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Declining Nutrients from Our Plates

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Abstract

Change in climate directly effects on the agricultural ecosystem that results in changing agricultural climatic elements such as temperature, precipitation and sunlight. The impacts of climate change on global food system, nutrition and health will depend on a variety of environmental factors. Due to continuously increasing global temperature, the negative impact of climate change on agricultural crops includes reduction in crop quality and quantity. The increasing population demands more food which resulted intensive agricultural practices like the use of pesticides, livestock generation, extensive use of water resources. The high anthropogenic activities result, degradation of natural resources. Now, it is the need of the hour to strengthen our capacities to combat these constant environmental changes with integration of knowledge from, ancestors, communities and scientific innovations. Technological innovations to meet the local needs of food and nutrition with best practices for producing, preserving and preparing healthy foods.

1. Introduction

Climate change is predicted to bring about increased temperatures across the world in the ranges of 1.6 °C to as much as 6 °C by 2050 (IPCC, 2007). Due to greenhouse gases (carbon dioxide, methane, nitrous oxide, CFCs, Ozone) emissions in the atmosphere, the average mean temperature is risen by 0.9 °C since 19th century (IPCC, 2007). According to the IPCC (2007) and other studies, temperature increases of 1-2 °C will result in an increase in production of some of the world's major staples with increasingly negative impacts. Climate forecast have also continued to predict increasing surface temperature, carbon dioxide level and rainfall pattern. The abrupt fluctuations in the earth's environment, is one of the major concerns of global world that has created a devastating effect on the earth's ecology.

The unprecedented use of agro-chemicals in farming land areas degrades the land productivity and its fertility. It has been established that forests act as a sink to accumulate large amounts of CO_2, but increasing rate of deforestation (due to agricultural activities) have an imbalanced natural process of the carbon cycle (Singh *et al.,* 2020). The increasing level of CO_2 in atmosphere induced uneven pattern of climatic condition that effects major impact on agricultural production. Climate change has not only created a drastic impact on food production (Kanwal *et al.,* 2019) but also affects its quality in the form of declining nutrients. The schema of the Impact of climate change is represented in the Figure 1.

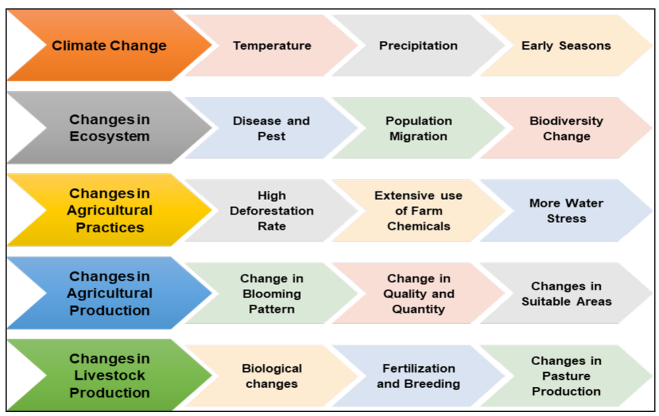

Figure 1: Impact of climate change on ecosystem, food and livestock productions

Green Revolution started in India in the 1960's, was responsible for increasing the productivity of agricultural crops. As a result, in the last 20 years, total food grain production in India increased from 198 to 269 million tonnes (FNSAI, 2019). The development of modern agricultural machinery, fertilizers and other farm chemicals helped in the immense production of agricultural crops and it is increasing day by day. But ironically, the nutrient contents like proteins, calcium, phosphorus, iron, riboflavin, carbohydrates, minerals and vitamin C in conventionally grown cereal grains, fresh fruits and vegetables have declined noticeably. Also, continuously declining fertility in the soil is affecting

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the quality of agricultural crops. The high rates of pesticides, herbicides and improved irrigation facility can lead to higher yields, but sometimes at the cost of nutrient deficiency in the crops. When farmers apply high amount of fertilizers, it causes plants take up more water that results high yielded crop but lower nutrient density. The environmental effects and genetic dilution effects on fruits, vegetables and cereals are inadvertently declining nutrient values in foods that indirectly affect human health. The degrading quality of food is the essence of people's health and its intrinsically linked to quality of environment. The persistent and growing presence of toxic content in the environment has led to our improvised habitat. These agro-toxins accumulate in our food chain which directly influence to human health.

The health-related issues we face a global level remind us that the Earth is facing its degradation and extinction, which gave us an alarm call to conserve the Earth. As we use insecticides and herbicides to kill crop pest and diseases, it also pollutes water, soil, air as well as our biodiversity. The degrading part of soil, water and air lead a threat to our biodiversity and played a key role in the current climatic crisis due to industrialization of our food system. The Covid-19 pandemic situation gave an alarming wakeup call from our mother Earth to humankind. It prompts us that we are a part of the Earth, not separate from it. The Covid-19 pandemic gives us a planetary wakeup call that we violate the Earth and its species at our own risk. So, it would be important to value and learn from our ancestral knowledge. The scenario of emerging disease epidemics is directly caused by anthropogenic activities.

2. Pesticides and Its Risks for Human Health

Pesticides are those substances which have toxic, persistent and bio-accumulative properties with negative impacts on living species, on the entire ecosystem. However, the agro-toxins, such as insecticides and herbicides are immunosuppressants, that effect the body and make it more susceptible to infections. The use of agro-toxins in agriculture and industrial food systems give rise to several chronic diseases like birth defects, cancer, endocrine disruption, diabetes, neurological problems, and infertility (Figure 2).

Every year in Europe, 13 million IQ points (Intelligence quotient) are lost due to exposure to organophosphates (Attina *et al.,* 2016). The exposure of 133 pesticides in 24 countries effect human health in Europe in 2003 were equivalent to costs incurred for the purchases of almost 50% of the total amount of pesticides applied in that year (Fantke *et al.,* 2012). The World Health Organization (WHO) cites 20,000 deaths through use of organophosphorus pesticides alone (Blain, 2011). Globally, it was estimated that the pesticide action affected to be between 1 and 4 million people (Shiva *et al.,* 2019). Agro-toxins have not only damaged the environment and human health, but also failed to reduce pests from the fields. The parasitic insects shown unexpected genetic plasticity and are able to continuously transform themselves to resist to toxic chemicals.

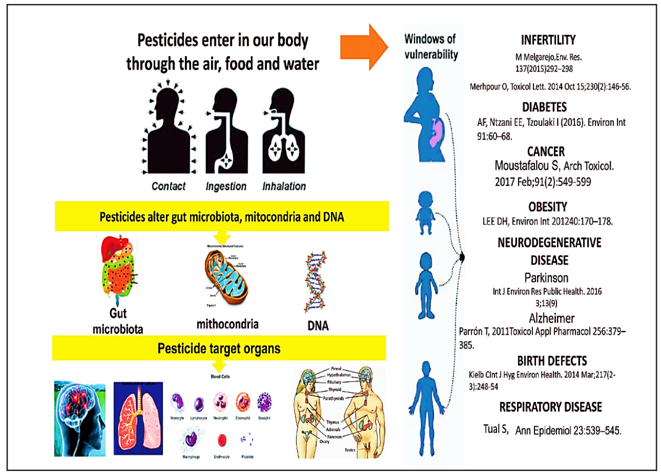

Figure 2: Harmful effects of pesticides in human health system (Shiva *et al.*, 2019)

In the past 30 years, we have seen a public awareness on environmental issues for protection of the ozone layer, air and water quality. However, at the end of the 20th century, one of the major issues is declining nutrient content of our daily food. Industrialisation of agricultural practices and massive use of fertilizers and herbicides have reduced the number of crops and their varieties. The richest source of vitamin and nutrients are vegetables and fruits. The declining nutrient concentration in these crops is most undesirable. Declining nutrients from our food crop result, nutritional problems for public health. Several diseases are generated due to decreasing minerals in our diet specially protein energy malnutrition in children, chronic energy deficiency in adults, micronutrients malnutrition and chronic diseases. The increasing use of herbicide and pesticides in agricultural crop results severe health issues (*e.g.*, increasing cancer rate, digestion problems, skin disorders, stunted or defective bone growth, dementia, accelerated aging, *etc.*). Micronutrients [*viz.* vitamin A, iron (Fe), magnesium (Mg), iodine (I), *etc.*] deficiencies are the most common forms of malnutrition. In the world, over 3.0 billion population is malnourished in nutrient elements and vitamins (FAO and others, 2018).

There has been an unpredicted decline of biodiversity and nutrient diversity in food. In current situation, food produces 10 to 25% less iron, zinc, protein, calcium, vitamin C, and other nutrients. Today, world is witnessing hunger, wasting, stunting, underweight, overweight, obesity and variety of nutrient deficiencies. These issues can lead to increase in variety of diseases in human due to increasing rate of pesticides and other factors (Figure 3). There are several hidden costs in the industrial and agricultural systems which are not taken into account. Particularly these costs are affecting human health, which refuses to take the responsibility for the damage caused by agro-toxins. The economic costs of health care due to food system related illnesses are projected in trillions of dollars resulting pushing millions of people below the poverty line (Table 1). Peoples around the world are facing the problem of paying bills for the diseases spread through agro-toxins. It is clear that the aim of the current system cannot provide adequate nutrition for human being, but to maximize the profits to big fertilizer companies.

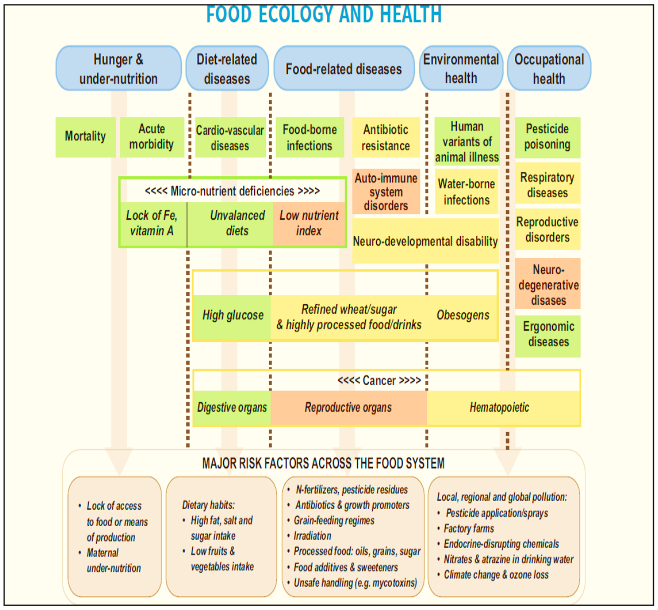

Figure 3: Relationship between food ecology and health (Shiva *et al*., 2019)

Table 1: Projected costs of health care due to food system related illnesses (Source: Shiva *et al.*, 2019)

S. No.	Diseases	Global Cost (in $)
1.	Neurodegenerative disease	2.4 trillion
2.	Autism	171 billion
3.	COPD	4.8 trillion
4.	Birth defects	22.9 billion
5.	Obesity	1.2 trillion
6.	Cancer	2.5 trillion
7.	Diabetes	2.5 trillion
8.	Endocrine disruptors	549 billion

A nutrient rich diet is a basic need for humans and prerequisite for a healthy life. The food which was grown decades ago was much richer in nutrients than the varieties we get today. The food we get nowadays is less nutritive because of modern intensive agriculture methods and extensive use of farm chemical (Rai *et al.,* 2014). A diet which is rich in mineral and nutrients can lower blood pressure, reduce the risk of heart disease, prevent the lower risk of eye and digestive problems and keep good appetite. Climate change affects the production of food crop, but also affects their quality, harvesting time and storage.

3. Is Nutrition Period Siege in Our Food Plate?

To further investigate the nutritional decline in Indian crops, change pattern of nutrients between 1989 and 2017 of selected produce of common cereal grains (06 nos.), vegetables (06 nos.) and fruits (07 nos.) were examined. The mineral contents data were extracted from the National Institute of Nutrition, Indian Council of Medical Research, Hyderabad (India) for the period of 1989 and 2017 (Gopalan *et al.,* 2004 and Longvah *et al.,* 2017). Seven major nutrients – (i) Carbohydrate (g), (ii) protein (g), (iii) calcium (mg), (iv) energy (kcal.), (v) phosphorus (mg), (vi) iron (mg) and (vii) moisture (g), showed a significant decline in almost all the crops (Table 2). Nutrients, which are essential for growth and development, have decreased in cereal grains, vegetables and fruits.

Mostly, 7 nutrients are observed to be reduced in all cerealgrains, while a significant amount of protein and energy in rice; calcium in barley and iron in maize and ragi were increased (Table 2). Further, these nutrients were found to be declined in all the vegetable crops, while a significant amount of carbohydrate in lettuce; protein in okra; calcium, phosphorus and, iron in both lettuce and okra; and as the moisture content in tomato, carrot and potato were increased (Table 2). The levels of carbohydrate, protein, calcium, energy, phosphorus, iron and moisture in fruits like apple, banana, litchi, mango, pomegranate, strawberry and peaches, have significantly reduced. However, considerable amount of protein in apple, banana and strawberry; calcium in apple, mango and pomegranate, energy content in apple, iron content in banana and all studied fruits except apple were observed to be increased. Moreover, the latest dataset released by the National Institute of Nutrition are also suggesting that the nutrient contents in Indian food crops are continuously declining (Longvah *et al.,* 2017).

Likewise, in India, the scenario of declining nutrient contents is worst in all over the world. The researchers of University of Texas at Austin, analysed nutrient composition of food in 43 crops between 1950 and 1999 (Davis *et al.,* 2004). The 6 nutrients – protein, calcium, iron, phosphorus, riboflavin and ascorbic acid were showed a significant decline in the 43 studied crops. Similarly, Mayer (1997) analysed nutrients in 20 fruits crop and vegetables between 1930 and 1980. The study suggested that significant reductions in the levels of calcium (Ca), magnesium (Mg), copper (Cu) and sodium (Na) in vegetables and magnesium (Mg), iron (Fe), copper (Cu) and potassium (K) in fruits. Ekholm *et al.* (2007) discussed the dynamic status (1970-2000) of nutrients in food. 17 vegetables, 06 berries, 04 grains and apples were analysed in terms of mineral content fluctuations. 4 minerals– potassium (K), manganese (Mn), zinc (Zn) and copper (Cu) showed an average decline with an increase of selenium (Se). The

Table 2: Fluctuations (1989 vs. 2017) in nutrients of selected produce of cereal grains, fruits and vegetables (g/ 100 g sample) (Source: Gopalan *et al.*, 2004 and Longvah *et al.*, 2017)

Crop Type	--- Carbohydrates (g) ---			--- Protein (g) ---			--- Calcium (mg) ---			--- Energy (kcal.) ---		
	1989	2017	% Fluctuation	1989	2017	% Fluctuation	1989	2017	% Fluctuation	1989	2017	% Fluctuation
---------- Cereal Grains ----------												
Bajra	67.50	61.78	-8.47	11.60	10.96	-5.52	42.00	27.35	-34.88	361.00	348.00	-3.60
Wheat	69.40	64.72	-6.74	12.10	10.59	-12.48	48.00	30.94	-35.54	341.00	321.00	-5.87
Barley	69.60	61.29	-11.94	11.50	10.94	-4.87	26.00	28.64	10.15	336.00	316.00	-5.95
Maize	66.20	64.77	-2.16	11.10	8.80	-20.72	10.00	8.91	-10.90	342.00	334.00	-2.34
Ragi	72.00	66.82	-7.19	7.30	7.16	-1.92	344.00	364.00	5.81	328.00	320.00	-2.44
Rice	78.20	78.24	0.05	6.80	7.94	16.76	10.00	7.49	-25.10	345.00	356.00	3.19

---------- Cereal Grains ----------

Crop Type	------ Phosphorus (mg) ------			------ Iron (mg) ------			------ Moisture (g) ------		
	1989	2017	% Fluctuation	1989	2017	% Fluctuation	1989	2017	% Fluctuation
Bajra	296.00	289.00	-2.36	8.00	6.42	-19.75	12.40	8.97	-27.66
Wheat	355.00	315.00	-11.27	4.90	4.10	-16.33	12.20	10.58	-13.28
Barley	215.00	178.00	-17.21	1.67	1.56	-6.59	12.50	9.77	-21.84
Maize	348.00	279.00	-19.83	2.30	2.49	8.26	14.90	9.26	-37.85
Ragi	283.00	210.00	-25.80	3.90	4.62	18.46	13.10	10.89	-16.87
Rice	160.00	96.00	-40.00	0.70	0.65	-7.14	13.70	9.93	-27.52

Crop Type	--- Carbohydrates (g) ---			--- Protein (g) ---			--- Calcium (mg) ---			--- Energy (kcal.) ---		
	1989	2017	% Fluctuation	1989	2017	% Fluctuation	1989	2017	% Fluctuation	1989	2017	% Fluctuation
---------- Vegetables ----------												
Tomato	3.60	3.18	-11.67	1.90	1.12	-41.05	20.00	8.49	-57.55	23.00	20.79	-9.61
Lettuce	2.50	3.01	20.40	2.10	1.54	-26.67	50.00	56.71	13.42	21.00	21.00	0.00
Broad beans	7.20	2.11	-70.69	4.50	3.85	-14.44	111.00	64.37	-42.01	48.00	29.39	-38.77
Carrot	10.60	5.55	-47.64	0.90	0.90	0.00	80.00	35.09	-56.14	48.00	33.22	-30.79
Potato	22.60	12.90	-42.92	1.60	1.35	-15.63	10.00	8.53	-14.70	97.00	69.79	-28.05
Okra	6.40	3.62	-43.44	1.90	2.08	9.47	66.00	86.12	30.48	35.00	27.49	-21.46

---------- Vegetables ----------

Crop Type	------ Phosphorus (mg) ------			------ Iron (mg) ------			------ Moisture (g) ------		
	1989	2017	% Fluctuation	1989	2017	% Fluctuation	1989	2017	% Fluctuation
Tomato	36.00	22.50	-37.50	1.80	0.42	-76.67	93.10	93.21	0.12
Lettuce	28.00	44.10	57.50	2.40	2.73	13.75	93.40	92.27	-1.21
Broad beans	149.00	67.97	-54.38	-	-	-	85.40	84.20	-1.41
Carrot	530.00	43.06	-91.88	1.03	0.60	-41.75	86.00	87.69	1.97

Table Continue...

Crop Type	------ Phosphorus (mg) ------			------ Iron (mg) ------			------ Moisture (g) ------		
	1989	2017	% Fluctuation	1989	2017	% Fluctuation	1989	2017	% Fluctuation
Potato	40.00	37.90	-5.25	0.48	0.53	10.42	74.70	80.72	8.06
Okra	56.00	57.48	2.64	0.35	0.84	140.00	89.60	89.06	-0.60

Table Continue...

Crop Type	--- Carbohydrates (g) ---			--- Protein (g) ---			--- Calcium (mg) ---			--- Energy (kcal.) ---		
	1989	2017	% Fluctuation	1989	2017	% Fluctuation	1989	2017	% Fluctuation	1989	2017	% Fluctuation
---------- Fruits ----------												
Apple	13.40	13.11	-2.16	0.20	0.29	45.00	10.00	13.68	36.80	59.00	62.38	5.73
Banana	27.20	24.95	-8.27	1.20	1.25	4.17	17.00	6.77	-60.18	116.00	110.66	-4.60
Litchi	13.60	11.41	-16.10	1.10	0.99	-10.00	10.00	5.77	-42.30	61.00	53.78	-11.84
Mango	16.90	8.18	-51.60	0.60	0.54	-10.00	14.00	15.77	12.64	74.00	41.83	-43.47
Pomegranate	14.50	11.58	-20.14	1.60	1.33	-16.88	10.00	10.65	6.50	65.00	54.73	-15.80
Strawberry	9.80	3.40	-65.31	0.70	0.97	38.57	30.00	15.28	-49.07	44.00	24.62	-44.05
Peaches	10.50	7.82	-25.52	1.20	0.86	-28.33	15.00	6.98	-53.47	50.00	40.15	-19.70

---------- Fruits ----------

Crop Type	------ Phosphorus (mg) ------			------ Iron (mg) ------			------ Moisture (g) ------		
	1989	2017	% Fluctuation	1989	2017	% Fluctuation	1989	2017	% Fluctuation
Apple	14.00	10.44	-25.43	0.66	0.26	-60.61	84.60	83.01	-1.88
Banana	36.00	20.85	-42.08	0.36	0.40	11.11	70.10	70.13	0.04
Litchi	35.00	23.32	-33.37	0.70	0.79	12.86	84.10	85.56	1.74
Mango	16.00	11.07	-30.81	1.30	0.51	-60.77	81.00	88.44	9.19
Pomegranate	70.00	27.20	-61.14	1.79	0.31	-82.68	78.00	83.55	7.12
Strawberry	30.00	26.31	-12.30	1.80	0.36	-80.00	87.80	92.03	4.82
Peaches	41.00	19.08	-53.46	2.40	0.35	-85.42	86.60	88.31	1.97

results of the study also suggested the downward trends in manganese (Mn), calcium (Ca), phosphorus (P) and iron (Fe) in theses crops with no increasing trend of nutrients. Increasing nutrient concentration in the edible parts of the plants is the foremost objective of researchers in order to achieve nutritional security (Kumar *et al.*, 2015, Rai *et al.*, 2016a). Soil management with integrated nutrient management is one of the easiest and conventional methods to improve the nutrient content in the crops (Chattopadhyay *et al.*, 2017, Rai *et al.*, 2016b). However, the nutrient concentration in many staple crops can be improved through biofortification approaches *viz.*, biopriming (Rakshit *et al.*, 2014, Rani *et al.,* 2015), micronutrient priming (Rakshit *et al.*, 2013) and biotechnological approaches.

4. Conclusion

Mitigation of climate change and improving food security with minimizing malnutrition needs to be addressed simultaneously. The unforeseen environmental changes have majorly affected the nutrition and health of human being. The declining macro and micronutrients from our food crops are being depleted proportionally from soils which can be protected by using our conventional agricultural practices or organic farming. The widely use of fertilizers and intensive agro-farming techniques in modern agriculture also argues strongly against the concept of widespread soil degradation of mineral nutrients. Considering the recent health issues in a human being, there is a need to develop such research-based frameworks that help to estimate the further losses of nutrient consequences of environmental changes on crops. Organic farming on a global scale might be one of the options to cut down the issue of declining nutrients in foods. Several past researches had evidenced that the organic agriculture produces a significant superior crop than conventional agriculture. To protect life on earth, we should adopt organic farming practices to conserve the nutrients in soils as well as in crops. Also, practices that are based on the climate resilience agricultural techniques should be used to mitigate the environmental dilution effect.

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