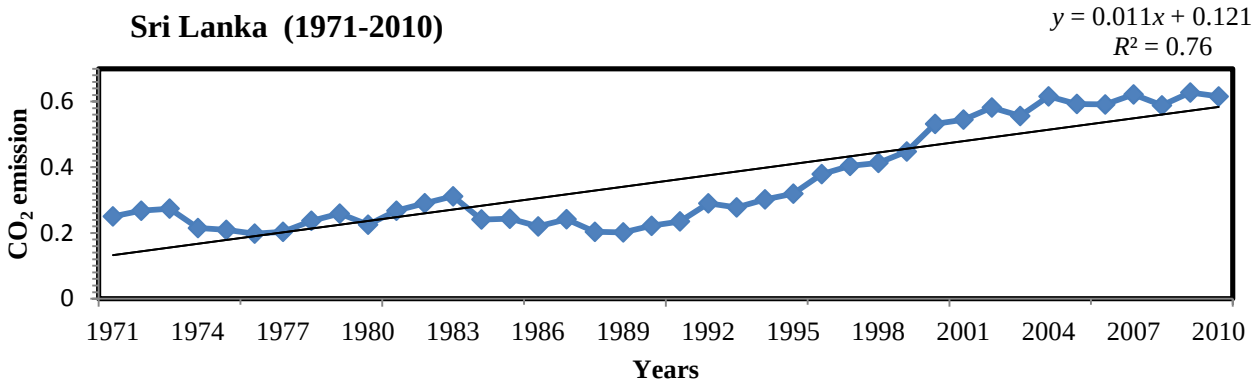


(d)

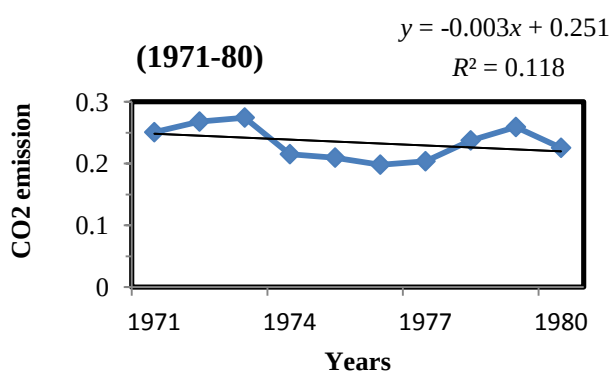


(e)

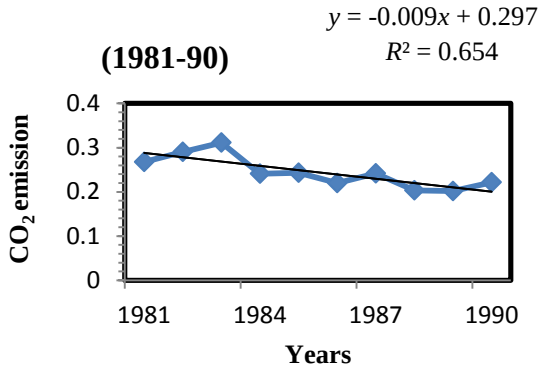
Fig 4: Variation of CO_2 emission(in metric ton per capita) over Bhutan for (a) 1971-2010; (b) 1971-1980; (c) 1981-1990; (d) 1991-2000 ; (e) 2001-2010.



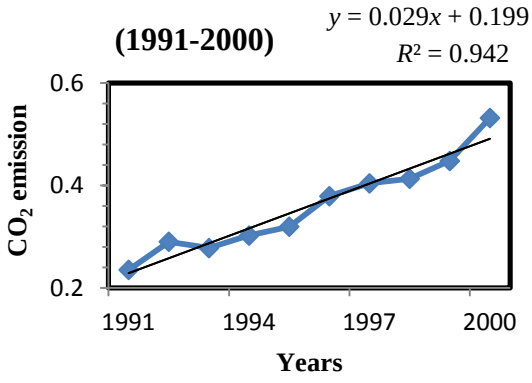
(a)



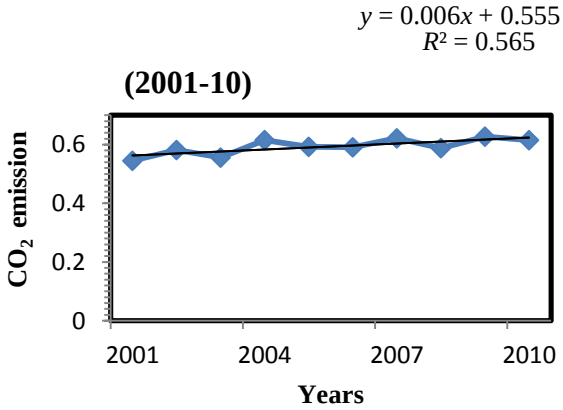
(b)



(c)

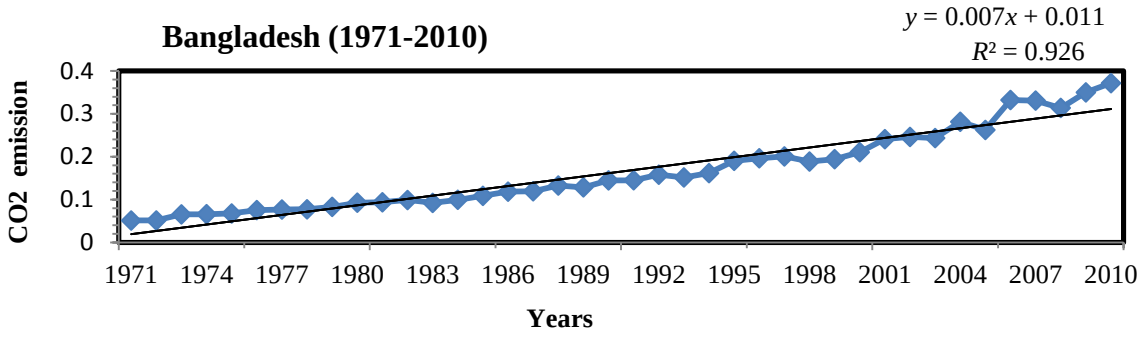


(d)

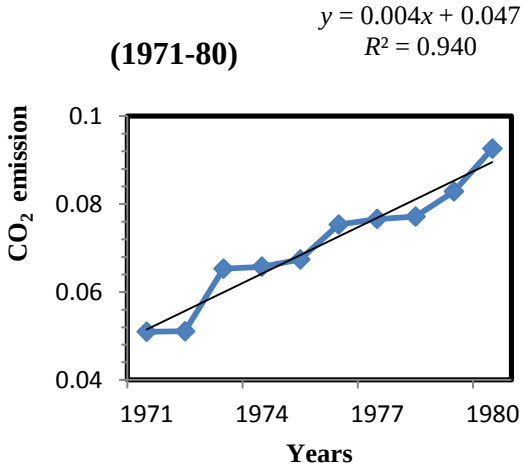


(e)

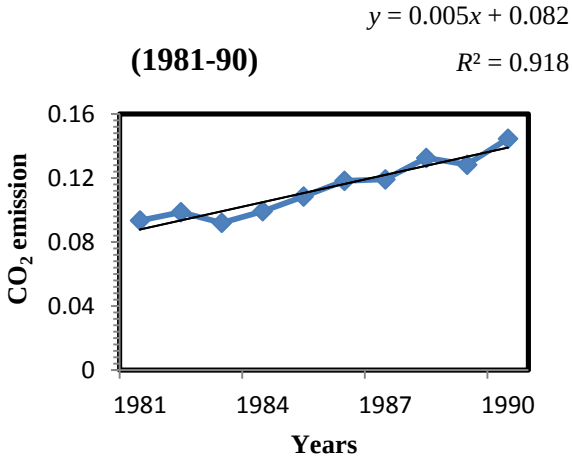
Fig 5: Variation of CO_2emission (in metric ton per capita) over Sri Lanka for the period (a) 1971-2010; (b) 1971-1980; (c) 1981-1990; (d) 1991-2000 ; (e) 2001-2010.



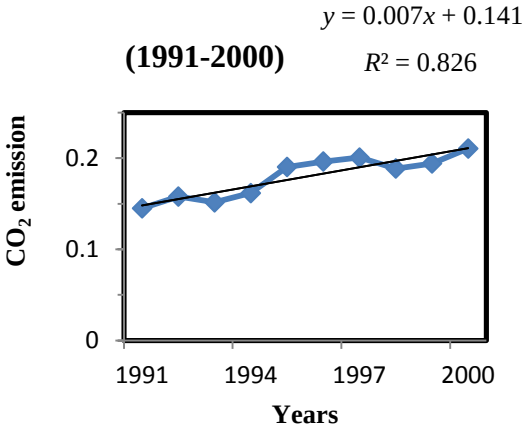
(a)



(b)



(c)



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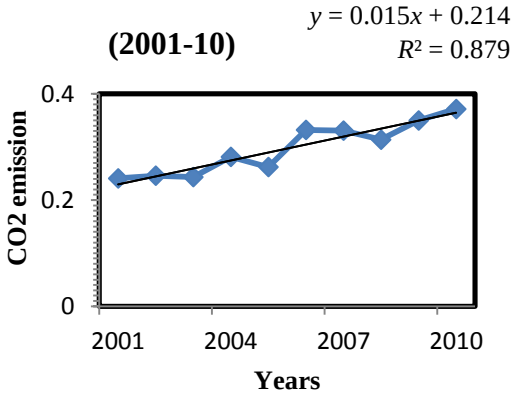

(e)

Fig 6: Variation of CO_2emission (in metric ton per capita) over Bangladesh for (a) 1971-2010; (b) 1971-80; (c) 1981-90; (d) 1991-2000 ; (e) 2001-10.

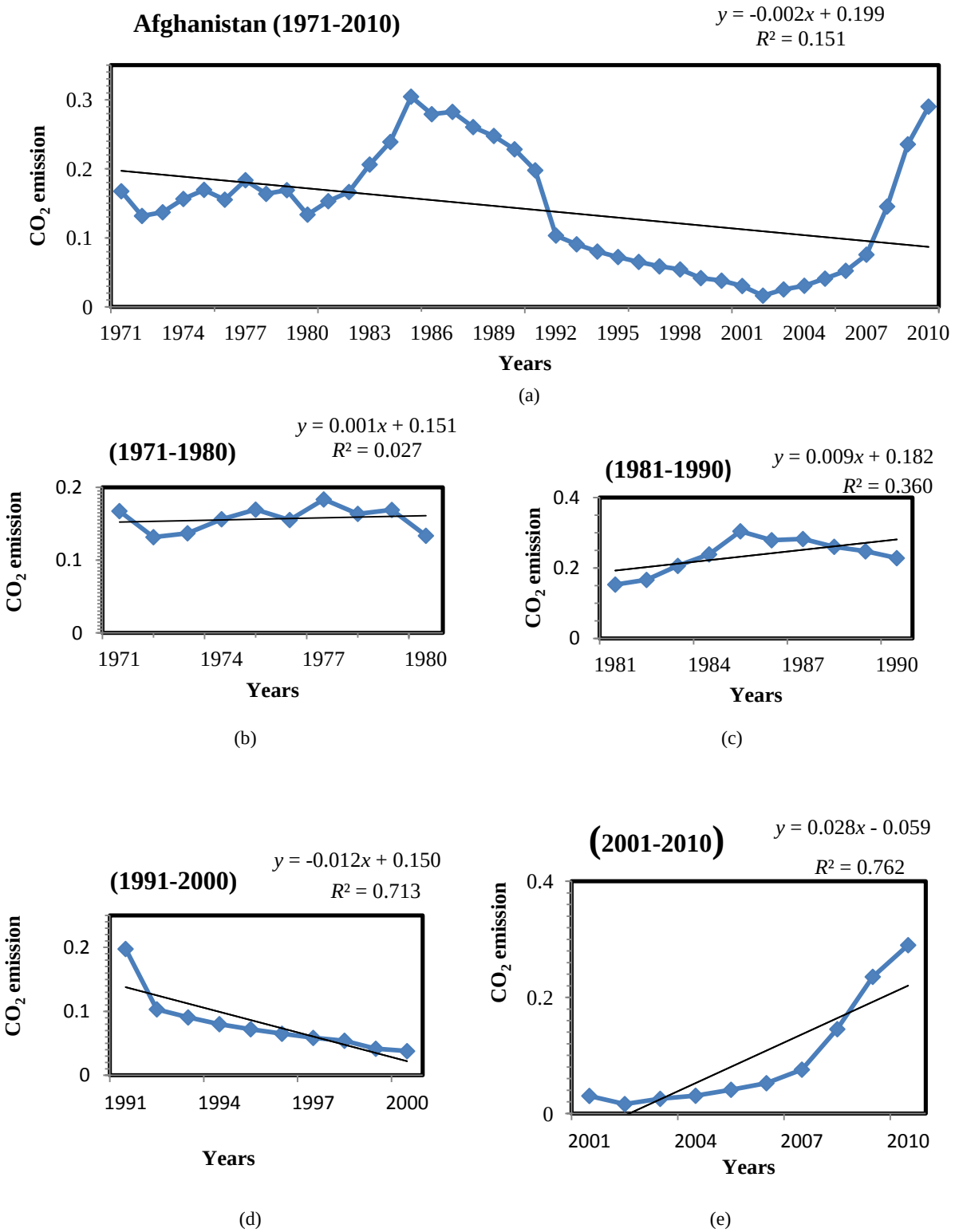

Fig 7: Variation of CO_2emission (in metric ton per capita) over Afghanistan for (a) 1971-2010; (b) 1971-1980; (c) 1981- 1990; (d) 1991-2000 ; (e) 2001-2010.

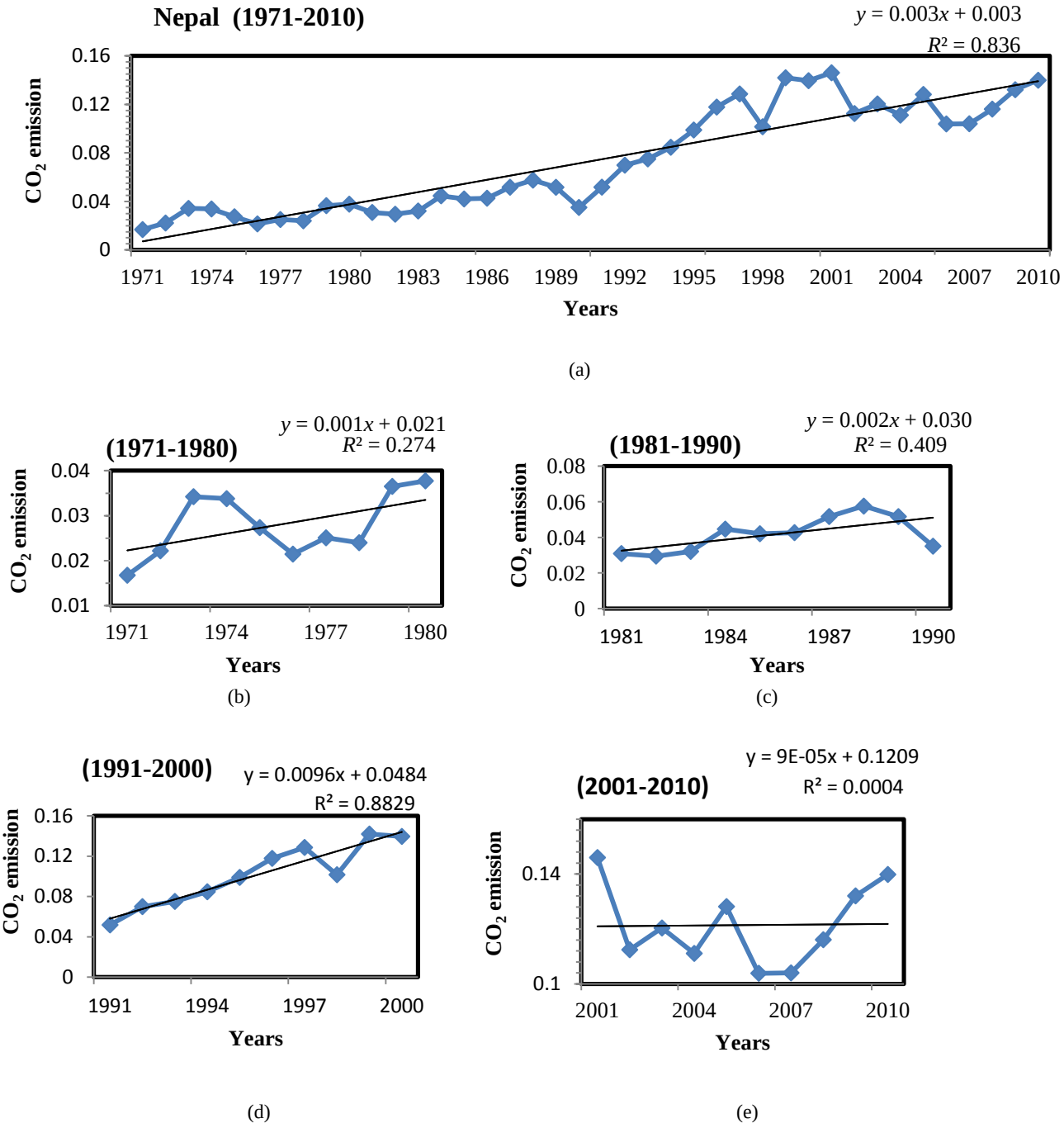

Fig 8: Variation of CO_2emission (in metric ton per capita) over Nepal for (a) 1971-2010; (b) 1971-1980; (c) 1981-1990 ; (d) 1991-2000 ; (e) 2001-2010.

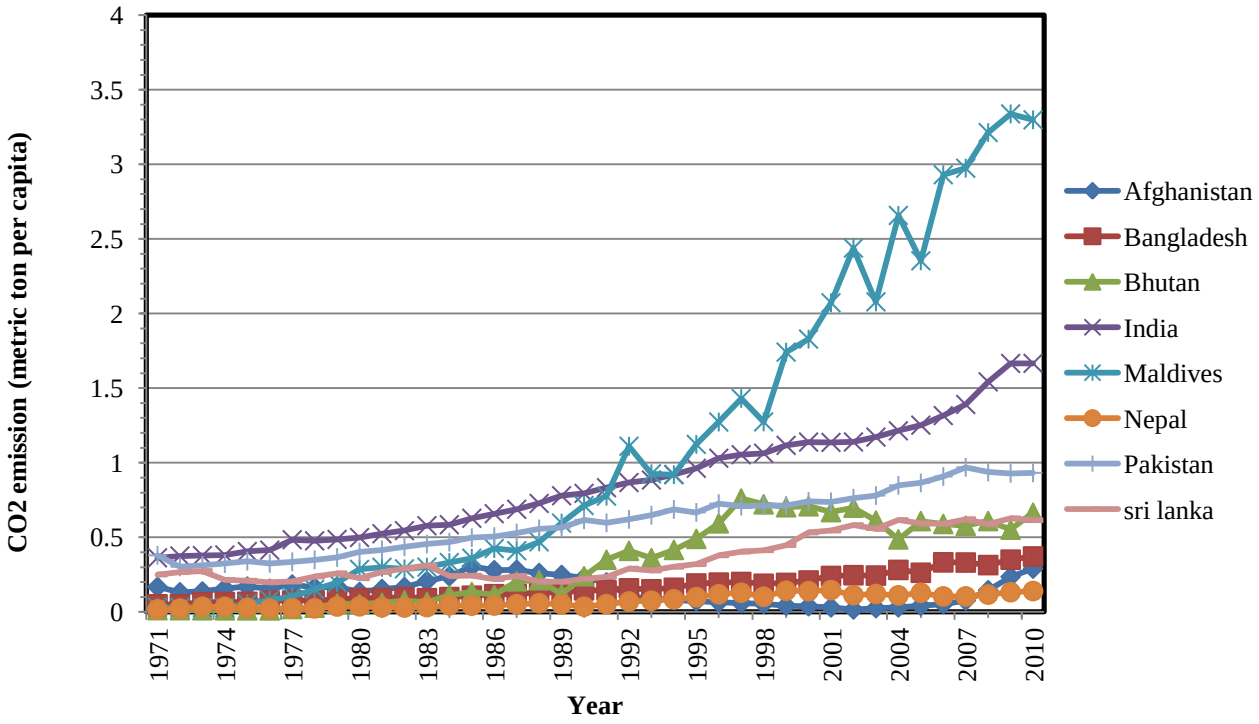

Fig 9: Variation of CO2 emission (in metric tons per capita) over SAARC countries