



Role of Pollution and Climate Change in Food and Nutrition Security

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Abstract

Production and distribution are the two major components for the Food and nutrition security [FNS]. Successful distribution relates to the governance. In the case of production aspects, internationally FNS is linked to climate change by taking Climate change as de-facto global warming. Climate change is a vast subject that varies with space and time in terms of meteorological parameters. Pollution [air, water, soil and food] is the hall mark of development, a major culprit for hindering nutrition security in which water is the main player. Also water is the main player in agriculture. Therefore, understanding of (1) climate change issues, (2) water resources availability issues, (3) pollution menace issues and (4) agriculture production related issues at local and regional levels play the pivotal role in achieving FNS. Under these scenarios, to achieve sustainable FNS in India, governments must put thrust on studies to characterize agro-climate and sustainable water resources availability at local and regional scales. Also, in warm tropical country like India, controlling pollution is more important over Paris agreement on controlling CO₂ emissions wherein CO₂ is not a pollutant. Present day mono-crop system of agriculture must be replaced by multi-crop system that includes animal husbandry as a component of farming systems. To achieve food security, food production is not sufficient but governments must see the wastage is at a minimum. Governments must implement all facets of FNS Act of 2013 by giving priority to locally produced food items. Governments must discourage producing and distributing to needy the food items that are contaminated by pollution and food items adulterated by greedy wherein they counter the objective of FNS.

Keywords: Pollution; Climate Change; Food and Nutrition Security

Introduction

Providing quality food and poverty eradication are an important issues of concern now a days with ever growing population pressure on unit area cultivated, is plagued by several compounded factors. International agencies are attributing this scenario to climate change, wherein climate change is used as de-facto global warming. With this the real issues are being sidelined to meet the vested greed. Pollution is a major component in food and nutrition (agriculture and water) security; and in addition animal husbandry is an important component in nutrition security. Though Indian Government passed a Food and Nutrition Security Bill in 2013, with the apathy from ruling clan, this is not moving in the right direction – with the poor governance. That means food and nutrition includes products from agriculture, animal husbandry [eggs, meat, milk, etc] and water born [rivers, tanks and oceans].items [fish, prawns, etc].

The two natural resources that are vital for agriculture are soil and climate [1,2]. Man has no control as yet over the latter and needs to adapt to it. Soil is affected by pollution, which is in the hands of humans. This could be minimized through proper planning. The nature of climate is complicated because of the wide range of ecological and topographical diversities and hence requires in depth studies to develop such adaptive measures.

Water is a natural renewable resource fundamental to life, livelihood, food security, sustainable development [3]. Thus water management plays vital role. We continued to overlook environmental damages until polluted land, water, food and air began threatening human health and until native species and ecosystem began disappearing. Resulting groundwater contamination, rivers became efficient channel to carry pollution, reservoirs became cesspools of poison, etc. Around 80% of global fresh water is contaminated and thus purified water is used for drinking. The coastal ocean waters are also polluted with the urban sewage, industrial effluents, agricultural runoff, etc. Developed countries instead of taking action on this global phenomenon, masked this scenario and brought in the concept of global warming. Thus controlling of pollution, that has maximum impact on nature, has taken the back seat and global warming with little or no impact on nature took front seat as in this billions of dollars are there to share [4,5]. Thus, the primary part of FNS depends upon understanding of climate change issues, water resources availability issues and agriculture production related issues [3-5] wherein pollution is a part -- Though FAO/UN looked in to the FNS but in a different direction. These issues in brief as relevant to Food and Nutrition Security [FNS] system are discussed in the present article.

“Climate Change” is not “Global Warming”

Weather and Climate: Climate is what you expect, weather is what you get. Weather and climate respectively refer to short-term and long-term events in the atmosphere. Averages and extremes in climate in terms of meteorological parameters such as temperature, precipitation, wind, relative humidity, etc. for individual stations can be seen in normal books published by meteorological departments using 30-year period. Thus, temperature is only one parameter of weather and climate. Meteorological parameters do not act independently but they interact with each other in the atmosphere. Change in one parameter has an impact on the other parameters. They vary with climate system [IPCC, AR5]. The major components of climate system are the atmosphere, the hydrosphere, the cryosphere, the land surface and the biosphere. General circulation patterns relating to wind systems are superposed on the climate system. These play vital role on local and regional weather and climate. Thus, weather and climate vary with space and time.

Climate Change: Changes in climate are not new. They were there in the past and will be there in the future. These are inbuilt natural variations in nature. However, with the increased interference of humans on nature, the natural variations are being modified at local and regional scales. The combination of these is known as climate change. However, climate change has turned in to political satire of “global warming and carbon credits”, which carry billions of dollars to share that is evident even from the 2015 Paris Agreement. The global averages in climate have little or no use in agriculture as it is local in nature.

IPCC’s AR3 defined climate change as “a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period [typically decades or longer]. Climate change may be due to natural internal processes or external forcing or to persistent anthropogenic changes in the composition of the atmosphere or in land use”. That means, according to IPCC, climate change can occur naturally or from man-made causes. UN Framework Convention on climate change [UNFCCC], in its Article 1, defined climate change as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods”. From these definitions it is clear that climate change consists of several components in addition to global warming component. WMO presented a manual in 1966 to separate natural from manmade. From all these climate change is given as:

- Natural variability consists of (a) irregular variations that include intra-seasonal and intra-annual variations and (b) systematic variations expressed by fluctuations or cyclic variations of different durations. These are beyond human control and thus needs to adapt to them. That is exactly what our forefathers did in the case of water resources and agriculture. This is presented based on the experiences acquired in several countries by Reddy [1,2].

- The man-induced variations have two parts. They are changes through (a) greenhouse effect and (b) non-greenhouse effect. The former has two components, namely (i) global warming since 1951 through anthropogenic greenhouse gases -- Carbon Dioxide (CO₂) from fossil fuel use, and (ii) impact of aerosols from volcanic eruptions. The latter is ecological changes associated with the changes in land and water use and cover, which are defined by (i) “urban-heat-island effect” and (ii) “rural-cold-island effect”. Reddy [4,5] presented these aspects.

Global Warming: The global average annual temperature anomalies were derived from the data series over the land and the ocean but they present non-uniform distribution with both space and time. It is also the case with the Carbon Dioxide (CO₂). Systematic measurements over oceans started only since 1990 and prior to that the ships used to take observations en-route. Contamination and covering with filth of the ocean waters steadily increasing. From 1973 onwards though satellites started measuring the data but officially the data is available since 1979. For the same period balloon data series are also available. As this data series showed lower annual average temperature over that of ground based measured data, this data was withdrawn from Internet. To show there is significant increase in global temperature due to global warming, some organizations that are maintaining the ground-based data lowered the past data and raised the current data. With all these the past two decades the trend showed a hiatus-pause. In the global [land and ocean] temperature anomaly data series of 1880 to 2010, the trend component presented an increase of 0.6°C per Century. Over this trend superposed a 60-year cycle wherein the sine curve varied between - 0.3°C and + 0.3°C. According to IPCC from 1951 more than half of the global average temperature anomaly is associated with anthropogenic greenhouse gases effect (Ba). Global warming is part of this (Bai). Even if we assume global warming component as 50%, the trend associated with it is only 0.30C per Century. Even this is basically because of lowering the past data and rising current data. Also, the data is corrupted by having met network concentrated in urban areas and thus over-emphasizing urban-heat-island effect and by having sparse met network in rural areas [which is more than twice that of urban areas] and thus underemphasizing rural-cold-island effect. This is not the case with satellite data. Thus, so far the Global warming component is less than 0.15oC only. It is insignificant when compared to intra-annual and intra-seasonal changes in temperature and thus has little impact on nature. The global warming component was attributed to cause sea level rise, ice melts, glaciers retreat, impact crop production, cause extreme weather events, rainfall-monsoon changes, etc. There is no way we can expect these with that meager change in temperature.

Destruction of Nature: Nature is being destroyed by both natural disasters such as cyclonic activity, earthquakes, volcanic activity, tsunamis, etc; and activities to meet human greed such as wars, oil-gas-water extraction, physical destruction of ecologically sensitive zones and destruction of natural water flow systems, etc. Many-a-time such destruction and their associated changes in nature are attributed to global warming. The reality is quite different. Let me present few cases in this direction.

- (i) **Flood Disasters:** Droughts and floods are common to India for that matter world over. Each year one part or the other in India experiences the floods and droughts. The severity of destruction change with the time of the year, the terrain, with the population growth, and growth in infrastructure. However, with the violation of existing local, state and national laws the destruction is aggravated. This is the case with flood disasters in Uttarakhand in June 2013 and Jammu and Kashmir in 2014; November-December 2015 floods in Chennai in Tamil Nadu and Nellore in Andhra Pradesh; and September 2000 floods in Hyderabad in Telangana. All these disasters are associated with the apathy of government agencies – poor governance -- as they were unable to control the illegal construction activities along the river beds and converting rainwater channels, rivers, water bodies in to concrete jungle. Now governments are putting the blame on global warming, as it cannot defend against such onslaught by politicians and bureaucrats to protect themselves for wrong doings.
- (ii) **Heat and Cold waves:** Heat and cold waves are also common to certain parts of India in summer and winter in association with the Western Disturbances, part of General Circulation Pattern. The high-pressure belt over Nagpur region determines the impact zones. They have not crossed the extremes published in Normal Book.
- (iii) **Himalayan Glaciers Melt:** IPCC pronounced in its AR4 Report stating that the Himalayan Glaciers will melt by 2035. Same way Al Gore concluded that Greenland will be ice free in five years. When we questioned UN Secretary General through a letter the veracity on such pronouncements in 2009, these conclusions were withdrawn but only after they received Noble Prize. Government informed to Indian Parliament after Paris meeting in 2015 that 86.6% of 2181 of Himalayan Glaciers are not receding.

Natural Variability: Water is a natural resource, fundamental to life, livelihood, food security and sustainable development; it is also a scarce resource. India has more than 17.11% of the world’s population, but has only 4.6% of world’s water resources with 2.3% of world’s land area. Precipitation and snow melt provide the fresh water; though they are renewable, they are highly variable with space and time; natural variability part of climate change plays vital role in the year to year water availability over different parts of India. Based on such knowledge, forefathers developed location specific farming system practices.

At national level the variability of southwest monsoon precipitation [June to September] appears to be very low – coefficient of variation is 9.9% -- but as we go to smaller areas like state or met sub-division they are higher – Coastal Andhra, Rayalaseema and Telangana sub-divisions, respectively they are 22.2%, 28.8% and 23.5%. The rainfall in July, August and September months over Telangana met sub-division varied highly between 25 - 50 mm and more than 400 - 425 mm in a month. This is the type of temporal variability we experience. In the case of spatial variation, the

drought proneness (Figure 1) reaches as high as 60% of the years in rain shadow zones of Western Ghats like Anantapur-Bellary-Sangly belt to zero percent in good rainfall zones [1,2]. Temperature follows the rainfall condition over seasonal and annual variations. Figure 2 presents an example of annual rainfall as deviation from normal and annual temperature as deviation from normal over India. In 2002 and 2009 with severe drought conditions of 81 and 79% of average rainfall presented a raise of 0.7 and 0.9oC, respectively.

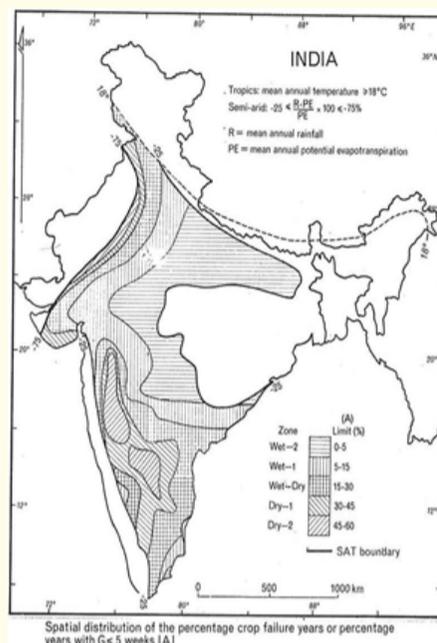


Figure 1: Drought proneness zones in India.

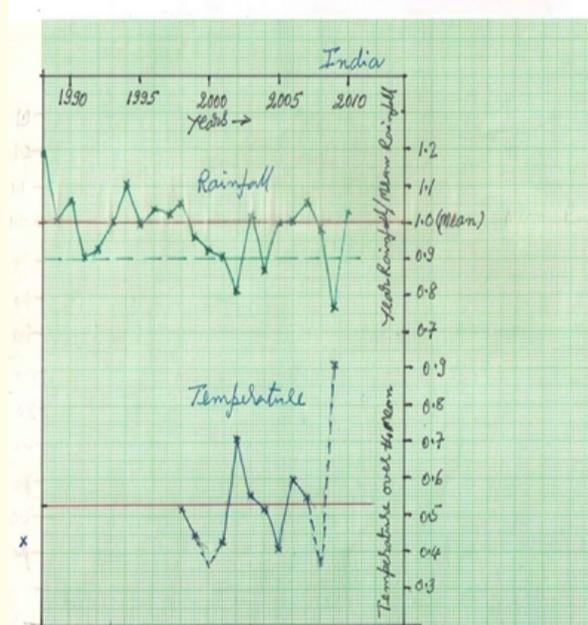


Figure 2: Droughts and floods impact on temperature in India.

Destruction of Western Ghats and Himalayas, more particularly foothills, will have disastrous effect on climate, more particularly on precipitation as Indian rainfall is Orographic in nature. For example, with the removal of hillock in the Santacruz Airport for the expansion of runways, reduced the rainfall by about 300 mm; but subsequently with densely built tall structures all around brought the rainfall to more or less to the original condition.

Earth’s climate is dynamic and always changing through the natural cycle. What we are experiencing now is part of this system. All India Southwest monsoon precipitation, that constitutes

78% of the annual, since 1871 to date followed a 60-year cycle [6]. By 1987, two cycles have been completed. The third cycle started in 1987 and will continue up to around 2046 in which the first 30 years form part of better rainfall period [this will end by 2016] and the next 30 years form part of poor rainfall period [starting from 2017]. The frequency of occurrence of floods in the northwestern Indian rivers followed this pattern. Hurricanes and Typhoons also followed this cyclic pattern but hurricanes cycle is in opposite direction to typhoons cycle. It is the case with ocean temperatures in Atlantic and Pacific oceans.

However, this is not so with individual states or regions. For example, undivided Andhra Pradesh a southeastern part of Indian States receives rainfall not only in southwest monsoon season but also in the northeast monsoon season [October to December] and as well as from cyclonic storms in summer [pre-monsoon season, April-May]. Both the monsoons rainfall presented a 56-year cycle but in opposite pattern. The frequency of occurrence of cyclonic activity in Bay of Bengal followed northeast monsoon 56-year cycle pattern – these are discussed by Reddy [3].

The annual rainfall presented 132 year cycle (Figure 3a) in which in the 66 year below the average cycle part [prior to 1935] presented 12 years with excess rainfall [$> 110\%$ of the average] and in 24 years with deficit rainfall [$< 90\%$ of the average]; in the 66-year above the average cycle part [from 1935 to 2000] presented 24 years with excess rainfall and in 12 years with deficit rainfall. The current below the average part of 66 years cycle part will be similar to prior to 1935, started in 2001. Water availability in the Krishna River basin (Figure 3b) presented similar pattern in terms of surplus and deficit. Thus, this controls the irrigation.

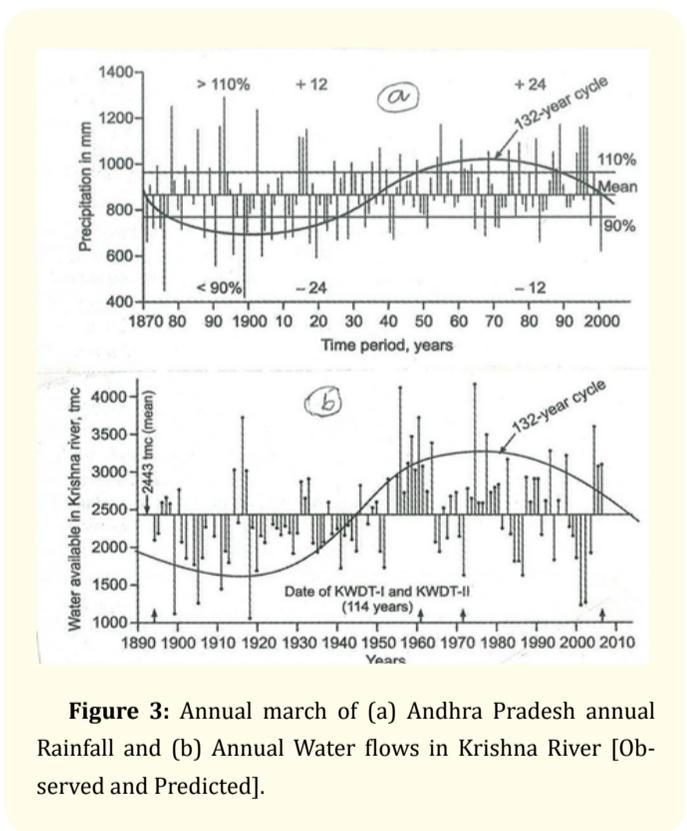


Figure 3: Annual march of (a) Andhra Pradesh annual Rainfall and (b) Annual Water flows in Krishna River [Observed and Predicted].

Agro-climate studies: Because of these scenarios, there is a need to carryout detailed agro-climate analysis at individual station level and region level to develop adaptive measures (Figure 4) and as well development of water resources like interlinking of rivers, construction of dams and application of micro-irrigation (Figure 3a and b) etc. In fact such analysis provides basic information such as drought proneness, sustainable growing period [G, weeks] and sustainable period for planting [S, week number]. The author presented such a study using the data of several countries [1,2].

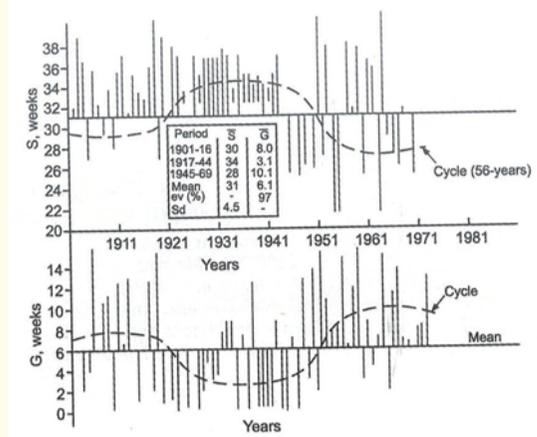


Figure 4: Drought under climate change conditions for Kurnool in Andhra Pradesh India.

Sustainable Water Resources Availability

General issues: Water is a God given gift, a renewable source. However, human greed is affecting this life saving source in a variety of ways. Unless we address them, the future will be bleak in getting sustainable water resources availability [3]. The four pillars of Indian constitution are corrupt to the core. This is the major hurdle in resolving water issues in India. Some of these can be seen from the below discussions.

- (i) **Tribunals:** To resolve the water resources sharing by riparian states central government appoints the Tribunals headed by retired judges with unfettered powers. This has got both positive and negative repercussions on the riparian states. This is glaringly seen in the case of Krishna River water sharing among the three riparian states. Justice Bachawat headed the first tribunal and Justice Brijesh Kumar headed the second tribunal. The basis for sharing the water is the water availability data series in the catchment area over years. The former followed scientific path but the later followed “technical fraud” path to favour one state over the other. This disrupts the entire irrigation pattern in the affected state. Now, to resolve this issue states are fighting before the Supreme Court of India and before the 2nd tribunal. Everybody forget the fact that this is not a legal issue but it is a technical issue. These are major issues in India. To resolve these issues, the central government must establish a permanent technical body.
- (ii) **Vote Bank Politics:** Vote Bank politics is the major hurdle in resolving inter-state or intra-state disputes. This has become worse with regional party culture. Let us take the case of two Telugu states. The two Telugu states chief ministers, instead of taking opposition in to confidence, are encouraging defections from opposition parties, so that there will not be any opposition, and thus creating dictatorial rule. “Both of them are intolerant to criticism. The Constitution is blind on this vital corrupt act. For example, Telangana CM has been planning to spend lakhs of crores on water related projects. The Congress party presented a slide show showing that it is a wasteful expenditure. But CM warned critics through press, which is most unfortunate. Here the fact is, if the government completes the pending projects, the cost could be brought down to less than 30% of the 65,000 crores allocated towards Mission Kakatiya and Mission Bhagirtha - though they are ongoing activities and nothing new, they just coined new words. Unfortunately the outsiders do not know the facts

on the issues make statements that strengthen the bad policies of ruling parties. Andhra Pradesh CM has initiated temporary capital city building and another lift irrigation project in Pattiseema by wasting public money. Instead of completing the Polavaram Project, which was initiated by the previous government, which has got all statutory clearances for the project and project was allotted to a builder, who is now MP of the ruling party. The amount spent on Godavari and Krishna Puskaralu and Pattiseema should have helped the building of the main dam and that would have helped the Godavari water reaching Krishna River water through gravity by this time as the right canal was built by the previous government. Instead he initiated a lift to put the water in to right canal - inaugurated three times with three times breaching the canal. This needs Power as it is not gravity system.

Mismanagement of water resources: The other major issue is the mismanagement of water resources by the government and as well by the people starting from urban water to major dam water irrigation. In modern society people spend lavishly when they get wind-fall on wealth. It is also seen with water resources. Traditionally the tank water is well managed at village level based on the water availability in the tank. Under vote bank politics this disappeared. There is an urgent need to restore such system for efficient utilization of water resources at all levels and at all sectors.

Quantity and quality of water availability: The other major issue in the water resources availability, in addition to quantity, is quality of water. Chemical input agriculture, industry, urban culture, etc. are contributing to reduction in quality water availability [surface and groundwater]. In and around urban areas using such water crops are produced and supplied to urban areas for consumption and thus causing severe health hazards.

Agriculture Production System

Reddy [1,2,6,7] presented issues related agriculture. The traditional agriculture was soil and climate driven farming systems that encompasses the animal husbandry. It provided socio-economic, food and nutrient security with the healthy food. Those were the "Golden Days" in the history of farming. It was an environment-friendly system and was highly successful and sustainable. No pollution, no worry about seeds and fertilizer adulteration as they used good grain as seed and compost of farmyard manure and green manure as fertilizer. This system of agriculture was clouded by the chemical inputs agricultural technology in 1960s.

Following growth in population the food production balance got disrupted and in order to find a solution to ever growing problem, 60s saw the chemical inputs technology and later genetically modified [GM] seed technology entered India in the form of much eulogized Green Revolution Technology. With the help of those technologies, food security was achieved up to an extent. But, it came at huge costs with disastrous impact on environment. The Green Revolution increased the production substantially in terms of quantity but failed to achieve the quality of traditional agriculture in terms of food and fodder. The technology includes high yielding seeds, chemical inputs (fertilizers and pesticides, insecticides, herbicides, etc.) and irrigation at huge cost. However, newly developed high yielding seeds used in 'Green Revolution Technology' created new problems hitherto unknown to farmers. Use of chemicals in the crop management caused the cost of production jump several folds. Here entered government's input subsidy, a huge component.

Studies on paddy/rice production figure of 70s and 80s in Andhra Pradesh [undivided] revealed that the traditional paddy

under irrigation yielded 1300 kg/ha; by adding high yielding seed this increased by 500 kg/ha; and by adding chemical fertilizers the yield level rose further by 2000 kg/ha. That means total yield achieved was 3800 kg/ha under farmers' fields. This was far less than research station yields of 5000 to 6000 kg/ha. The present average yields of farmers' field are 2600 - 2800 kg/ha as the yield curve flattened since 1984-85. Only increase in area under irrigation contributed to additional increase in production after 1984-85.

Studies clearly reflect that high yielding seeds introduced during and after the Green Revolution were tailored to chemical fertilizers under irrigation. This severely affected dry-land agriculture that constituted around 60% of the cultivated land. This led dry-land farmers migrating to urban areas as the dry-land agriculture with high input costs became unsustainable and non-remunerative. This is a mono-crop system that severely hampered the animal husbandry component in farming system that used to provide food and nutrition security. The traditional agriculture system is inter-cropping/multiple cropping system that provided good fodder feed to animal. Unfortunately present day economists rarely look into this aspect while calculation the income/profit.

Under this system, though we are producing in excess but in reality we wasting 40 to 50% and thus natural resources to produce that amount - globally it is estimated at around 30% by FAO/UN. India market is driven profit mongering businessmen and as a result, farmers rarely get the minimum support prize for what they produced. This led farmers suicides rampant in India as farmers started looking at cash crops under high inputs.

Forty years later, genetically modified (GM) seed entered into Indian agriculture system. Most innovations in this have been profit-driven rather than need-driven. Global seed industry is controlled by four western multinational companies [MNCs] and at the same time GM seed industry is in one MNC's hands. The GM technology responds to the need of GM companies to intensify farmers' dependence upon seeds protected by the so-called intellectual property rights, which conflicts directly with the age-old rights of farmers to reproduce, share or store seeds. In fact, to get overnight profits, the Indian seed companies changed their high yielding seed into GM seed and ensured that non-GM seed is "not sold in the market". This has resulted markets flooding with spurious/adulterated GM seed varieties under different names. One such GM Seed, Bt-cotton, is in use since 2002-03 in India. Use of chemical fertilizers and irrigation increased the area under cotton under GM seed and reduced the area under non-GM seed without much yield advantage. The Bt-cotton area during 2002-03 to 2010-11 increased from 0.04 Lha to 17.95 Lha in Andhra Pradesh and at the same time area under non-Bt-cotton reduced from 8.03 Lha to 0.22 Lha. At all India level area under cotton increased from 7.667 Mha to 11.161 Mha. During the same period the yields increased from 212.5 to 545.7 kg/ha in Bt- and 229.1 to 919.5 kg/ha in non-Bt at Andhra Pradesh level. At all India level cotton yields increased from 302 in 2002-03 to 554 in 2007-08 and there onwards declined to 475 kg/ha in 2010-11. That is, the productivity has been stagnant for the past five years. The yield increase is associated with the high yielding cotton - seeds of both GM and non-GM to chemical inputs and irrigation.

Newer Agriculture Technologies Impact on Environment: Newer technologies were portrayed as a solution to all human problems, especially the problem of hunger and poverty forgetting their impact on the environment. However, the use of chemical inputs reduced the quality of food and created bad impact on en-

vironment. This “western profit driven” chemical input technology was found to be more dangerous on long-term, over the short-term gains. It has destroyed the environment drastically- soil degradation and salinization health hazards to human, animal and plant life with air, water, soil and food pollution. The pollution related health hazards necessitated the introduction of drug manufacturing industry and establishment of hospitals which in turn causing air and water pollution, turning this into a vicious circle. Even with all these ill effects, the yield growth curve has flattened after 1984-85. In fact, the chemical input technology is like “scratching the head with fire”. When this technology was introduced nobody knew that this technology is going to create such environmental catastrophe. Even the Nobel Prize awarding organization was not aware of this while awarding Nobel Prize to Norman Borlaug.

We must not forget the fact that GM technologies also work under chemical inputs - irrigation only; and thus those impacts also apply to GM seed technology - here high yielding traditional seeds were converted in to GM, that helped the seed companies to mint profits overnight. Farmers have no option of re-use of the GM seed like in traditional seed and in addition, GM seed technology presents several other impacts on biodiversity, contamination, re-generation, herbicide-tolerant weeds, new pests-diseases etc. Because of some of these, in USA and China GM crops were not permitted to grow in some zones. In India GM crops are grown everywhere including prohibited zones. There are several other aspects like food safety and ethics. India has no mechanism to study such aspects. Thus, with the GM seed technology, the cure has become more dangerous than the disease.

What is to be done?: To achieve sustainable agriculture, therefore, the governments must change the policy on agriculture. The policy must include low input costs, pollution free quality food technology such as organic inputs under cooperative farming setup. This not only brings down the cost of production but also reduces drastically man hours spent on procuring basic inputs by individual farmers, improves the utilization of natural resources and thus helps to reach sustainable agriculture.

In fact progressive farmers with traditional wisdom have developed technologies and achieved far higher yields than the research station yields and received national and international awards/rewards and recognition but neither the government nor the scientists showed any interest, though there is a mechanism in government departments, to stabilize that technology and provide packages to farmers to achieve environmental friendly progress in agriculture. The states and central governments must allocate sufficient funds to collect traditional inventions of progressive farmers and integrate these in traditional technology to achieve the 2nd Green Revolution that safeguards the environment and provide food safety, biosafety, food and nutrient security; and protect the farmers from committing suicides and provide socio-economic security.

Also, as proposed in new Food Security Bill, distribution of locally produced foods can be given under PDS by which the food subsidy component will come down substantially. This shall also reduce wastage and loss in FCI storage facilities and transportation.

Agriculture Production System

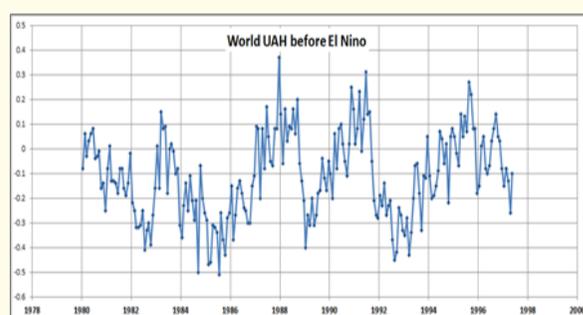
Crop development and crop growth form two facets of crop production system. Understanding these two process in an integrated system in terms of meteorological parameters is useful in several ways, namely to develop and to adopt new crop varieties and for the development of agriculture over different regions and sectors of production. Knowledge of how the weather at a particular site affects crop performance during different seasons is important, more particularly with modern high yielding seeds. In fact while developing new seeds scientists tests its adaptability in terms of season

and in that season tolerance to range of temperature. For example Reddy, *et al.* [8] studied the Sorghum varieties to test this. This test shows some are suitable to Kharif season and some to Rabi season and few others to both the seasons. Also, this study show, other meteorological and soil conditions also play important role. They include air and soil humidity [Relative humidity and soil moisture]. Let me give one such equation: In nature, we must not forget the fact that, temperature alone will not act but jointly act with other meteorological-weather parameters.

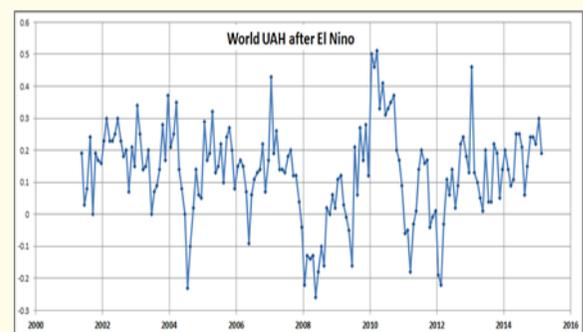
$Y = a + b ([19.6 - T])^{1/3} + ch$ where in a, b and c are regression coefficients, h is the relative humidity in %, T is the average daily temperature for the duration of growth phase in °C, Y is the duration in days to complete a given phenological phase [planting to harvest is divided in to three phases]. 19.6 - T present absolute value as the biological process follow a normal curve pattern with the peak as optimum and there onwards tapering on either side. That is the change in T from critical value 19.6°C [lower side or higher side] has the same effect - that is 20.6°C and 18.6°C have the same effect on crop development. However they may be modified by relative humidity and soil moisture. Within this soil moisture will control the crop growth and crop yield - which may be affected by pests-diseases.

Relative growth and relative yield present a steep increase with relative radiation stress, relative water stress and relative nutrient stress between two points. There will be no significant change below the lower point and above the higher point [9]. The region above the upper point, growth and yield are marginally related to radiation stress. This is the commonly encountered range in reality. With the irrigation and good management, the water and nutrient stresses are controlled, which is also the case for crops grown on soils with saturated profiles at the start of planting.

The only real warming in the past 40 years has come from two major El Nino natural events - 1997-98 and 2014-2016. Before these two events (a) 1980-1997 and (b) 2001-2015 presented zero trends (Figure 5). This is part of seasonal and annual variability and other naturally occurring events [Southern Oscillation - El Nino warm] and La Nina [cold] and volcano eruptions.



[a] No warming from 1980 - 1997



[b] No warming from 2001 - 2015.

Figure 5: No warming periods in global average temperature anomaly: (a) 1980-1997 and (b) 2001-2015.

Practical aspects to achieve Sustainable FNS

In addition to the three broader issues discussed above, few other issues also help to build sustainable FNS system in Indian context [7]. Food and Nutrient security Bill was passed in 2013 by the Indian Government. This Act integrated all activities that come under food and nutrition security. This bill carries several components of food and nutrient supplements to needy. However, with the change of governance at center and state levels, these are not moving as speculated in the bill. This needs implementation in true spirit. Under PDS [public distribution system] the government though introduced minor millets the state governments are not coming forward to implement this in terms of production, procurement and supply under PDS. This must be implemented. The minor millets are considered as pollution free foods.

UN agencies must put pressure on Indian Government to discourage in supplying polluted food such as wheat and rice under PDS system. Also, put pressure on controlling adulterated food supplies, which are common all over India now. Food production in quantity alone is not the parameter to achieve food security but there are several other factors involved, namely food wastage – FAO reported it is around 30% but from my calculation it is around 40 to 50% in India --, needs better storage facilities, minimum transport losses. To achieve this, governments must encourage locally produced foods under Public distribution system [PDS] as envisaged under Food Security Bill of 2013.

Environmental groups must play a role in eradicating polluted food production through organic farming and consumption; and as well adulterated food production and distribution in which they create awareness among people. Government must discourage mono-crop system of agriculture under high chemical inputs and under intensive irrigation system, as this will hamper linking of animal husbandry under farming systems that will be a major input to nutrient security aspect.

Concluding Remarks

Though it is possible to achieve food and nutrition security in terms of quantity – more than 30% of food is going as waste --, it is rarely possible to achieve the quality under the existing circumstances globally. The main culprit is the pollution. The governments must come up with ways and means to reduce the pollution component [soil, water and food]. Also, adulteration of food in the market supplies is also affecting the quality of food we consume. Global warming has no significant role in either quantity or quality of achieving food and nutrition security. However, natural variability part of climate change plays a critical role in food security in terms of quantity. In food production, the species used have a range of tolerance to temperature. While natural variability defines the water resources availability in both space and time. To achieve proper adaptation, local level agro-climatic analyses play the crucial role, which is evident from the traditional system of agriculture. This is lacking in the present day agriculture system and thus affecting the animal husbandry component that plays crucial role in nutrition security. Now-a-days, human component entered as a major hurdle for food and nutrition security. This primarily depends upon the component, namely “Good Governance”. Unfortunately the four pillars of Indian constitution are reeling under corruption!!! This scenario leads to severe health hazards. This is causing new avenues for pollution.

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