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Review Article

Climate Change and it's Impacts on Water Availability in Rivers and Crop Productivity

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Abstract

Climate change has two parts, namely natural rhythmic variations, which are beyond human control and thus needs to adapt to them; and human induced trends. The two primary climate parameters that play vital role in agriculture and river water availability are temperature and rainfall. Temperature presents both trend and natural rhythmic variations but they are insignificant when compared to annual and seasonal variations wherein agriculture/crop is adapted to them. Rainfall presents natural rhythmic variations. The rhythmic patterns are not the same at national, regional and local scales. However, there is a danger of using truncated data set of such rhythmic variation data series, which may show fictitious trend. Sometimes these are modified by climate systems like the presence of Western Ghats that helped creation of wet and dry zones on wind-ward and lee-ward sides respectively; and general circulation patterns like heat and cold waves associated with Western Disturbances. The water availability in Indian rivers showed a relationship with the rhythmic variations in rainfall. Moisture is the limiting factor for crop growth in tropical warm regions wherein most of the developing countries are located. Here temperature is not a limiting factor. The crops are adapted to them through available effective growing period in terms of moist period. In extra-tropical regions it relates to available warm period – cumulative degree days within that period – that basically relates to withdrawal and onset of winter season. In view of these variations, the average crops production at global scale or at national scale, the technology based trend dominates and masque the climate change trend by sowing small ups and downs. The climate change components are clearly seen only at local and regional scales wherein moist period is the limiting factor. In extra-tropical regions, crop production clearly reflects the climate factor.

Keywords: Water Availability; Climate Change; Macro and Micro Levels; Rhythmic Variation; River Water; Dry-Land Agriculture; Krishna River; Godavari River

Abbreviations

AP: Andhra Pradesh; CO_2: Carbon Dioxide; CWC: Central Water Commission; IITM: Indian Institute of Tropical Meteorology; GM(O): Genetically Modified (Organisms); IMD: India Meteorological Department; Mha: Million Hectares; NEM: Northeast Monsoon; SWM: Southwest Monsoon; WMO: World Meteorological Organization of United Nations; IPCC: Intergovernmental Panel on Climate Change; UNFCCC: United Nations Framework Convention on Climate Change.

Introduction

Background

"Dr. Jeevananda Reddy – writes Droughts, floods, heat and cold waves will keep threatening India. We cannot expect the Paris Agreement to solve the crisis associated with these extreme weather events. The way was to minimize their impact is through the mechanism in which they occur by quantifying the agro-climate of the region" – Ecologise.in, 6th June 2016; "Precautionary measure for natural calamities: A letter to the Prime Minister" – such analysis was carried out for few countries and the summary was published [1,2].

Literature Review

The traditional agriculture was soil and climate driven farming systems that encompasses the animal husbandry [3]. It provided socio-economic, food and nutrient security with the healthy food. Those were the "Golden Days" in the history of farming. Traditionally farmers adapted to this based on their forefathers hundreds of years of experiences. To achieve food security, we need sustainable agriculture system under variable soil and climate conditions wherein the soil is static and the climate is dynamic [1,2]. Climate is beyond human control and thus needs to adapt to it. Climate is always changing through the natural cycles. What we are experiencing now is part of this system only. Floods and droughts are part of this system only and thus water availability in rivers. The two main climatic parameters that play vital role in agriculture are temperature and precipitation. Temperature presents high seasonal and annual variations (Table 1). Agriculture was/is adapted to such variations in temperatures. However, in the last two decades groups are polluting agriculture research under the disguise of global warming, a component of climate change [4].

Month	Temperature (°C)						
	Tw	Tmax	Tmin	Thm	Tlm	Th	Tl
Highest	23.7	38.7	26.2	42.4	22.5	44.4	19.4
Lowest	17.2	27.8	13.4	30.6	09.9	33.3	06.1
Range	06.5	10.9	12.8	11.8	12.6	11.1	13.3

Table 1: Hyderabad Temperature Extremes

Tw = mean afternoon wet bulb, Tmax = mean maximum, Tmin = mean minimum, Thm = highest mean, Tlm = lowest mean, Th = highest in a day, Tl = lowest in a day.

Rainfall presents natural rhythmic variations. The rhythmic patterns are not the same at national, regional and local scales. However, there is a danger of using truncated data set of such rhythmic variation data series, which may show fictitious trend. Sometimes these are modified by climate systems [4] like the presence of Western Ghats that helped creation of wet and dry zones on wind-ward and lee-ward sides respectively; and general circulation patterns like heat and cold waves associated with Western Disturbances [5].

Problem statement

There are two important issues, namely (1) climate and weather may not be the same over a region or over a country, for example during 2009 India faced drought at all India level with 79% of the average rainfall and with this temperature has raised by 0.9oC. However, Krishna River received severe floods causing major damage to people and to property; (2) Researchers use truncated data set from a rhythmic variation data series, as it is easy to handle. This might lead to misleading inferences. Here the researchers are least bothered on the issue of climate change but use this word as an adjective to get hype to their study. These issues are discussed in this review with reference to rainfall versus river flows. In this context discussed in brief temperature and presented rhythmic variations in rainfall at national (India), state (Andhra Pradesh) and station (Kurnool) scales; and also discussed the agriculture issue as a function of climate change and technology aspects.

Climate change and it's impacts

Methodology

Agriculture point of view the two climate parameters that play vital role are temperature and rainfall which are part of climate change. Climate change consists of (a) Natural or rhythmic variations and (b) Human induced trend [6]. WMO presented methods to separate them [6], one such method is "Moving Average Technique". Figure 1(a) presents the annual march of onset dates of southwest monsoon [SWM] over Kerala along with 10-year moving average [7]. This suggested 52 year cyclic pattern in terms of early and late start of SWM. Figure 1(b) presents the annual march of global average annual temperature anomaly along with 10-, 30- and 60 year moving averages. The 60-year moving average showed the trend. This suggests presence of a 60 year cyclic pattern [8].

Figure 1: Annual march and moving averages of (a) onset dates over Kerala and (b) global annual average temperature anomaly.

Data collection

The data involved in this review includes climate data in terms of temperature and rainfall, river water availability data and crop data. Some of the data was collected and used in the past four decades and included in several publications/books. The following is some specific data that the author used [mostly published in earlier reports/books]:

In the case of global temperature anomaly, several groups created their own data sets with their own adjustments-manipulations. The author selected WMO data series and few other sources as refereed in the text. The author used Indian rainfall data for 1871 to 1994, from a book published by IITM/Pune [monthly, seasonal and annual for individual years for all met sub-divisions in India] and the rainfall data supplied by IMD at 0.25 x 0.25 degrees grid to CWC for the estimation of water availability in Indian rivers for the period 1985-86 to 2014-15.

The river water availability data for Krishna and Godavari Rivers the author used the data from Bachawat Tribunal Award on Krishna River [KWDT-I] and Godavari River, and Brijesh kumar Tribunal Award on Krishna River [KWDT-II]. Crop data either collected by the author from the published government reports or some from internet [the author herewith express sincere thanks to those authors].

Results

Climate change

Trend and Natural variation in temperature

Figure 2 presents the natural variability and trend in global annual average temperature anomaly of 1880 to 2010. This is not raw data but it is an adjusted data [9]. From the figure it is seen that the natural variability followed 60-year cycle and the sine curve varied between - 0.3 and + 0.3°C. Linear Trend is 0.6°C per century. According to IPCC [5] (i) more than half is associated with greenhouse effect; and (ii) less than half is due to non-greenhouse effect [changes in land use and land cover]. Greenhouse effect component consists of global warming and others; if we assume global warming itself is 50%; then global warming is 0.3oC per century. According to IPCC, the starting year of global warming is 1951. Thus the global warming from 1951 to 2100 is 0.45°C under linear trend.

However, from IPCC reports it is clear that "climate sensitivity factor" is gradually coming down -- 1.95 in AR4 and 1.55 in AR5 – and thus it can be said that the trend may not be linear but it must be curvilinear/non-linear and therefore global warming is insignificant. This is corroborated by the fact that the energy emitted by the Sun is constant under the natural variability {follows the Sunspot cycle (global solar radiation and net radiation follows: 10.5±0.5 years cycle and its multiples) [10]}.

Figure 2: Global yearly mean temperature anomaly patterns (Observed and Predicted).

Figure 3 presents the Sydney's [in Australia] hottest daily maximum temperature annual march during 1896 to 2016. This shows that there is practically zero trend. Carbon Dioxide [CO_2] increases linearly with increasing population. However, CO_2 is lower in the Southern Hemisphere over that of Northern

Figure 3: Annual march of Sydney maximum temperature.

Hemisphere. This is also true with the temperature. That means global warming is not global in nature.

Trend and natural variations in rainfall

Moisture is the limiting factor for crop growth in tropical warm regions wherein most of the developing countries are located. Moisture availability varies with the climate change expressed by the natural variability in rainfall and snowfall. In rainfall there is no trend except abrupt shifts due to modifications in the local terrain/land use [1,2]. All over the world, rainfall presents clear cut rhythmic variations [1,2]. However, they present variations at national, regional and local scales.

Recently [11] a report "NASA Study: Human Influence on Global Droughts Goes back 100 years, May 3, 2019, by Jessica Murzdorf, NASA Goddard Space Flight [GISS] in New York" states that human generated greenhouse gases and atmospheric particles were affecting global drought risk as back as the early 20th century. This is a false theory [12]. Recently both national and international media made big hue and cry on Sofala-Beira cyclone in Mozambique and Cape Town drought in South Africa and Brazil drought. Even the Secretary General of WMO made such statements attributing to global warming. The author sent mail to him referring to his book of 1993 [1] that is available in WMO Library. Durban in South Africa presented 66 year cycle and 22 years cycles; and Beira in Mozambique presented 54 year cycle and 18 years cycles. The integrated predictive patterns were presented in a book of 1986 submitted to Mozambique government [12]. They presented W and M patterns. According to this, 2012-22 in Beira is wet period with mean rainfall of >1480 mm and 2010-23 in Durban is a dry period with mean rainfall <1050 mm [1,2].

Indian rainfall

Figure 4 presents the annual march of all-India annual rainfall [June to May] from 1871-72 to 2014-15 [13]. Vertical lines represent observed rainfall relative to the mean and the predicted pattern is represented by dotted line. It presents a 60-year cycle. Two cycles have been completed and above the average 30-year part of third cycle has been completed. Now, India is in below the average 30-year part of the third cycle.

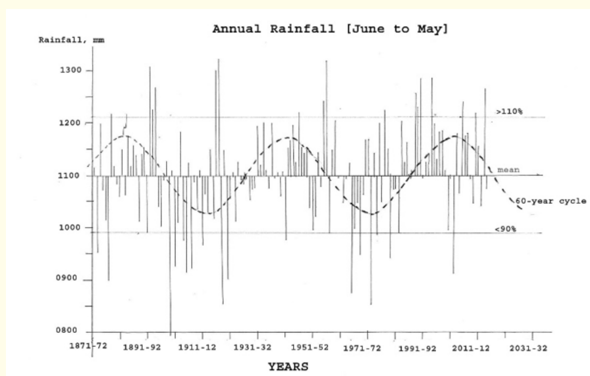

Figure 4: Annual march of all India Annual Rainfall. [Observed, vertical lines and Predicted, dotted curve].

AP State rainfall

AP is divided in to three met sub-divisions, namely Coastal Andhra, Rayalaseema and Telangana. The analysis of AP's three met subvisions rainfall data series [14] showed 56 years cycle in the SWM rainfall. The same was observed in the NEM rainfall but it is in opposite direction to SWM cycle. Figure 5 presents the annual rainfall march of Coastal Andhra met sub-divisional rainfall for SWM and NEM along with 56-year cyclic pattern [dotted pattern]. The cyclonic activity in the Bay of Bengal followed the 56 year cycle of SWM rainfall pattern (Table 2). In this table presented % years with rainfall < 90% of the averages for the three met sub-divisions under both SWM and NEM. Also presented the number of cyclones observed in Bay of Bengal during those periods of above and below the average 28 year periods [only in two cases they are less than 28 years]. More than 10 cyclones per year were observed in above the average period and less than 10 cyclones during below the average periods. That means the main driving force for good rainfall is the occurrence of cyclones during SWM.

Memoirs published a figure (Figure 7) presenting the scenario of severe drought during 1876-78 in Bangalore. This can be seen from Figure 6a, wherein during 1878 received less than 50% of average rainfall and also the previous few years received less than average rainfall. Since 2001below the average part of 66 years started. This will be similar to 66 years prior to 1935 wherein around 24 years presented drought years.

Period	Rainfall [% years with < 90% of average] SWM			NEM			Cyclones in Bay of Bengal [May to November]$ number
	CA	R	T	CA	R	T	
1861-1888*	72	61	72	33	28	66	<10
1889-1916	53	43	46	60	71	71	>10
1917-1944	75	78	68	46	50	60	<10
1945-1972	43	43	32	64	60	46	>10 [10-16]
1973-2000**	54	54	54	41	45	41	<10 [0-8]
2001-2027							>10

Table 2: SWM and NEM and Cyclonic activity in Bay of Bengal Statistics.

*1871-1888; ** 1973-1994, average cyclones 10; SWM = southwest monsoon; NEM = northeast monsoon; CA = Coastal Andhra, R = Rayalaseema, and T = Telangana met sub-divisions.

$: Joint Typhoon Warning Centre – Bay of Bengal Region Cyclones per year during 1945-2000 (May-November) – Reddy [11] page. 160.

Figure 5: Coastal Andhra rainfall of SWM and NEM [Observed and Predicted].

Figure 6: (a) Annual Rainfall of AP and (b) Annual Water Availability in Krishna River.

Figure 7: 1876-78 severe drought impacts on Bangalore.

Kurnool rainfall

Figure 8 presents the annual march of available effective rainy period (G) for Kurnool in the state of AP [1,2]. It followed the 56 year cyclic pattern of SWM rainfall. In this figure the vertical lines present length with respect to the average and the dotted curve presents 56 year cyclic pattern. The average drought proneness showed 45% of the years with 30% and 70% respectively during above and below the average 26 year periods. The average drought proneness in percent years was estimated for semi-arid tropical India. This is shown in Figure 9a. The zones were divided at 5% interval. Using the same method [1,2] drought proneness map for Maharashtra was presented [15] in Figure 9b. These figures clearly show the impact of Western Ghats on rainfall [leeward side dry condition and windward side wet conditions]. Though the authors claimed [16] that the index In Figure 9c includes climate change but it appears that they have only used the word climate change as an adjective. This figure showed the maximum drought proneness is around 25% of the years and that too around Gujarat. This is unrealistic.

Figure 8: Annual march of agroclimatic variables: G and S.

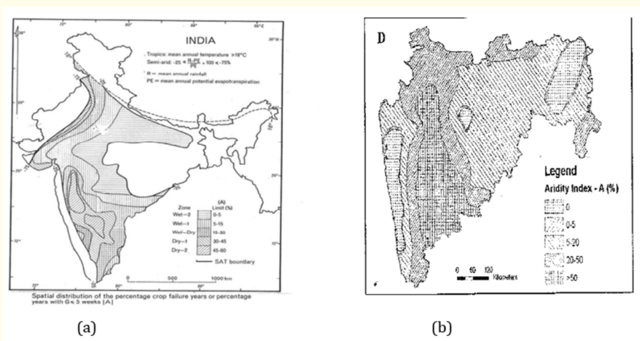

Figure 9: Drought Risk (a) India, (b) Maharashtra and (c) India by Rao., *et al.* (2013).

Figure 10: Annual march of annual Water Availability in Godavari River. [Observed, vertical lines and Predicted, dotted curve].

If the data series follow the natural variability:
Bachawat Tribunal used the data [60-year cycle]: 1881 to 1946 [one year missing]
Mean of the data series = 3978 tmc ft
Mean of above the average 30 year period = 4271 tmc ft
Mean of below the average 30 year period = 3614 tmc ft
The impact of data selection: 4271 - 3614 = 657 tmc ft

Table 3: The Impact of "data set & method used" on the Water Availability Estimates Godavari River.
Note: CWC used above the average 30 year period for the estimation of water availability in Indian Rivers.

Climate change impacts

Impacts on water availability in rivers

It is common to researchers and planners use truncated data set with Natural Variability series. This type of selection leads to misleading conclusions or lead to biased inferences. Let us see four segments in Figure 4 – all India annual rainfall:

Bachawat Tribunal Award on Godavari River used 1880 to 1946 [with one year data missing] annual water availability. This data series followed the pattern of 60-year cycle (Figure 10) as seen in Figure 4. The difference between the means of 30 year below and above the average periods is 650 tmc ft (Table 3).

With reference to a question raised in the Parliament, IMD/IITM scientists prepared a report and submitted to the concerned minister, who in turn informed the parliament that the Indian rainfall is decreasing. Here they used the data set of 1930 to 1990 – if they would have used the data set of 1960 or 1900 onwards, it would have shown increasing trend. This is a fallacy of random selection truncated data set in a rhythmic data series.

Table 4 presents the frequency of occurrence of high magnitude floods in few northwest Indian Rivers (Chenab, Ravi and Beas). It shows that during the below the average period the frequency is around one in ten years; and during above the average period it is around one in three years [Figure 4].

CWC used the data of high annual rainfall period 30 years 1985-86 to 2014-15 and estimated annual water availability in Indian rivers. This over estimates as they used the above the average part of the cycle (Figure 4) similar to Table 3. In addition the method adapted in the runoff estimation overestimates the water availability (Table 5).

Figure 6b presents the annual march of water availability in Krishna River with reference to mean. The water availability in Krishna River followed the AP annual rainfall pattern Figure 6a]. Before 1935, the 66 years part is below the average in which 24 years were drought years and 12 years were flood years; and from 1935 to 2000, the 66 years part is above the average in which 12 years were drought years and 24 years were flood years. From

Frequency of high magnitude floods*			
River	Period	Frequency	Climatic cycle
Chenab	1962-1990	1 in 9 years	(a) below the average cycle
	1990-1998	1 in 3 years	(b) above the average cycle
Ravi	1963-1990	1 in 14 years	(a)
	1990-1998	1 in 3 years	(b)
Beas	1941-1990	1 in 8 years	(a)
	1990-1995	1 in 2 years	(b)

Table 4: Frequency of occurrence of high magnitude floods in few northwest Indian Rivers.

Note: around one in three years during above the average 30 year period; and around one in ten years in below the average 30 year period.

*State of Environment Report, India – 2009, MoEF/GoI: The frequency of floods in India is largely due to deforestation in the catchment area, destruction of surface vegetation, changes in land use, increased urbanization and other developmental activities – this is a false statement but it is more in association of cyclic variation in rainfall.

If the data series follow the natural variability				
S. No.	Method	Data Period	years	Water Availability (tmc ft)
1	KWDT-I	1894-95 to 1971-72	78	2393
	Distribution: negatively Skewed, mean at 43% probability			
2	KWDT-II	1961-62 to 2007-08	47	2578
	Distribution: positively skewed, mean at 58% probability			
	Part of 47 years	1981-82 to 2006-07	26	2400
	Distribution: normal, mean at 50% probability			
	Fictitious data	1981-82 to 2006-07	26	3088
	Distribution: available at less than 25% probability			
3	CWC	1985-86 to 2014-15	30	3188
	Distribution: normal, mean at 50% probability			
4	sjreddy	1894-95 to 2007-08	114	2443
	Distribution: normal, mean at 48% probability			
	Impact of method: 3188 – 2443 = 745 tmc ft			

Table 5: The Impact of "data set & method used" on the Water Availability Estimates in Krishna River.

2001, below the average part of 66 years started and so far majority of the years [including the last three years] presented deficit rainfall [2002 and 2009 were drought years at all India level and showed a temperature raise of 0.7°C and 0.9°C, respectively]. Water reached Srisailam dam during 2009-10 to 2018-19 in tmc ft are: 1222, 1028, 736, 197, 848, 614, 59, 345, 489, and 562 – similar to 2009 [all-India level this was a drought year], after ten years gap in 2019 dams were full with water. Table 5 presents the impact of selected methods and data sets on the mean water availability estimates in Krishna River.

Impacts on crop productivity

The traditional agriculture was soil and climate driven farming systems that encompasses the animal husbandry [3]. Traditionally farmers adapted to this based on their forefathers hundreds of years of experiences. The traditional system of agriculture is clouded by the chemical inputs-mono crop-GM seeds agricultural technologies after 1960s, mostly under irrigation. The input costs increased multi-fold and introduced a new system of drought, known as "technology drought". This introduced farmers' suicides.

For agriculture planning in real time, we need to study the time variation in rainfall and agro-climatic parameters [1]. Figure 9 presents one such an example for Kurnool in AP state. S and G in the figure refer to week of commencement time of planting rains and G is the available effective rainy period from S. This figure presents the pattern of 56-year cycle in which the drought risk is 45% of the years on an average. During below the average 28 year period, drought risk is 70% and during above the average 28 year period it is 30%. Figure 10(a) presents the average drought risk in the semi-arid tropical India and Figure 10b presents the same for Maharashtra [15] estimated using the same procedure. This clearly shows the impact of climate system [5] – here it is Western Ghats – on rainfall and thus on drought proneness. This is not seen in Figure 10c [16] estimated based on elaborate study on "Vulnerability of Indian Agriculture to climate Change". The study used climate change as an adjective only. This figure showed except coastal Gujarat, all parts of India present drought < 25%, which is unrealistic.

Figure 11 presents the temperature impact on agriculture. Figure 11(a) presents the crop progress/phenology stages and condition for corn in Indiana (USA) in terms of withdrawal and onset of winter season. This indirectly defines the period conducive for crop growth or effective growing period in which production temperature impacts the productivity. This indirectly refers to change in heat units or degree days during the growing season – models have been developed to link degree days to crop production/phenology stages [1,2]. Figure 11(b) Presents Yield per hectare versus El Nino events in India. No systematic impact is evident on crop yield with changing El Nino temperature rise or fall. El Nino and La Nina are part of Southern Oscillation that has certain relationship with Indian Monsoon. Generally it is said that El Nino means warmer conditions with poor rainfall and La Nina means colder conditions with good rainfall. In the figure 1, 2 and 3 refer to El Nino intensity condition. This is basically because that the weather conditions in space and time are highly variable as we have seen in the above section plus changes in area under irrigation and the yield refers to average of all these conditions.

Figure 11a and 11b: Temperature impact on agriculture.

Figure 12a and 12b: Technology impact on Indian agriculture.

Figure 12 presents the impact of technology on area under different crops and crop yields – the author present these at different seminars and conferences and presented a compilation of these in a book form "Agriculture and Environment: Few Thoughts" in AP, (2007), 112p. Figure 12(a) Presents the impact of technology on area under different crops in AP. Under traditional farming system based technology with crops/cropping system was replaced by mono crop system under high input costs plus government input subsidies plus irrigation and at the same time causing air and water pollution. The areas under traditional cropping systems have come down drastically, like sorghum [pearl millet followed sorghum]. The crops grown under chemical inputs-irrigation increased. Figure 12(b) presents the impact of chemical fertilizer on yield in AP. Rice yield followed the chemical fertilizer use (top two curves) with the time but other crops under traditional agriculture did not show this. Under the traditional paddy cultivation the yield on an average was 1300 kg/ha. This rose to 1800 kg/ha by replacing traditional seed with improved high yielding seed; and this further rose to 3800 kg/ha by replacing the traditional fertilizer with chemical fertilizer [17]. However, they are highly variable with country to country period to period. Let us see these:

In 2008-09 the yield (kg/ha)/area under paddy (Mha) in WB was 2533/5.94, in AP 3246/4.39, in UP 2171/6.03, Odisha 1529/4.45, Punjab 4022/2.74 and Assam 1614/2.48. At all India level they were 829.9/31.37 during 1950-60, 998.9/35.85 during 1960-70, 1156.4/38.63 during 1970-80, 1467.1/40.65, during 1980-90, 1852.0/43.21 during 1990-2000 and 2052.8/43.40 during 2000-10. The same [yield (tons/ha)/area (Mha)] 6.61/29.2 in China, 3.37/43.91 in India, 4.88/11.85 in Indonesia, 4.01/11.60 in Bangladesh, 4.88/7.35 in Vietnam, 2.75/10.68 in Thailand, 2.61/6.70 in Myanmar, 3.82/4.40 in Philippines, 4.45/2.92 in Brazil and 6.78/1.63 in Japan. In 1951-52, fertilizer use in India averaged less than one kg per hectare, which has now gone up to 133 kg/ha. According to World Bank data, per hectare fertilizer consumption in India, China, Japan, Bangladesh, Pakistan and Israel in 2007 stood at 142.3, 331.1, 171.2, 166.2 and 524 kg/ha, respectively. However, still Niger uses only 0.4 kg/ha and Canada 87.6 kg/ha. According to World Bank data, per hectare fertilizer consumption in India, China, Japan, Bangladesh, Pakistan and Israel in 2007 stood at 142.3, 331.1, 171.2, 166.2 and 524 kg/ha, respectively [3].

Figure 13 (a and b) presents crop production under global scenario. Figure 13(a) presents the soybean production in top five countries (1965-2013). They are more in association with seeds used under soil and climate conditions existing over those countries in addition to fertilizer use, which varies with country to country crop to crop. However, the weather related variations are clearly seen in the later part. Figure 13(b) presents the world corn, wheat, and rice production (1960-2011) with smaller fluctuations as the yield refers to average weather conditions over the globe with high yield variations, fertilizer use variations, variation in seeds, etc.

Figure 13a and 13b: Technology Impact on global agriculture.

Figure 14 presents the IPCC projection on food, water, etc. with reference to raise in global warming temperature. Figure 15 (a and b) presents the crop production in India and in USA in terms of inputs and outputs. Figure 15 (a) presents the total food grains production closely follows the fertilizer use plus irrigated area. Figure 15 (b) presents the USA Corn – Inputs and Outputs. Also shown is the baseline yield referenced to 1981 (6.2 t/ha). The stacked bar on the far right side shows the total contribution, as of 2017, from each of these components and the associated 95% CIs.. The yield data showed high variation, it is primarily related to "degrees days" availability in effective available growing period.

Population versus CO_2

On August 7, 2019 IPCC released a summary report on "Climate Change: Land". On this the author submitted observations [18]. In this report IPCC tried to tell the people that the greenhouse gases are the primary cause for global warming and thus its impact on the nature. Since 1950 the population is growing non-linearly (Figure 16) – though it is said that the year 1921 is considered as the

Figure 14: IPCC projections on the impact of global warming on food, water, etc.

(a)

(b)

Figure 15: Agriculture inputs and outputs in (a) India and (b) USA.

"year of Great Divide" that started the rapid increase in population -- and thus by 2050 it is expected to reach 9.0 billion. The author in his comments proposed bringing down the population growth curve to reduce CO_2, a gas dominating the greenhouse gases after industrialization in the atmosphere. Figure 17 presents the linear relationship between CO_2 and Population. To achieve this goal all UN agencies, warmists groups, NGOs who are harping on global warming should come up with a solution. This will help in several other ways in protecting the environment. Also, they must come up with a solution to overcome the urban heat-island-factor also. Figure 18 presents the world electricity production by type. This clearly demonstrates the fact that the dominating role played by fossil fuel in the global electricity production. This also brings out the fact that the only viable solution is to bring down CO_2 through the control of population growth. However, Bill Gates backs plan to tackle climate change by blocking out the Sun. The Harvard Researchers have claimed that, it would cost $3.5 billion + 2.25 billion per year. This will have more negative impacts over the global warming (if any) itself. This is clearly evident from the urban-heat-island effect.

Figure 16: World population Growth.

Figure 17: Variation of carbon dioxide with growth of population.

Figure 18: World Electricity Production by Type.

Indian scenario

On August 15, 2019 on the 73rd Independence Day message, the Indian Prime Minister Narendra Modi emphasized the need to control the population growth. In the past Shri Sanjay Gandhi, the younger son of late Prime Minister Smt. Indira Gandhi and younger brother of late Prime Minister Rajeev Gandhi spear headed this movement with coercion strategy but unfortunately he died in an accident. Also, population control has been accorded to the highest priority in the 5th Five Plan Document. A Committee of the National Development Council (NDC) has been set up, to evolve a holistic approach to population control. However, with the entry of regional political parties under the disguise of caste, religion, region, etc. to get power (vote bank politics) the population control disappeared – the economy based reservations was replaced by caste/religion based reservations; and thus this encouraged the production of more population, even crossing the China. Now, there is a need to revive all these to bring down the population growth.

Conclusion

Agriculture point of view, global warming has no impact as it is insignificant when compared to annual and seasonal variations in temperature, wherein agriculture is adapted to them. Climate change in terms of natural variability in rainfall impact water resources availability and thus agriculture and Food Security; and needs developing adaptive measures. Too generalization is too dangerous; scientific institutions must change from copycat mode to real science mode. The natural variability in rainfall data series may differ at different scales of studies in space, such as national, state and station level. Climate change is modified at local and regional levels by "climate systems and general circulation patterns". It is common to researchers and planners use truncated data set of a natural variability series and this type of selection leads to misleading conclusions or lead to biased inferences. Finally, international and national agencies must look in to bringing down population growth curve to bringing down Carbon Dioxide levels in the atmosphere and thus improve the quality of Air/Oxygen.

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Volume 3 Issue 10 October 2019