Review Article

www.bombaytechnologist.in

BOMBAY TECHNOLOGIST

ISSN: 0067-9925

Dietary Choice and Environment Impacts: A Critical Review, with special consideration to Non-Vegetarian Diets

Prashasti Keshari[1]

Department of Chemical Engineering,, ICT Mumbai

Abstract

The amendment in human lifestyle has been dramatic over the years. Food consumption and patterns have varied exponentially. According to studies, the human population is expected to rise by 25% and reach 9.9 billion by 2050. This increase will lead to a hike in meat consumption by 60% worldwide. It is projected to reach 460 million to 570 million tons of meat. The excessive growth in meat consumption and production will lead to several environmental impacts. In this paper, we will discuss changes in lifestyle and consumption patterns, energy footprints, GHG emissions of different diets, and the environmental impacts on land, water, and climate change, and animal torture. Also, we will be comparing various diets; vegan, vegetarian, and omnivorous, and their impacts on the planet. The paper also focuses on the solutions regarding how we as an individual can contribute to the environment, and protect our animals and the climate by choosing better alternatives and substantially decreasing meat consumption.

Keywords- Environment impacts, GHG emissions, Carbon footprint, non-vegetarian diet, meat

1

INTRODUCTION:

Over the last century, the worldwide population has quadrupled. According to the United Nations, the world's human population is expected to grow to 9.9 billion by 2050, which is an approximate increment of 13% with respect to the current population of 7.8 billion. Natural resources such as land, water, raw materials, etc. need to be shared among all beings; including wildlife and farm animals. Simultaneously, human life expectancy has continuously increased. So, fulfilling the needs

of the growing population for a longer duration requires more of those natural resources. The population growth demands more food, particularly meat, crops, and dairy products to fulfill the dietary requirements. The meat trade is one of the first contributors to food, water, land, and energy shortage, pollution, and also the evacuation of our oceans. By next 30 years, the global food demand is predicted to increase by 70%. Livestock consumption has become a trend that has boosted up meat production globally. One of the most major drivers of climate change is global food production. It is responsible for more than a quarter (20–35%) of global anthropogenic greenhouse gas (GHG) emissions. Being the major driver of biodiversity loss; it also responsible in restricting about 38% of the Earth's ice-free land.

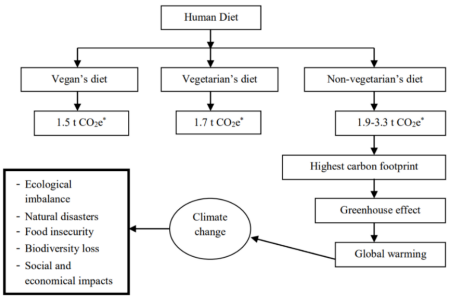

Figure 1: Inter-relationship between climate change, carbon footprint, and human diet.

CARBON FOOTPRINT AND GREENHOUSE GAS EMISSIONS OF NON-VEGETARIAN DIET:

Generally, any sort of industrial activity contributes towards the carbon footprint through different steps, such as raw materials, goods, land, storage building, transport, road, land clearance, production/manufacturing, and consumption of the product, fuels, and similar activities. Although, due to insufficient data and knowledge, it is not possible to calculate the total carbon footprint by the complex contributing processes. Pollutants namely carbon dioxide (CO2), methane (CH4), ammonia (NH3), and nitrous oxide (N2O) are the major global warming contributors and affect soil characteristics are majorly obtained by meat production.

Life Cycle Stage	Process Creating Emissions	Type Of Emissions
Production Of Animal	Production Of Nitrogenous And Other Fertilizers, Agricultural Machinery, Pesticides Etc	N_2o Emissions From Grazing Land, Fertilizer Production; Co_2 From Fertilizer Production
Housing, Maintenance, Machinery	Heating, Lighting Etc	Co_2
Digestion (Ruminants)	Enteric Fermentation	Ch_4
Waste Products	Manure And Urine	Ch_4 And N_2o
Slaughtering, Processing, Waste Treatment	Machinery, Cooking, Cooling, Chilling, Lighting, Leather And Wool Production, Rendering And Incineration	Co_2 And Refrigerant Emissions
Transport, Storage, Packaging	Transport, Chilling, Lighting, Packaging Materials	Co_2 And Refrigerant Emissions
Domestic Consumption	Refrigeration And Cooking	Co_2 And Refrigerant Emissions
Waste Disposal	Transport, Composting, Anaerobic Digestion And Incineration	Co_2, Ch_4 And N_2o

Table1: Life Cycle Stages of Livestock and Associated Emissions (Garnett, 2007).

There are two ways in which livestock production can affect the environment: directly and indirectly. Direct impacts are the emissions caused by the animals directly, such as urine excretion, burps and farts (mass contributor of methane), manure, and enteric fermentation of fiber by ruminants. Followed by, indirect impacts are the impacts caused indirectly. The sources of the indirect emissions are the crops used to feed animals, transportation emissions from processing, fertilizer production, refrigeration, etc. When compared the carbon footprint, that of a non-vegetarian is almost double in comparison to a vegetarian, whereas for a vegan it's even lesser than a vegetarian.

As per figure 2, it is clearly visible that food products obtained from animals (pork, beaf, meat, poultry, milk, etc.) are the major contributors of methane (CH4) emissions. Mutton emits 11.9 times, 12.1 times, 12.9 times, and 36.5 times more GHG than milk, a fish, rice, and a chapatti respectively.. According to Gerbens-Leenes and Nonhebel model, CO2e for pig and beef is 0.9kg

and 14.8 kg, respectively.

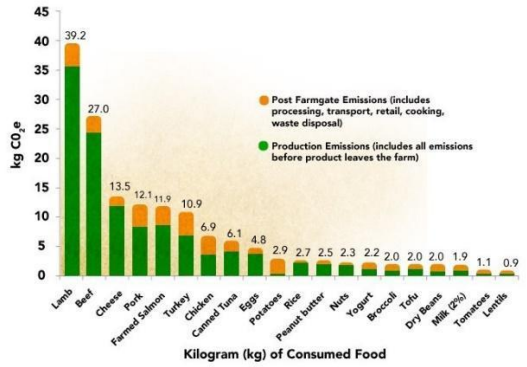

Figure 2: Relation between the food consumed and CO2 emitted.

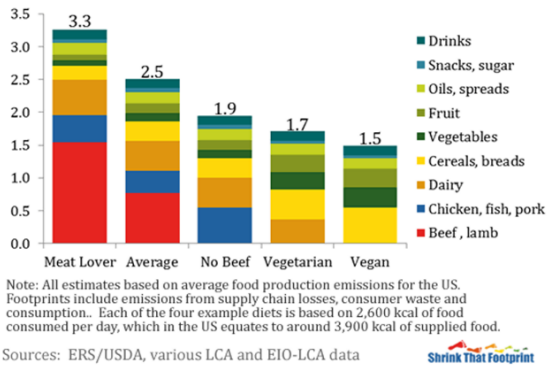

Figure 3: Footprints by Diet Type

In a balanced vegetarian diet, an adult Indian man consumes 1165g of food and emits approximately 724g CO2 eq. GHG. A mutton inclusive non-vegetarian meal emits 1.8 times more GHG than that of a vegetarian meal, 1.5 times more than a chicken inclusive non-vegetarian meal and an ovo-vegetarian meal, and 1.4 times more than that of a Lacto-vegetarian meal. Look through Table 2 to have an idea about the emissions. Hence, changing food habits can surely play a role in GHG mitigation.

Crop/animal product	GHG emission (g kg^{-1})			
	CH_4	N_2O	CO_2	GWP (CO_2 eq.)
Wheat	0.0	0.3	45.0	119.5
Rice	43.0	0.2	75.0	1221.3
Rice, basmati	53.7	0.3	82.5	1515.4
Pulse	0.0	0.8	83.3	306.8
Potato	0.0	0.1	10.0	24.9
Cauliflower	0.0	0.1	13.3	28.2
Brinjal	0.0	0.1	12.5	31.1
Oilseed	0.0	1.3	50.0	422.5
Poultry meat	0.0	2.7	50.0	846.5
Mutton[a]	482.5	0.0	0.0	12,062.7
Egg	0.0	2.0	1.0	588.4
Milk[a]	29.2	0.0	0.0	729.2
Banana	0.0	0.2	10.0	71.6
Apple	0.0	1.0	41.7	331.4
Spice	0.0	2.5	100.0	845.0
Fish	25.0	0.3	18.8	718.3

Source: calculated from Bhatia et al. (2004), NATCOM (2004), Chhabra et al. (2009), Pathak et al. (2009b) and Jain et al. (unpublished).

Table 2: GHG, CH4, N2O, CO2, and CO2 eq. emissions of different types of food.

ENVIRONMENTAL IMPACT:

In the Indian agricultural setup, meat production plays a vital role in the setup. India is ranked 5th in the world in terms of the volume of production. The country in the year 2020, had produced over 8 million metric tons of meat, which can be accounted to be an increase of approximately 30% from being 2.3 million metric tons in 2006. Apart from this, the world poultry meat production soared from being 9 million metric tonnes to 135 million metric tons between 1961 and 2021. Apart from these, the egg production and demand shot up from being 15 million metric tonnes to 91 million metric tonnes.

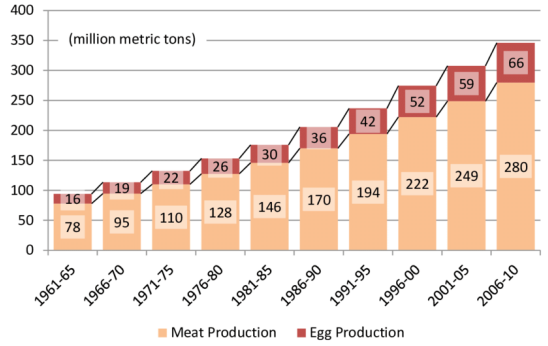

Figure 4: Growth graph of meat and egg production (in million metric tonnes)

Looking through major growth in Asia, the world egg production has increased by more than 150 percent in the last three decades. Due to the large cattle populations, Latin America, regionally tops the list in terms of GHG emissions. Similar is the case for other beef exporting countries. Methane (CH4) is the highest potential gas for global warming in the atmosphere, and cattles very majorly contribute to it. Per year, a dairy cow produces about 75kg of methane (CH4), which is equivalent to more than 1.5 metric tons of carbon dioxide (CO2). Around 6% of the GHG is contributed by livestock in the form of CH4. Over the past 25 decades, the atmospheric CH4 concentrations have raised up by 150%; and by 2030, it is further expected to rise by 60%.

Meat production is a very inefficient procedure. This can be explained further by using the '10% Law'. During the involvement of every step while the production, 90% of the energy is lost and only less than 10% of energy is retained. The more the number of transitions involved, the lesser would be the efficiency of any food. For livestock production, there are two phases involved (Figure 5). Firstly the solar energy is captured by plants and trees, then those food grains are further consumed by the animals, which are then consumed by human beings. Hence, the efficiency of the meat is hardly 1-3%. Although, in the case of plants/vegetables,

the product is directly available for humans to consume, without the involvement of other extra phases. Hence, this is why vegetables and plants, mainly the vegetarian diet are so efficient.

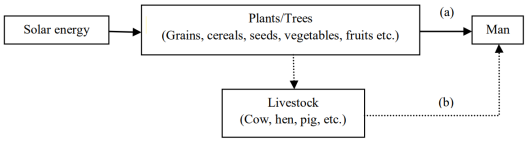

Figure 5: Trophic level(s) in vegetarian's ('a') and non-vegetarian's ('b') diet

IMPACTS OF ANIMAL PRODUCTION ON LAND AND WATER:

To meet the driven demand for poultry, meat, and eggs, we additionally require more food grains, crops, water, land, resources, energy, and cereals for the purpose of growth and reproduction of livestock. More land resources would be required for housing and crop production for the increased meat production, which can further shoot up the use of fertilizers of pesticides, increased water pollution, degradation of wildlife habitat, rise in soil erosion, and water pollution. According to the United Nations, 30% of the available land is used for raising animals/ livestock for food production; such as to grow feed crops and grazing. Approximately 21 m2 of land is required to produce 1 kg of beef, 8.9 m2 for pork, and about 7.5 m2 for broilers. According to similar considerations, in 2002, the total land used for meat production was 2.54 million km2, whereas this is expected to be around 6.6 million km2 by the year 2050. This is an increment of about 2.5 times. 70% of the agricultural land is utilized in the rearing of livestock for eggs, poultry, and meat.

In 2002	Beef	Pork	Poultry	Total
Land usage (km^2)	1252849	657692	615806	2526347
In 2020				
Land usage (km^2)	2144609	936180	1017447	4098236
In 2050				
Land usage (km^2)	3604887	1324532	1664808	6594227

Figure 6: Land Usage for Beef, Pork, Poultry, and total land consumption

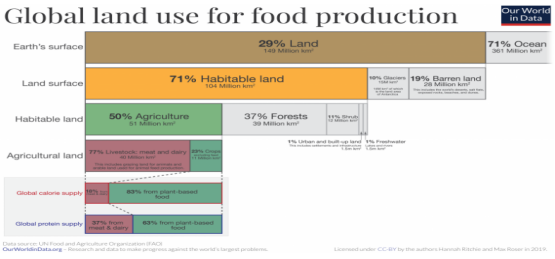

Figure 7: Global land use for food production

According to Mishra (2012), to grow 1 kg of wheat it takes 95 litres of water, whereas to produce 1 pound of meat takes more than 9000 litres of water. To produce 1 kg of chocolate, coffee beans, beef, sheep and goat meat, pig meat, fruits, and vegetables it needs 24,000 liters, 21,000 liters, 15,500 liters, 8,800 liters, 6,000 liters, 1,000 liters, and 300 liters respectively. For producing 1 kg animal protein, it straight up needs 100x more water than that of production of a kilogram of grain protein. Livestock directly requires only 1.3% of the total water used in agriculture but when the water required for forage and grain production is included, the water requirements for livestock production significantly increase. One can save more water by not eating a kilogram of meat than by not showering for 6 days.

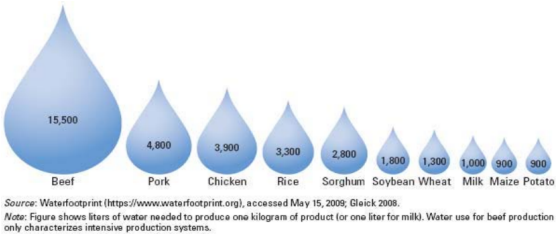

Figure 8: Water requirement of meat, poultry, milk and vegetables

Around a total of 300 gallons of water per day is required for a totally vegan diet, whereas more than 4,000 gallons of water per day is required for a typical meat-eating diet.

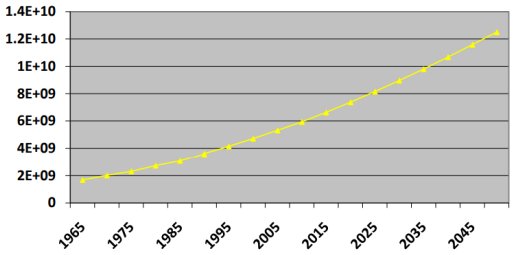

Figure 9: Water required for meat production (In 1000 kilo litres)

RELATION BETWEEN MEAT CONSUMPTION AND PER CAPITA INCOME:

Modern lifestyle and per capita income go handy. The higher the per capita income is, the better would be the lifestyle. Meat in comparison to fruits and vegetables is expensive, and hence only the people with high per capita income can actually afford it. Over time, the Per capita Purchasing Power (PPP) of people has increased with the increase in Per capita GDP, as seen in the trends and the data indicated in Table 3, the per capita meat consumption has also proportionally driven

up.

Year	Per Capita GDP $2000	Population	GDP $2000	Total Meat/ 000 Metric Tons	Per Capita Meat in kg
1965	$2,825	3,337,974	$9,429,556	84,437	25.3
1970	$3,299	3,696,588	$12,194,430	100,624	27.2
1975	$3,581	4,073,740	$14,587,570	115,765	28.4
1980	$3,966	4,442,295	$17,616,910	136,682	30.8
1985	$4,136	4,843,947	$20,032,840	154,421	31.9
1990	$4,535	5,279,519	$23,944,060	179,958	34.1
1995	$4,727	5,692,353	$26,910,310	206,755	36.3
2000	$5,217	6,085,572	$31,745,760	235,121	38.6
2005	$5,654	6,464,750	$36,554,731	265,236	41.0
2010	$6,103	6,842,923	$41,765,656	296,199	43.3
2015	$6,588	7,219,431	$47,562,691	331,138	45.9
2020	$7,111	7,577,889	$53,888,672	368,316	48.6
2025	$7,676	7,905,239	$60,680,624	407,148	51.5
2030	$8,286	8,199,104	$67,934,006	447,475	54.6
2035	$8,943	8,463,265	$75,691,056	489,447	57.8
2040	$9,654	8,701,319	$83,999,657	533,234	61.3
2045	$10,420	8,907,417	$92,817,529	578,429	64.9
2050	$11,248	9,075,903	$102,083,102	624,530	68.8
1965-2005 Increase	100.2%	93.7%	287.7%	214.1%	62.2%
2005-2050 Increase	98.9%	40.4%	179.3%	135.5%	67.7%

Table 3: Comparison between Per Capita GDP and Meat consumption

The richer the country, the greater is the meat consumption. It is quite evident and self-explanatory in the comparison attached below (Figure 10). All the countries having $12,000 to $15,000 per capita GDP are considered to be the developed nations. As observed, almost all the 'developed nations' have higher meat consumption rates as compared to the developing nations.

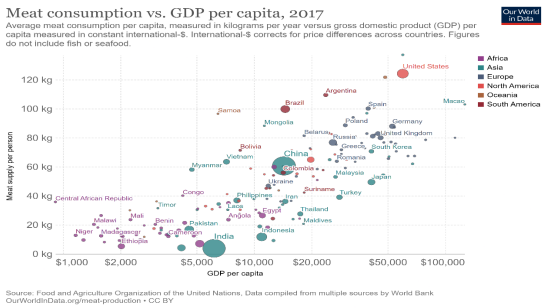

Figure 10: Meat consumption vs. GDP per capita (country-wise)

IS HIGH CONSUMPTION OF MEAT A PROBLEM?

Meat is a very inefficient food to consume. Inefficient with respect to our body, and for the environment. In comparison to corn, meat takes up 75 times more energy and resources to be produced. It also requires 7 times the land we actually require for vegetation for humans to feed the livestock animals. The production, compared to any other food source takes up more land, water, and energy. As explained in the above sections, meat production has the highest CO2 and GHG emissions, hence playing a vital negative role in climate change. The human diet has changed drastically over the years. Looking through current food consumption patterns in western countries, with the population reaching almost 10 billion by 2050, the world would be too big to feed.

The reasons are many to state that yes, high consumption of meat is genuinely a problem. Not just for your body, but the environment, and the climate more.

SOLUTION:

According to the current emission levels, the rise in GHG emissions expected are of a drastic 150% by 2050. So, to get in control and minimize all of it, there is an urgent need in finding ways in which we can mitigate the negative impact of environmental footprint and climate change due to the current lifestyle and food system. According to research published in Nature from Oxford University, western countries must cut short their meat consumption by 90% to mitigate climate change. A sure shot solution to minimize the overall negative impacts for this worldwide issue is having a sustainable diet. A sustainable diet is one with production that has minimum environmental impact, is respectful and protective of ecosystems and biodiversity, and is nutritionally adequate, safe, healthy, culturally acceptable, and economically affordable. Meat consumption is not economically and ecologically sustainable and feasible for Earth. Radical changes in food consumption patterns and lifestyle, emphasizing vegetarian food over livestock, poultry, and dairy are a must for the sustainability of our mother Earth. People must shift towards consuming low carbon print diets (vegetarian or vegan), which is comparatively has a lower environmental impact. Environmental educationists can bring on a huge impact by educating and guiding children and adults about the changemakers that they can be. It is now, or never.

CONCLUSIONS:

Going through the above sections, the scenario is very clear and understandable. The ongoing scenarios of food consumption and production is neither environmentally sustainable nor practically feasible, mainly non-vegetarian (meat, poultry, and seafood). There is an urgent need to take into count the environmental impacts caused by our consumption patterns and interests. Issues such as water pollution, land usage, global warming, animal slaughtering, and climate change can be negatively inclined towards a positive change by either shifting towards vegetarianism (or veganism) or by lowering meat consumption and other animal-based products. According to the available data, the damage caused to the wildlife, climate, water systems, soil cannot be sustained. Quickly replacing livestock with a vegetarian diet can help us achieve reductions in atmospheric GHGs, food and water crisis, and help us reduce animal slaughtering. Slaughtering animals in the name of self-satisfaction and joy is not ethical, and should be stopped or at least reduced as soon as possible. Animals deserve a life, so does our future

generation. Vegetarian diets must be encouraged and promoted by the government and the people. Because of every gram of meat, and every life of an animal matter.

REFERENCES:

[1] Foresight, The future of food and farming. Final Project Report, London: Government Office for Science (2011).
[2] Fanzo, J., & Mattei F., Ensuring agricultural biodiversity and nutrition remain central to addressing the MDG1 hunger target. In: Burlingame, B., & Dernini, S. (editors), Sustainable diets and biodiversity: directions and solutions for policy, research and action. Rome: Food and Agriculture Organization, 44-53 (2012).
[3] Jessica, L. J., Jessica, C. F., & Bruce, C., Understanding sustainable diets: A descriptive analysis of the determinants and processes that influence diets and their impact on health, food security, and environmental sustainability. Advances in Nutrition, 5, 418-429 (2014).
[4] Nemecek, T., Jungbluth, N., Canals, L. M. & Schenck, R., Environmental impacts of food consumption and nutrition: where are we and what is next? International Journal of Life Cycle Assessment, 21, 607-620 (2016).
[5] Audsley, E., Brander, M., Chatterton, J., Murphy-Bokern, D., Webster, C., & Williams, A., How low can we go? An assessment of greenhouse gas emissions from the UK food system and the scope to reduce them by 2050. Food Climate Research Network & WWF, London, UK (2009).
[6] Garnett, T., Where are the best opportunities for reducing greenhouse gas emissions in the food system (including the food chain)? Food Policy, 36, S23–S32 (2011)
[7] Bouwman, L. , Goldewijk, K. K., Hoek, K. W. V. D. , Beusen, A. H. W., Van Vuuren, D. P., Willems, J., Rufino M. C. &, Stehfest, E., Exploring global changes in nitrogen and phosphorus cycles in agriculture induced by livestock production over the 1900–2050 period. In Proc. of National Academy of Science of the United States of America, 110 (52), 20882–20887, Nov. (2013).
[8] Godfray, H. C. J., Beddington, J. R. Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., Pretty, J., Robinson, S., Thomas, S. M. & Toulmin, C., Food Security: The Challenge of Feeding 9 Billion People. Science, 327(5967) 812-81812 (2010).
[9] "This Survey Found Out How Many Indians Are Non-Vegetarians And Which State Is The Least Vegetarian" June (2016). https://www.scoopwhoop.com/This-Survey-Found-Out-How-Many-IndiansAre-NonVegetarians-And-Which-State-Is-The-Least-Vegetarian/
[10] https://www.reuters.com/article/2015/07/21/us-israel-food-vegan-idUSKCN0PV1H020150721
[11] "The slow but steady rise of vegetarianism in Australia". August (2016). http://www.roymorgan.com/findings/vegetarianisms-slow-but-steady-rise-in-australia-201608151105
[12] "Vegetarians, vegans 'hated and bullied in Australia', author says". ABC. August (2016). http://www.abc.net.au/news/2016-08-02/vegetarians-vegans-hated-bullied-australia-richard cornish/7680900
[13] "One in ten Swedes is vegetarian: survey" March (2014). http://www.thelocal.se/20140321/one-in-tenswedes-is-vegetarian-survey
[14] "Il popolo dei vegetariani e vegani in Italia: l'infografica". http://www.repubblica.it/cronaca/2015/09/17/news/il_popolo_dei_vegetariani_e_vegani_in_italia_l_infografica-123063811/
[15] Linseisen, J., Welch, A. A., Ocke, M., Amiano, P., Agnoli, C., Ferrari, P., Sonestedt, E., Chajes, V., Bueno-de-Mesquita, H. B., Kaaks, R., Weikert, C., Dorronsoro, M., Rodrıguez, L., Ermini, I., Mattiello, A., van der Schouw, Y. T., Manjer, J., Nilsson, S., Jenab, M., Lund, E., Brustad, M., Halkjær, J., Jakobsen, M. U., Khaw, K. T., Crowe, F., Georgila, C., Misirli, G., Niravong, M., Touvier, M., Bingham, S., Riboli, E. & Slimani, N., Dietary fat intake in the European prospective into cancer and nutrition: results from the 24-h dietary recalls. European Journal of Clinical Nutrition, 63, S61–S80 (2009).
[16] Pan, A., Sun, Q., Bernstein, A. M., Schulze, M. B., Manson, J. E., Stampfer, M. J., Willett, W. C., Hu, F. B., Red meat consumption and mortality: results from 2 prospective cohort studies. Archives of Internal Medicine, 172, 555-563 (2012).
[17] Food and Agriculture Organization, Meat and meat products. Food Outlook, June (2008).
[18] Food and Agriculture Organization, Livestock's long shadow, environmental issues and options (2007).
[19] "An Analysis of Changing Food Consumption Pattern in India", National Council of Applied Economic Research, New Delhi. http://nfsm.gov.in/
[20] Sample registration system baseline survey (SRSBS) (2014). www.censusindia.gov.in/vital_statistics/BASELINE%20TABLES07062016.pdf
[21] http://www.deccanchronicle.com/lifestyle/food-and-recipes/110616/telangana-is-india-s-most-non-veg state.html
[22] Wathes, C. M., Holden, M. R., Sneath, R. W., White R. P. & Phillips, V. R., Concentrations and emission rates of aerial ammonia, nitrous oxide, methane, carbon dioxide, dust and endotoxin in UK

broiler and layer houses. British Poultry Sciences, 38(1), 14-28 (1997).
[23] IPCC, The regional impacts of climate change: An assessment of vulnerability. Cambridge University Press, U.K. (1997).
[24] Gerbens-Leenes, P. W. & Nonhebel, S., Consumption patterns and their effects on land required for food. Ecological Economics, 42(1-2) 185-199 (2002).
[25] United States Environmental Protection Agency. https://www.epa.gov/energy/greenhouse-gasesequivalencies-calculator-calculations-and-references
[26] https://www.theworldcounts.com/challenges/consumption/foods-and-beverages/world-consumption-of-meat/story
[27] https://hbr.org/2016/04/global-demand-for-food-is-rising-can-we-meet-it
[28] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7068262/
[29] IPCC. (1997). The regional impacts of climate change: An assessment of vulnerability Cambridge University Press. UK.
[30] Ashutosh Kumar Choudhary , Nagendra Kumar, “ENVIRONMENTAL IMPACT OF NON-VEGETARIAN DIET: AN OVERVIEW” IJESRT, 16 August, 2017, 6 PP. 251-257 (8). doi: 10.5281/zenodo.843908
[31] Mukesh Kumar Mishra, “Modern Lifestyle, Non Veg Food and its Impact on Environmental Aspects”, Global Journal of HUMAN SOCIAL SCIENCE, Volume 12 Issue 7, April 2012.