

SUSTAINABLE DIET WITHIN GLOBAL FOOD SYSTEM: FROM PEOPLE TO PLANET TO PEOPLE

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ABSTRACT:

Sustainability in the global food system is a pressing matter. Healthy and nutritious diet should have Minimal environmental footprints, it is a highly debatable topic. Food scientists, local farmers, food manufacturers, private sectors and governments regularly plan round-tables to dictate new policies. However, one or more party usually oppose the new policy, which is the major conundrum of Sustainable Diet within global food system. This paper deals with Sustainable Diet Notions, tackling food waste and agro-waste, understanding different supply chains in the food system and how circular economy should be effectively implemented. Multiple innovative approaches are introduced from multidisciplinary and circular economy perspectives to: a. Reduce carbon footprints, b. Save resources and huge economic burden of waste control, c. Provide an idea for a new possible merging market based on eco-friendly technology, d. Significantly reduce food waste, e. Significantly reduce food insecurity, hunger and hidden hunger.

KEY-WORDS: Circular economy, Food insecurity, Food waste, GHG emissions, Sustainable diet.

1. INTRODUCTION

Sustainable Diet as per UN SDG2 (Zero Hunger), is to provide healthy and nutritious diet which meets sociocultural norms, economically affordable, available throughout the year, and finally with minimal environmental impacts. Sustainable Diet has a pivotal role on reducing Greenhouse Gas emissions (air footprint), Soil footprint (protection of topsoil, low erosion, low intensive farming and reforestation) as well as water footprint

with (no physical and chemical pollutants), with minimal exploitation to rangelands, maintaining sustainable fishing methods, adopting regenerative traditional agriculture methods with recent innovative technologies and limiting industrialized conventional agricultural methods, i.e. monoculture (planting one crop in the field such as rice, maize or wheat) with intensive use of insecticides, pesticides and inorganic fertilizers, accompanied by heavy machinery reliance and low labor in the field. (Medicine et al, 2019).



Fig. 1. Elements of sustainable diet (Environmental, Social and Economic) which illustrate the meaning of sustainability in the global food systems.

Obtained from: https://www.researchgate.net/figure/The-key-components-and-determinants-of-a-sustainable-diet-Johnston-et-al-2014_fig1_360239396 The key components and determinants of a sustainable diet (Johnston et al, 2014). Sustainable Diet had environmental, Social and economic aspects. That food has to be healthy, balanced, affordable, available and with minimal ecological impacts.

Green revolution: 1960s is a turning point from traditional farming to industrialized farming (Crain, 2024)

- It increased crops production but also increased insecticides, pesticides and unprecedented rise of new diseases.
- It merged inorganic fertilizers use for more land fertility, but also harmed the environment, as in Eutrophication which reduces the water quality of lakes and rivers, as well as harming aquatic life.
- Machinery replaced labor, but also there is intensive farming, soil erosion, loss of topsoil and land fertility.
- Monocrop and loss of biodiversity: Nowadays 50% of energy crops comes from rice, wheat, and maize.

Theoretically, sustainable diet implementation seems applicable, but in practice it is not easily possible since multiple drivers have to be considered in achieving Global Sustainable Diet System.

Stakeholders of sustainable diet usually make it a very hard controversial choice, it is quite difficult to convince manufacturers, local farmers, private sectors, food banks, governmental and non-governmental institutions to finalize legislations towards achieving Sustainable Diet System (Herens et al., 2022). Civil society and consumers are a major target in achieving Sustainable Diet goals, the challenge is in resistance to adopt Sustainable Diet System. What makes it more challenging is that many people lack awareness of home economics, proper dietary and culinary knowledge. Nevertheless, it is promising that many food industry entities started to have commitments towards applying SDGs in their businesses with

circular economy multi-sectorial cooperation to reduce food emissions, enhance livelihood of people and raising proper sustainable diet awareness (Private Sector Engages with FAO on Improving Food Security and Agriculture Sector Sustainability, 2024).

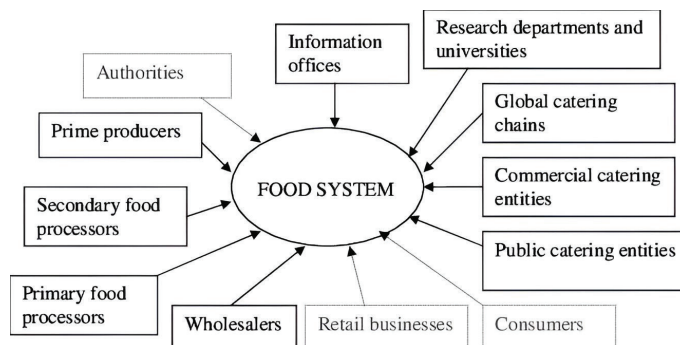


Fig. 2. Stakeholders in the food system.

Obtained from: https://www.researchgate.net/figure/Organisations-represented-in-the-two-empirical-studies_fig1_277204301. Food systems have multiple stakeholders (Governmental & non-governmental organizations, local farmers, private sector, processing factories, research centers, retailers and consumers), each has a profound role in maintaining sustainable food system.

2. A CHALLENGE OF ACHIEVING HEALTHY FOOD SECURITY FOR PRESENT AND FUTURE GENERATIONS

Diet is a interconnected topic. The aspect of healthy food is an enormously studied topic in terms of diet-related diseases, disease-care and prevention (overweight and obesity, severe hunger diseases, i.e. stunting and wasting and hidden hunger diseases, i.e. anemia), in another word non-communicable diseases as in: Cardiovascular diseases, high blood pressure, cancers, osteoporosis and diabetes type 2. In 2024: 695 million people, approximately 10% suffer from mild to severe hunger (HungerMap LIVE, 2024).

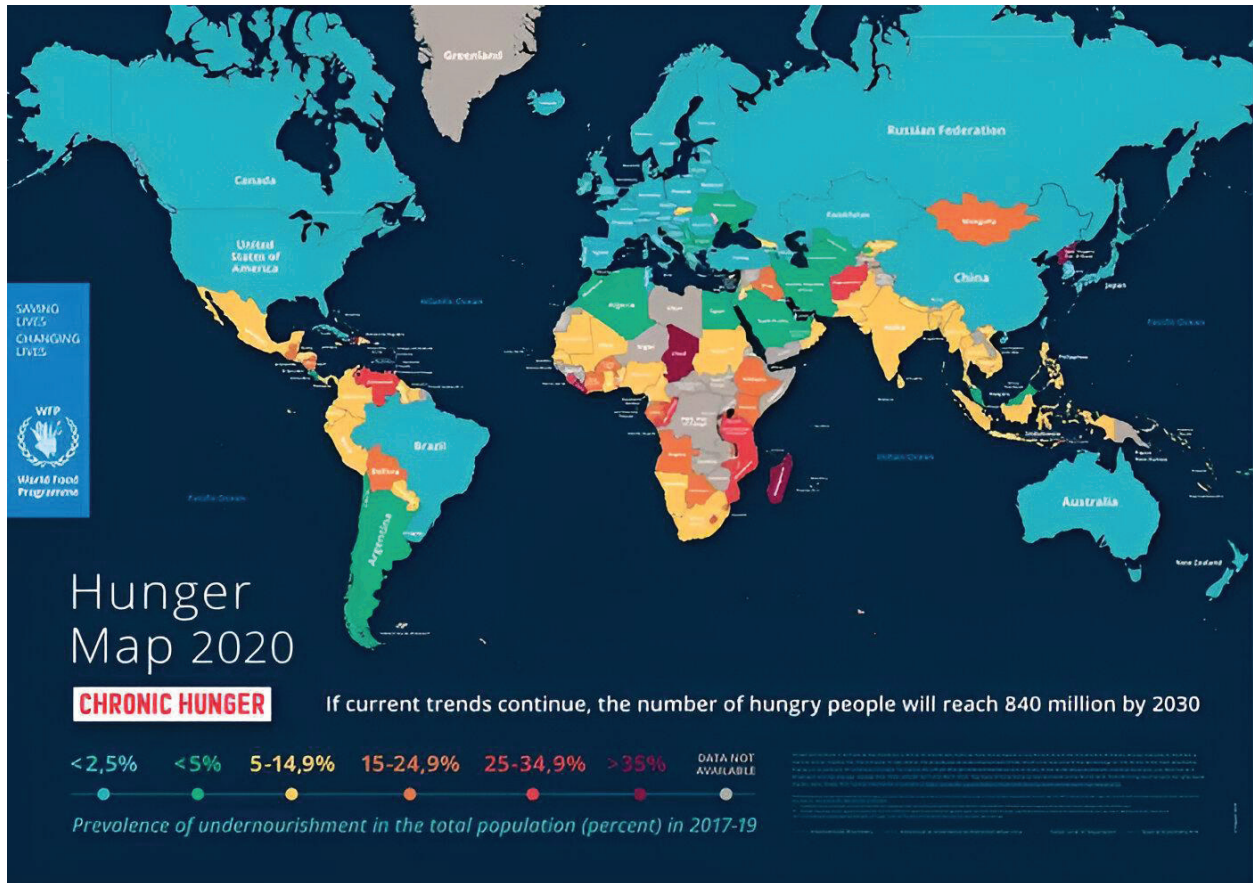


Fig. 3. Hunger map 2020.

Obtained from: <https://reliefweb.int/map/world/hunger-map-2020> (WFB, 2020). Blue and Green colors represent countries with low levels of hunger, Yellow and Orange countries indicate mild levels of hunger, Deep Orange and Red represent severe food insecurity and Grey means no data available. As per analytical provisions: hungry people will reach 840 million by 2030 if no further actions taken.

1 billion people suffer from obesity (diabetes 2 and/or CVDs) which costs \$2 trillion annually, it is

projected to reach 1.53 billion by 2035. (Prevalence of Obesity | World Obesity Federation, 2024).

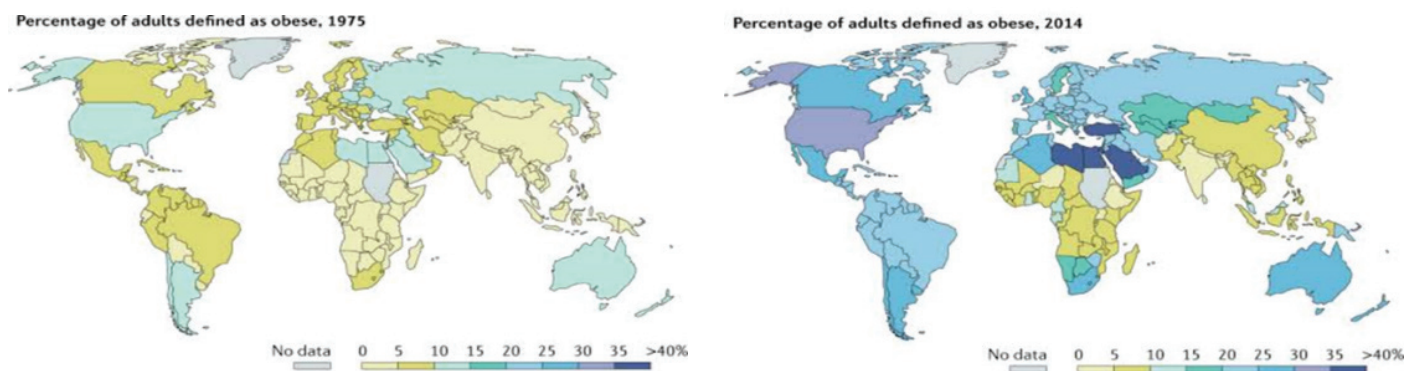


Fig. 4. Obesity prevalence in years 1975 and 2014.

Obtained from: <https://www.nature.com/articles/s41574-019-0176-8>, (Blüher, 2019). The picture on top shows obesity prevalence between adults in 1975, where there were no obesity levels even in developed countries. In the contrary the picture below illustrates the obesity prevalence between adults in 2014, where obesity has drastically increased in the world especially in the developed countries, where there are surplus of food throughout the year. Deep Blues and Blue colors show extreme and high levels of obesity; deep and light Green colors show low and mild percentages of obesity, White color shows no obesity and Grey color shows no data available.

2 billion people suffer from hidden hunger (lack of one or more essential micronutrients) with continuing rise in mortalities because of diet-related diseases (Micronutrient Forum, 2023).

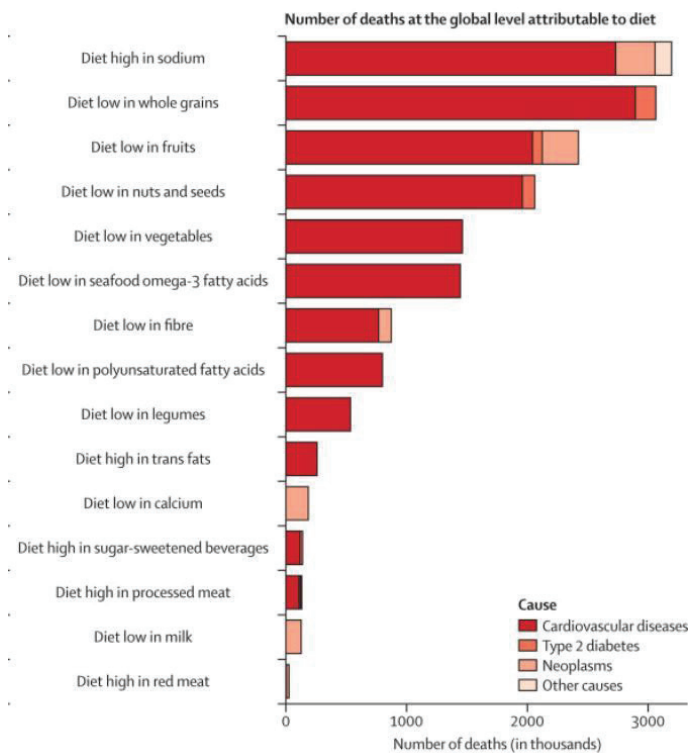


Fig. 5. Diet-related mortality rate and number of deaths in thousands.

Obtained from: [http://dx.doi.org/10.1016/S0140-6736\(19\)30041-8](http://dx.doi.org/10.1016/S0140-6736(19)30041-8) (Ashkan et. al, 2019). High and low levels of different diets (high sodium, high sugar, high processed meat, low fruits, low whole grains...etc.) cause death between populations from CVDs, Diabetes 2, Neoplasms, and other causes. Statistically cardiovascular diseases have the highest number of deaths because of diet-related complications. For instance, diet low in fibres resulted in approximately 1000 deaths of people due to cardiovascular diseases.

In developed countries there is food surplus because of the continuous breakthroughs in the food production system. However, food need is not limited to availability of food, but it also goes beyond that to the quality of food and availability of essential micronutrients (Vitamins and Minerals), macronutrients (Protein, Fats and Carbohydrates) and other functional food elements for chronic diseases care and prevention, i.e. fruit flow, beta glucan, probiotics & prebiotics...etc.

Research undertaken by Dr. August Dunning (founder of Eco Organics) illustrates that in order to get the amount of iron one uses to get in 1950 from one apple by 1998 one needs to eat 25 apples,

nowadays to get the same amount of iron, one needs to eat 36 apples. This reflects the continuing deterioration in nutritional quality of food due to chemical usage in industrial farming with high CO2 emissions, this is compounded by bad eating habits that people tend to eat more refined sugars and saturated fats, which is associated with rise in chronic diseases like: Cardiovascular disease and Diabetes2, and Mineral Deficiencies - Team Dream Extreme (2019).

In developing countries people suffer from mild to severe food insecurity and hunger; food is neither available nor healthy. World population is projected to reach 9.7–9.8 billion by 2050 (Worldometer, 2024). There will be 2 billion people who will not find enough food resources, simply because the amount of natural resources is fixed. So, the challenge here is to increase food resources in the same land size without causing environmental impacts of climate change due to deforestation, land exploitation, destroying ecosystem and reducing biodiversity (The Challenge – Global Food Security, 2023).

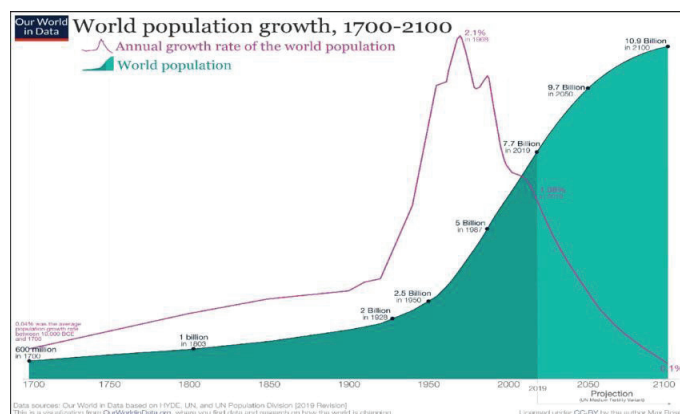


Fig. 6. World population growth from 1700 to 2100,

source: *Environmental Conservation Journal*, DOI:10.36953/ECJ.2021.SE.2202 (Karamveer et. Al, 2021). The annual growth rate was in a slight increase from 1700 till 1900, then it considerably peaked in 1963 with 2.3% increase rate. As per world population: it elevated substantially after 1950 to reach 8 billion in 2023 with projections of more elevation to reach 9.7 billion in 2050 and 10.43 billion in 2100.

Fortunately, sustainability awareness is considerably rising, many industries began to adopt sustainability commitment in their industries, such as Unilever which is committed to enhancing wellbeing and health for >1 billion people, reducing environmental impacts by half and consolidating livelihood for millions. Tesco is also committed to have a 300% sales increase in meat alternatives by 2025 (Smithers, 2020).

3. SOCIOCULTURAL ASPECTS OF DIET WITHIN THE GLOBAL FOOD SYSTEM

Sociocultural norms are not easily broken. Has one ever thought of how hard it is to gather all people around the world to accept certain types of food? Food for most people is about culture, beliefs, social activity, joy and traditions. As per Professor Claude Fischer, "Man feeds not only on proteins, fats, and carbohydrates, but also on symbols, myths and fantasies" (Fischler, 1988).

There are gender and age preferences & stigmas; for instance, male teenagers relate meet eating to masculinity. Furthermore, religious beliefs profoundly affect food choices; Muslims do not drink alcohol or eat pork as it is Haram in Islam religion. Geographical locations also have influence on how

food is cooked or served; in USA and UK food is individualized. On the contrary, in France, Italy and Switzerland, food is about joy in gatherings, eating takes times as family gather around the table.

Paul Morand (French), in 1937 described New Yorkers lunch: they eat standing up, fast, with their hat on, in a row "like in a stable.", which indicates absence of rules and lack of social exchange.

Daniel Lerner (American), in 1956 described French eating habits to be "rigid" and he was surprised to see them eating ritually and at set times: "like in a zoo". Excess of rules, seen as a hindrance to choice (Odile, 2012) as also mentioned in "EATING. French, European, and American Attitudes Toward Food" by Claude Fischler and Estelle Masson. (2008).

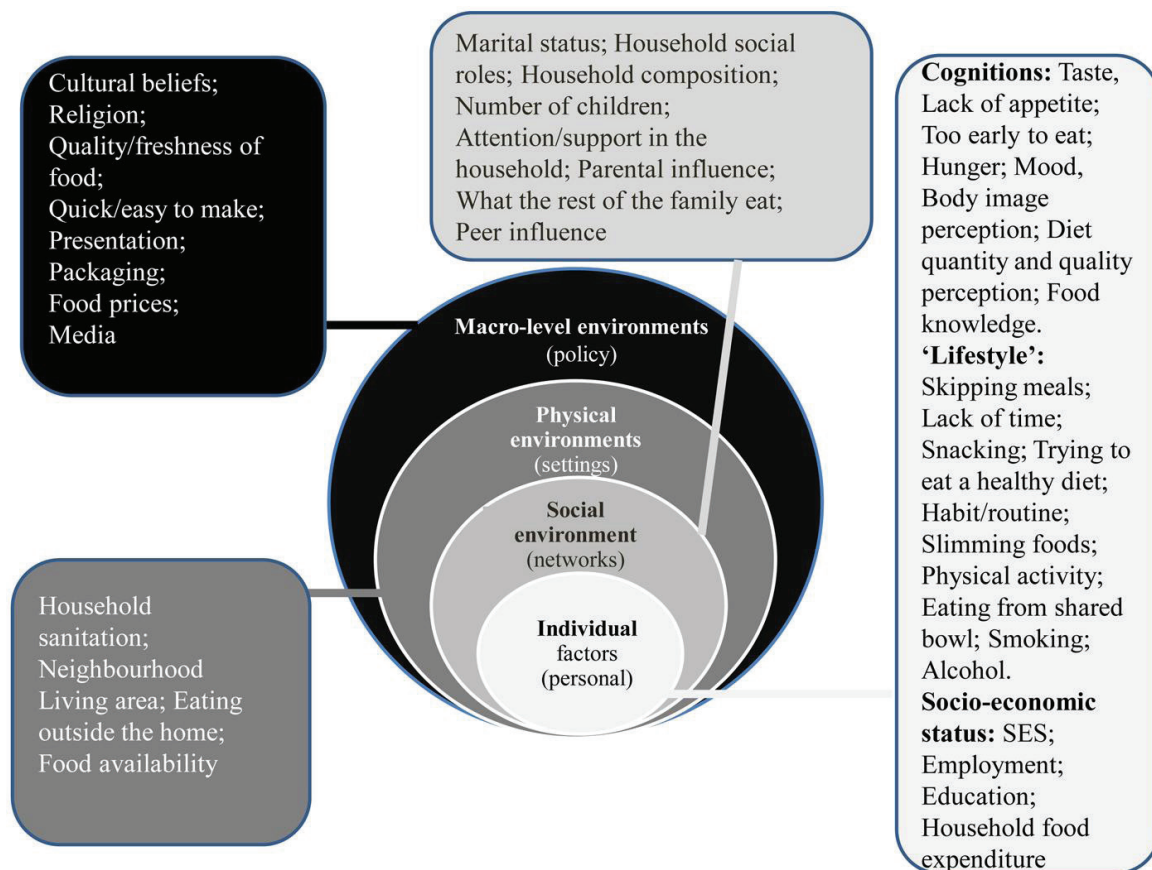


Fig. 7. Investigating different Food environments which affect sociocultural aspects of food.

Obtained from: <https://doi.org/10.1017/s0029665118002938> (Holdsworth & Landais, 2019). Factors influencing dietary behaviors from individualistic aspects (physical activity, employment, education...etc.), networks as in peer influence, physical as in (communities & neighborhood) and macro environments as in (country, culture, religion and beliefs).

4. SYNERGIES AND TRADE OFFS WHEN MOVING TOWARDS SUSTAINABLE FOOD SYSTEM

Alternatives to major emitters in the food system have pros and cons, accompanied with diet controversies and debates on both scientific, market and consumer’s level.

A. Animal-based Protein Alternatives

Livestock production is a major damage to the environment basically due to deforestation with extremely high levels of GHG emissions and endangering biodiversity. It is estimated that around 60% of environmental resources are already wasted or used unsustainably. In many western countries, people consume higher portions of meat than their daily requirements, by 2050 there must be 70% more food production in the limited food system resources to cover population dietary needs (Valli et al., 2022).

responded that they adopt meat substitutes in their diet, UK has the highest tendency towards plant-based proteins with 21% and India resembles the lowest meat consumer amongst countries with 53% consumption rates.

Meat alternatives could possibly be a highly recommended solution to this conundrum. Plant-based proteins are an option as in Soy, Legumes and Cereals; Edible Insects are also a recent trend as a sustainable alternative to livestock production; aquaculture, seaweeds and algae are a possible replacement that are part of global diets as in Okinawa Diet in Japan and other Asian cuisines; Finally, cultured meat is widely considered in recent scientific research as a sustainable source of animal protein that gives the same organoleptic as natural meat (Andreani et al., 2023).

All of the abovementioned choices are manufactured in environmentally sustainable ways. However, there is a controversy amongst the population that some options are repulsive, others are not tasty or may be culturally unacceptable.

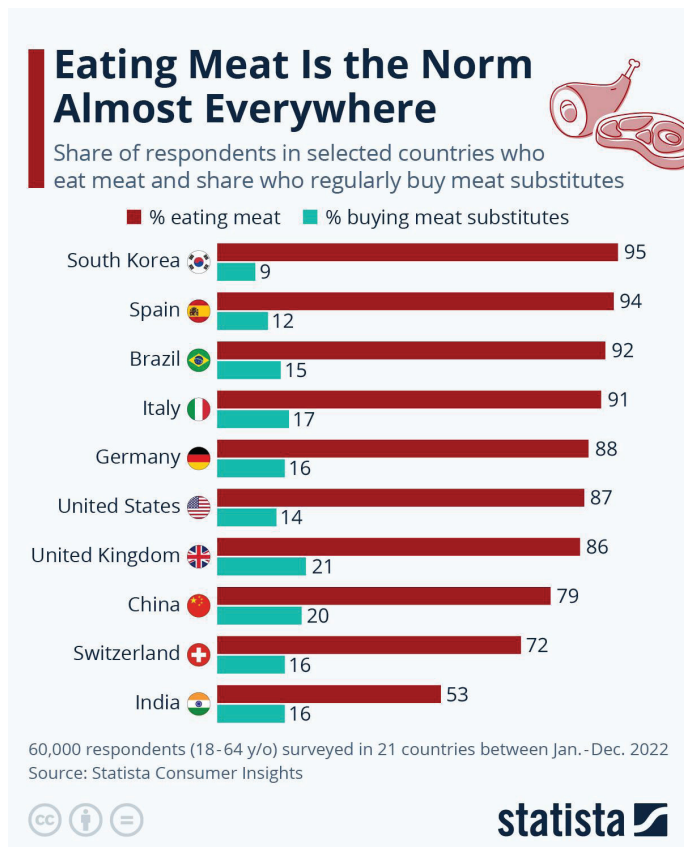


Fig. 8. People who identify themselves as meat eaters in different countries.

Obtained from: <https://www.statista.com/chart/24899/meat-consumption-by-country/>, (Buchholz, 2023). From 60,000 respondents (9-21%) preferred meat alternatives, compared to (53-95%) who preferred animal protein. South Korea has the highest levels of meat eaters representing 95% and 9% only

1. Edible insects:

Entomophagy: Eating insects by humans was popular since the prehistoric age. There are over 1900 species of edible insects. Insects are very high in protein (all of the essential amino acids) and they taste like chicken. Insect’s breeding is environmentally friendly and sustainable; there are no fertilizers involved in the process and more importantly with much lower feeding rates than livestock. What is more interesting about the fodder is that it comes from organic waste, so it applies 4R Framework of Circular economy with reducing, reusing, recycling and recovering.

Insects are introduced in the market as crushed, powder, burger, bars, pasta or as a whole. The only barrier nowadays is public acceptance and cultural taboos that many people find eating insects repulsive and culturally unacceptable (“Thinking About the Future of Food Safety,” 2022).

2. Cultured meat:

In vitro cultured meat burger was produced for the first time in 2013 with minimum environmental impacts and less land and water consumption compared to livestock breeding. Stems cells of animals are extracted then they grow further into muscle tissues. Burgers, minced meat and meat balls are produced to mimic slaughtered

livestock meat, but without slaughtering and more importantly, cultured meat can be tailored to be low in fat and meet nutritional needs (Wu, 2022).

The challenge in this business is to convince consumers to replace livestock meat products with cultured meat. There is a debate that although it is promising, it is still coming from animals and production takes so much time and money than conventional methods, at the same time the available options in the market are still limited and expensive.

3. Plant-based meat analogues :

Soy and legumes can be good replacements to animal-based protein. Although most of plant-based proteins lack one or more of essential amino acids such as: Methionine, Lysine and Tryptophan, with proper combinations from different plant sources as in cereals, pseudocereals and legumes, all essential amino acids can be obtained (Wild, 2016).

Recently, German entrepreneurs from Frosta Aktiengesellschaft invented vegan seafood alternatives, they call it "Fish from the Field" with 100% plant-based ingredients.

Legumes fix nitrogen into the soil, so they enhance soil fertility and productivity, especially when they are planted with crop rotations. Legumes lower the risk to chronic diseases, since they are saturated-fat-free and Cholesterol-free.

Soy is the only plant on earth which carries all essential amino acids, it can be used as meat analogues in Tofu or Tempeh. However, the regular consumption of Soy products causes disturbances in thyroid hormones and soy contributes to massive land deforestation and biodiversity loss.

4. Microalgae and seaweeds:

Algae is commonly eaten in Asian cuisine, as Sushi wrapping sheets and Miso soup. They are divided into one cell microalgae; as in spirulina and chlorella supplements, they exist also as macro algae as in seaweeds. Algae contains high amounts of proteins, PUFA (Poly Unsaturated Fatty Acids) and Iodine.

Micro and macro algae are friendly to the environment as they need few resources for

production, more interestingly they are fed on organic waste, their reproduction is very fast, twice as fast as soy and corn. Furthermore, algae are very effective in capturing CO₂ through photosynthesis process (Meng et al., 2022).

Mass production still needs further development, as it is susceptible to seasonal and climate changes and mass production requires high economic and ecological costs. Moreover, customer's acceptance of algae instead of meat products is still unanswerable.

B. Palm Oil: (Elaeis Guineensis)

It is estimated that approximately half of household items contain Palm oil in one way or another; as in food, cosmetics or cleaning products.

Palm oil is the most widely used oil on earth than rapeseed or soy oil, it has very high production rate per hectare compared to other competitors in the global food market, it requires much less fertilizers and pesticides than other oil seeds. Malaysia and Indonesia alone produce 85% of the total global harvest. The palm oil industry has profoundly contributed to improving the livelihood of people and increased the employment of millions of jobseekers around the world (Statista, 2024).

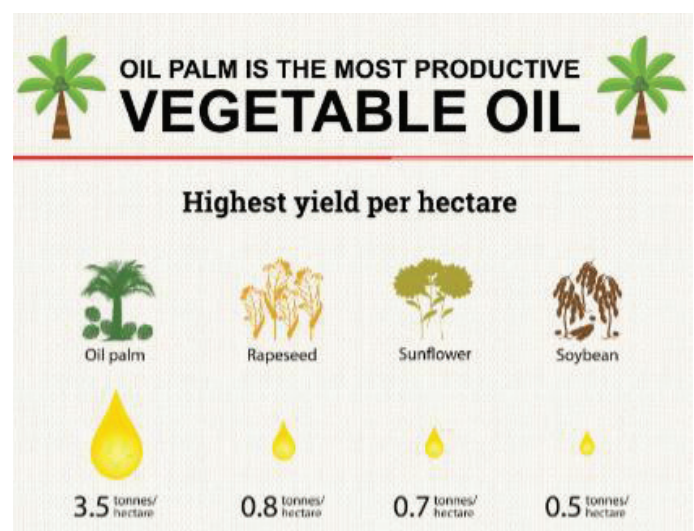


Fig. 9. palm oil production per hectare compared to rapeseed, sunflower and soybean oils.

Obtained from: <https://www.smart-tbk.com/en/lima-fakta-utama-2022/> (Smart, 2023). Palm oil production is the most productive and highly competitive amongst other oil seeds that reaches 3.5 tones per hectare of land compared to rapeseed with 0.8 tones per hectare, sunflower with 0.7 per hectare and soybean with 0.5 tones per hectare.

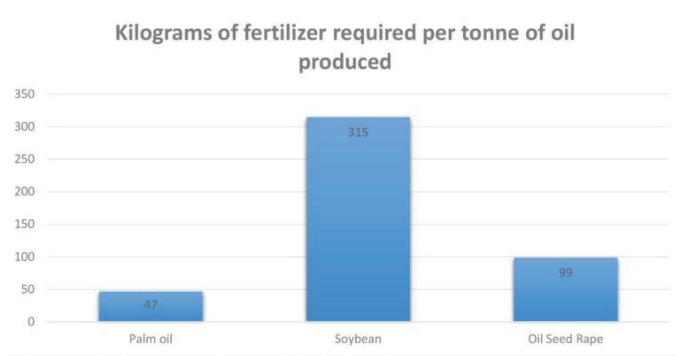


Fig. 10. Number of fertilizers required to produce Palm oil, Soybean oil and Rapeseed oil.

Obtained from: <https://www.futurelearn.com/info/courses/engaging-with-controversies-in-the-food-system/0/steps/63415> (EIT FOOD). Palm oil uses relatively low amounts of fertilizers for the production of 1 ton oil compared to rapeseed oil and soybean oil, which is 47 kg per tone compared to 99 kg in rapeseed and 315 kg in Soybean.

Palm Oil has a high melting point and multiple applications in food industries: It is responsible for the smooth and creamy texture in confectionary products, it contains 50% saturated fats and 50% unsaturated fats. In addition to that, it acts as natural preservative in processed & ultra processed foods and has non trans fats, as hydrogenation is not involved in the manufacturing process (Pande et al., 2012).

On the other hand, palm oil industries contribute to deforestation, high GHG emissions, loss of biodiversity and endangering many species (i.e. orangutans). Environmentalists have called it addiction to palm oil, production is escalating vigorously; from 1995 to 2015 production increased from 15.2 to 62.6 million tons and expected to quadruple by 2050. Furthermore, one of palm oil controversies is about labor rights; many original landowners have lost their land because of land acquisition (land-grabbers) for palm oil businesses (Shanahan, 2024).

Palm debates have led global leaders to have roundtables on palm oil production for more pledges on reducing deforestation and moving towards circular economy. Nowadays in Indonesia

and Malaysia more than 60 million tonnes of Palm Oil Mill Effluent (POME) are produced each year and used in energy production for both mill operations and providing energy for communities. (Roundtable on Sustainable Palm Oil (RSPO), 2023).

C. Dairy Milk Replacements

Dairy products are resource intensive food products, they are on the top list amongst the highest GHG emitters in the food system. Currently, there are many plant-based dairy replacements in the market, all options have pros and cons related to environmental footprints.

Soy milk is a good alternative since it has all essential amino acids. Also, it causes less water use and Eutrophication than other options. However, it has relatively high GHG emissions after dairy and rice milk (Clinic, 2024).

Almond milk has low GHG emissions and land use. However, it causes death of millions of bees each year through pollination process that is responsible for most of the food produced, it also consumes high amounts of water.

Oat milk is a satisfactory alternative that has relatively low environmental footprints; land, water, GHG emissions and Eutrophication. It also has a nice taste in terms of organoleptic.

Although **Coconut milk** has lower footprints compared to dairy milk, it has high levels of saturated fatty acids, coconut production raises an ethical issue of labor rights as people who work on picking the fruits are usually getting paid with approximately 1 USD per day. Rice milk and Flaxseed milk are widely popular among vegan communities.

Nevertheless, **Rice milk** is ranked as the highest emitter after dairy, rice has an issue of monocrop intensive farming, as well as intensive water consumption, so it should come as the last possible alternative to dairy (Kozicka et al., 2023).



Environmental footprints of dairy and plant-based milks

Impacts are measured per liter of milk. These are based on a meta-analysis of food system impact studies across the supply chain which includes land use change, on-farm production, processing, transport, and packaging.

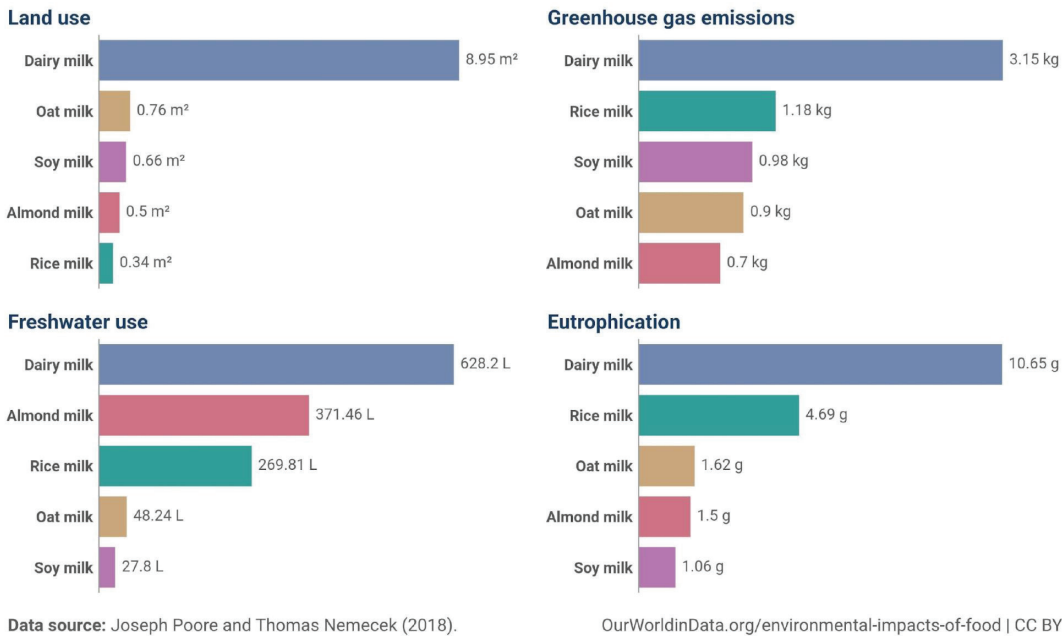


Fig. 11. Comparison of dairy milk vs. plant-based milk in terms of different environmental footprints.

Obtained from: <https://doi.org/10.1126/science.aag0216> (Poore & Nemecek, 2018). Dairy milk has the highest land, air and water footprints compared to plant-based milk alternatives, as in: Almond, Rice, Oat and Soy milks. There is no perfect option amongst non-dairy milks as all have trade-offs; Rice milk has the highest eutrophication after dairy milk, Almond milk contributes to the highest water consumption after dairies, Rice milk has the most greenhouse gas emissions after dairy milk and finally Oat milk contributes to the highest land use after dairy milk.

5. FOOD WASTE

Food valorization is critical in creating sustainable food system, especially because global food system is responsible for 20–30% of greenhouse gas emissions.

When food is wasted or lost, other critical resources are also wasted such as: land, water, labor, energy and capital. For example, half of bread purchased in Britain is almost wasted, which means that all resources used in bread making; wheat planting, flour milling, baking, manpower and transportation are wasted.

Greenhouse Gas Emissions from Food Loss and Waste Approach the Levels from Road Transport

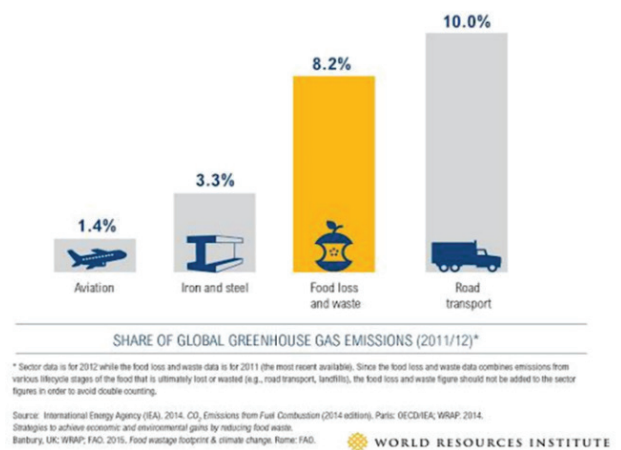


Fig. 12. GHG emissions from Food Loss and Waste approaches emissions of transportation.

Obtained from: <https://www.environmentenergyleader.com/2016/01/davos-nestle-unilever-ceos-join-food-waste-reduction-coalition/> (Jessica, 2016). In 2011/2012 food loss and waste had a share of 8.2% GHG emissions which is almost near road transport that contributed to 10% emissions and surpassed aviation emissions and footprints from iron & steel production.

As per FAO Annual Food Report, it is estimated that a third of food produced annually is wasted or lost during one or more stations of the food supply chains. Food waste is considered a huge economic burden, by numbers 143 billion euros are spent as food in EU in 2012 (Food Waste Index Report 2024 | FAO, 2024).

A. The Difference between Food Loss and Food Waste

Food Loss Index (FLI): It occurs at the preliminary stages of the supply chains before food reaches retailers and consumers. For example: Wonky fruits and vegetables are sometimes lost and discarded from the farm or processing factories before reaching the retailers and consumers. (Mingione & Lasinio, 2018). Food products are also lost from the farm because of the contamination which occurs through the intensive use of pesticides and insecticides.

Food Waste Index (FWI): It happens to retailers, supermarkets and households. For example, supermarkets dispose food that reach the expiry date because of low accuracy in managing and handling available stocks, low stakeholder multidisciplinary collaboration...etc. Consumers waste leftover food because of different reasons: Low awareness of the environmental and economic impacts of food waste, lack of culinary skills and lack of home economics skills (Food Waste Index Report, 2024).

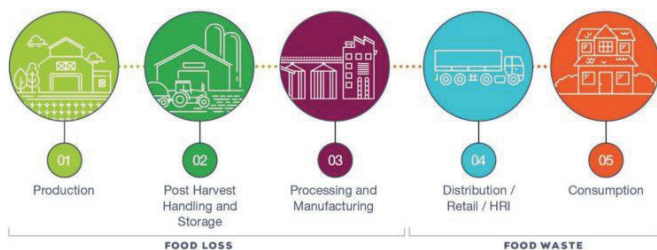


Fig. 13. Food loss and waste in supply chains.

Obtained from <https://www.nutriscope.ca/food-waste/> (Food Waste - NutriSCOPE Inc., 2016). Major food losses occur in farms and factories, whereas food waste occurs majorly in supermarkets and consumption in (schools, hospitals, hotels, restaurants and households). The first 3 parts resemble food loss possibilities and food waste occurs in the last 2 steps of the supply chain.

B. Food Loss and Waste in Supply Chains

At the farm, loss can be due to infestation, pests, poor soil handling, climate change i.e. drought or heavy rain seasons...etc.

- **Storage:** Poor logistic management and transportation problems.
- **In transit:** Transportation accidents, human errors or long-time gaps.
- **Processing and packaging:** Losses occur due to human mistakes, machinery malfunction, delivery problems...etc.
- **In the shop:** Most of the food waste in the shop happens when food reaches best before and use by dates.
- **At point of consumption:** Hospitals, restaurants, schools and hotels waste food mainly due to poor food handling, lack of menu planning skills, serving bigger portions and stock management issues.
- **At home:** Waste is due to poor meal planning, lack of home economics and gastronomy skills, lack of home storing and preservation techniques...etc. (Chauhan et al., 2021).

C. Environmental and Economic Burden of Food Loss & Waste

WRAP 2020: If people in UK stop wasting food for one day, it could have an impact on GHG emissions as planting half a million trees!

4.4 G tones of CO₂ are emitted because of food waste process; production, processing, distribution, transportation and disposal (Andrea, 2019).

Environmental impact of food waste



Fig. 14. Environmental impacts of food waste.

Obtained from: <https://epthinktank.eu/2014/02/07/tackling-food-waste-the-eus-contribution-to-a-global-issue/> (Ivana, 2016). Annually in Europe and North America each person wastes food equivalent to 2 basketball courts, as 2,054 kcal consumption per day and 60 m³ of water is equivalent to space of 832 m² per day and a size of 2 basketball courts annually.

If Food Loss and Waste Were its own Country,
it Would Be the Third-Largest Greenhouse Gas Emitter

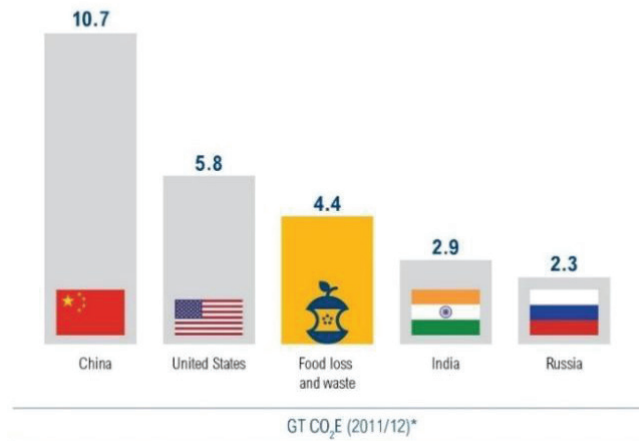


Fig. 15. Food waste is estimated to be the third largest GHG emitter.

Obtained from: <https://wri-indonesia.org/en/data/if-food-loss-and-waste-were-its-own-country-it-would-be-third-largest-greenhouse-gas-emitter>, (If Food Loss and Waste Were Its Own Country, It Would Be the Third-Largest Greenhouse Gas Emitter, 2018.) Food waste emits 4 billion tons of CO₂ annually, which is estimated to be the third largest GHG emitter after China which emits 10 billion tons of CO₂ and US which produce 6 billion tons of CO₂ each year.

In 2007, 1.4 billion hectares of agricultural land was exploited and wasted to produce food that was not consumed. Furthermore, food waste is one main cause of biodiversity loss and deforestation; 74% of annual deforestation happens to be used in food production.

70% of the earth's fresh water is used in agriculture to produce food, so when one third of food is wasted, water is also wasted. Coffee is a resource intensive food product; just one cup of coffee uses 125 liters of embedded water.

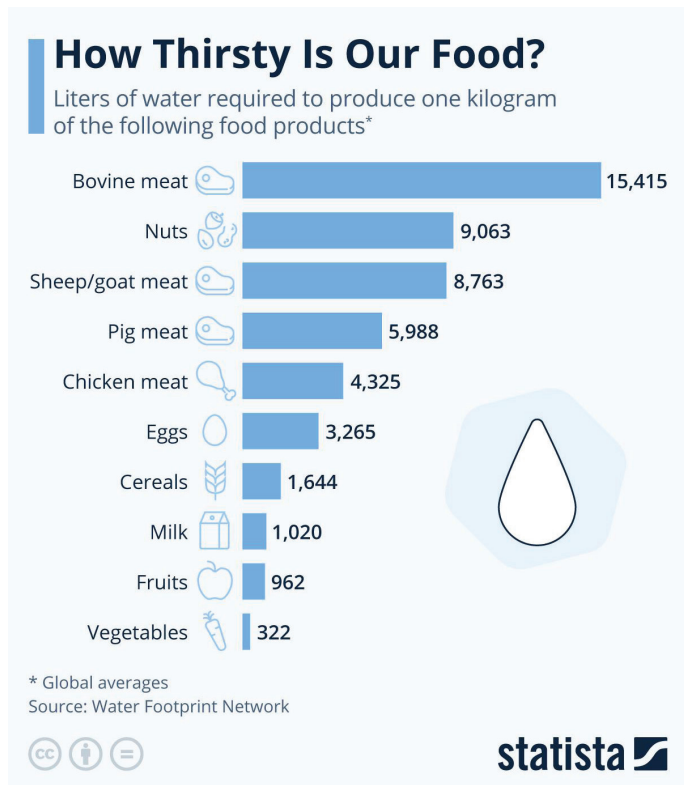


Fig. 16. Amounts of water required for production of some food products.

Obtained from: <https://www.statista.com/chart/9483/how-thirsty-is-our-food/> (Armstrong, 2023). Some food products are extremely thirsty to water, bovine meat come on the top of water consumption which requires 15,415 liters of water to produce 1 kg of meat, whereas fruits and vegetables are relatively low in water consumption as 1 kg of fruits requires 962 liters of water and 1 kg of vegetables requires 322 liters of water.

D. Social Impact of Food Loss and Waste

There is an absolute paradox between food production and food waste.

820 million people are undernourished, 1 billion people are overfed. One third of food production is wasted or lost annually, it is estimated that edible food waste can feed all hungry people around the globe.

Now the challenge is not to let food waste reach the landfills, since it releases methane which is 23 times more potent than CO₂. Currently food system stakeholders are moving towards circular-economy approaches by (reducing, reusing, recovering and recycling), with the aim of preventing food from

reaching to the incinerator or landfills (Roka, 2020).



Fig. 17. The waste pyramid from the best to the least preferred option.

Obtained from: <https://powerknot.com/2021/08/04/the-food-waste-hierarchy-how-to-apply-the-framework-to-your-sustainability-goals/> (powerknot, 2021). Green colors of Reducing, reusing and recycling food waste come on top as the best options to the environment, yellow and orange colors of recovery by sending waste to the incinerator or disposal into landfills are the worst options for the environment.

E. Successful Example of Governmental Legislations

- In 2005, South Korea banned food from being sent to landfills. Later in 2013 Seoul started an initiative of 'Pay as you Waste' where residents are required by law to discard food waste in biodegradable bags, then bag sizes are measured, by which residents pay tax money as per bag sizes and waste volume. With this initiative food waste was significantly reduced by 80% in Seoul (Mph & Mph, 2020).
- The Netherlands, Qatar, Sweden and Brazil incorporate environmental sustainability into their dietary guidelines based on scientific research and evidence-based policy (Ahmed et al., 2019).

F. Reducing Food Loss and Waste Can Help Achieve Multiple SDGs

SDG1 and 2: No poverty and ZERO hunger; reducing food loss and waste save resources such as: land, water, capital and energy. So, there will be surplus to fight against poverty and food insecurity.

SDG3: Good health: The more the food is required to be produced, the less nutritional quality it possesses and vice versa, achieving resilience in the food system allows food to be energy dense with higher quality than conventional intensive farming.

SDG4 and 5: Quality Education and gender equality; reducing food waste saves money for health, education and other necessities.

SDG6: Clean water and Sanitation; 70% of fresh water goes to the agricultural sector, so managing food waste removes a severe stress on freshwater consumption.

SDG8: Decent work and economic growth: Reducing farm losses saves resources for the farmers to sell more food.

SDG11: Sustainable Cities and Communities: Food waste is a huge economic burden on communities, if food waste is accurately managed and protected from being sent to landfills, a free space will be saved for the sustainability of cities and communities.

SDG12: Sustainable Consumption and Production; Controlling food loss and waste will automatically achieve sustainable production and consumption.

SDG13: Climate Action: Reducing food loss and waste significantly reduces severe GHG emissions.

SDG14: Life under water: The more food is produced, the more eutrophication occurs where fertilizers accumulate in the runoffs. So, reducing food loss and waste helps to keep water resources clean and pure (Food Waste Reduction and Sustainable Development Goals | LIFE FOSTER, 2019).

6. CONCLUSION

Sustainable diet can be one definitive solution to climate change issues, it is hard to achieve but not impossible. Moreover, it can be a key to achieving food security and lower environmental impacts. Food systems are responsible for one third of total

environmental issues, the paradox is that with the extreme food insecurity, there is extreme obesity and overfeeding amongst populations, more importantly, food waste can feed all hungry people around the world.

Stakeholders of the food system are the key to achieving sustainable diet goals with collaboration and effective communication agenda.

One legislation can save the planet. Legislations usually take quite long time with many debates between policymakers. However, in the time being a decisive legislation in the food system is an urgent necessity to cut down GHG emissions, preventing food waste and stopping the raising food demands. The more plants are grown, the better public health with more awareness, citizenship and lower emissions.

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