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Sustainable Food Consumption in Latin America

How to meet the Sustainable Development Goals

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ABSTRACT

This study first examines existing literature on agricultural consumption and production and how sustainability can be driven by consumer behavior. The thesis also explains the main differences between plant and animal-based diets to give a context for subsequent chapters. The thesis then turns to analyze to what extent recent trends in Latin American food-consumption align with the 2030 SDG goals. Mexico, Colombia, and Brazil are the countries of study in order to understand patterns in the Latin American region. Data about food consumption from different commodities are taken from the Organisation for Economic Cooperation and Development (OECD) with a time frame of 37 years; from 1990 to 2028. Furthermore, carbon dioxide emissions are linked with each commodity and then the analysis turns to understand how policymakers can close the gap in order to meet the 2030 SDG goals. Different scenarios are created where carbon emissions vary, and the analysis explains how much they align with the SDG goals. At last, recommendations are provided towards more sustainable food consumption and production to achieve the Sustainable Development Goals by 2030.

ACKNOWLEDGMENTS

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I dedicate it to my parents and brother, for they have always encouraged me to reach new heights and to create the best version of myself. I will be forever grateful for their advice, patience, faith, and financial assistance in every path I decide to take in life.

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GLOSSARY

ACSES: Agricultural Centre for Sustainable Energy Systems

CINVESTAV: Center of Investigation and Advanced Studies of Mexico

CO2: Carbon Dioxide

EROEI: Energy Return for Energy Invested

FAO: The United Nations Food and Agriculture Organization

GDP: Gross Domestic Product

GHG: Greenhouse Gases

GMO: Genetically Modified Organism

OECD: Organisation for Economic Cooperation and Development

PNAS: Proceedings of the National Academy of Sciences

PRI: Permaculture Research Institute Kenya

SDGs: Sustainable Development Goals

UN: United Nations

WEF: World Economic Forum

INTRODUCTION

Increasing greenhouse gas emissions (GHG) are driving climate change. In 2017, greenhouse gas concentrations reached new highs, and moving towards 2030 emission objectives requires a peak to be achieved as soon as possible, followed by rapid reductions. The United Nations set the Sustainable Development Goals as the roadmap, sustainable development goal 13, which focuses on climate action talks about limiting global warming to 1.5°C.

Around 9% of GHG come from agriculture (Farm Bureau, 2017), this makes the sector one of the highest contributors to greenhouse gas emissions and therefore, to global warming. A change in diet in a consumer-driven industry can positively impact emissions. The thesis will focus on Latin America; specifically, Mexico, Brazil, and Colombia to understand food consumption and production trends in the region.

An analysis will be conducted to understand if there will be a change in consumption from an animal-based to a more plant-based diet in Latin America the next decade. According to FAO, annual per capita meat consumption in the region averages about 45 kg, some 2.5 to three times the levels reached in Asia and Africa (FAO, 1986), however, little is known on their consumption trends towards the future and how this can affect climate change.

In order for this region of the world to implement changes, the gap has to be first understood and analyzed.

In order to address this topic, the following two research questions will be addressed:

- **RQ 1: To what extent do recent trends in South American food-consumption exceed the 2030 SDG goals?**
- **RQ 2: How can policymakers close the gap in order to meet the 2030 SDG goals?**

Data will be obtained from “The Agricultural Outlook” a Joint report prepared by the Organisation for Economic Co-operation and Development (OECD) and the Food and

Agriculture Organization (FAO) of the United Nations. The report provides thirty years of historical data along with a ten year forward-looking, assessment of trends and prospects in the major temperate-zone agricultural commodity markets of biofuels, cereals, oilseeds, and oilseed products, sugar, meat, fish and seafood, dairy products, cotton.

To conduct the analysis, the study will first focus on selecting and analyzing consumption and production data only from plant-based and animal-based products to understand trends from 1990 to 2028. The second part will link greenhouse gas emissions per type of product to the Sustainable Development Goals set by the UN in 2015 to analyze if there is a need to change consumption patterns to meet the goals.

After the analysis, for the discussion, the thesis will provide some recommendations to promote more sustainable food consumption in the region.

CHAPTER 1: LITERATURE REVIEW

1.1 AGRICULTURAL PRODUCTION AND CONSUMPTION

The history of agriculture records started with the domestication of plants and animals and the development and dissemination of techniques for raising them productively. Humankind has always faced the challenge of feeding a growing population while facing threats related to the weather and the availability of resources. Conventional agriculture methods gave different civilizations the opportunity to expand and survive by having stable sources of food and achieving food security for everyone. Nevertheless, time made consumers more knowledgeable about the different types of food and the benefits they could bring to their everyday life. Because of this, changes in consumer behavior drove the agriculture industry to constantly evolve. This happened because the two big sources of food, vegetables, and animals provide very different nutrients to the body, and therefore, it is key to study the differences between diets and how they coexist and impact agriculture as an industry. This will help the study address the research questions as production methods and levels of technology directly impact the emissions per type of product, different levels of technology also impact differently.

1.11 CONVENTIONAL PRODUCTION METHODS

Conventional agriculture has existed for centuries and it is non-organically certified, it is when farmers utilize synthetic and chemical inputs. It provides 98.9% of the world's food at present. (Willer, 2017). These types of production methods have brought enormous gains in productivity and efficiency to match the global increasing food demand. However, this efficiency has come with some trade-offs. Agriculture is the second largest contributor to global emissions by sector. Methane accounts for almost half of total agricultural emissions, nitrous oxide for 36 percent, and carbon dioxide for some 14 percent (IPCC, 2014).

The global human population is expected to continue rising from 7.3 billion today to 9.7 billion in 2050, according to UN projections (United Nations, 2019). A survey published by Food and Drink Europe (2017) states that as a consequence, this will require a 60% increase in food supplies globally, as well as a 30% rise in global demand for water for agriculture.
A report of the Intergovernmental Panel on Climate Change for 2014 has warned that climate change will eventually affect "all aspects of the food security", including food production and price stability, affecting many stakeholders in the value chain.

The task of providing food for the 11 billion people who are expected to inhabit the planet by the end of the century (United Nations, 2019) constitutes one of the most fundamental challenges facing humanity.
The debate about conventional food production is around three main environmental challenges: the use of pesticides, excessive use of water, and high energy consumption.

The first challenge is the use of pesticides that end up in the watershed after applied to crops. Pesticides and other chemicals are often used to increase yield, and they do not just stay in the crop, but they are transported by wind and water and affect the surrounding ecosystems. The traditional open-field production of crops has increased the use of strong pesticides due to the difficult control of diseases due to the open environment. Furthermore, antibiotic growth promoters used in livestock production have not only a negative effect on the environment but also on humans. According to CINVESTAV (2015), food that comes from fruits and vegetables that were exposed to high contents of pesticides can lead to chronic diseases like cancer or neurodegenerative diseases. Due to this reason, Monsanto, an agriculture company that mainly produces seeds, fruits, vegetables, and key crops has become one of the most-hated large companies in the world. Its name is regularly splashed across protest banners and invoked in arguments against the alleged harms of pesticides and genetically modified organism GMOs.

The second challenge linked with conventional food production has to do with the amount of water that crops and animals require. Agriculture is the industry with the largest water

consumption. (World Bank 2008). It takes a tremendous amount of fresh water to grow crops and one of the reasons for this is that they are commonly grown in environments that aren't suited. Currently, agriculture is responsible for more than 90% of freshwater consumption worldwide and competition for water is increasing (World Bank 2016).
Urbanization, industrialization, and climate change will provide agriculture an increased pressure and competition for water resources. Specifically, the water supply can potentially be affected due to changes in the seasonal timing of rainfall, snowpack melt, and higher incidence and severity of floods and droughts. Better management of water in agriculture is critical for the future in order to supply the agricultural production demand. Water needs to be shared with other stakeholders to maintain the environmental and social benefits of water systems.

The third challenge around conventional agricultural practices is the use of energy. Energy is an important input for agriculture and livestock production. It is used directly as fuel or electricity to run machines and different equipment. In addition, it is utilized to heat or cool the temperature in buildings mainly in winter when animals cannot stand outside freezing temperatures.

On another hand, according to the United Nations, not only water, energy and the use of pesticides need to be addressed but it is also critical to consider biodiversity conservation, urban, peri-urban and infrastructure development; land tenure, governance and gender; and migration, conflict, and human security food, water and energy security (United Nations, 2017)

The evaluation of the conventional agriculture dilemma at the global level needs to begin with the implications it will have for food security. Although many different assessments have been made, the most recent estimates calculate that, altogether, some 38% of Earth’s terrestrial surface is occupied by conventional agriculture (Alon Tal, 2018).

1.12 FOOD SECURITY AND AUTONOMY

The main goal for agriculture is to provide food security and autonomy, In the World Summit of 1996, The United Nations Food and Agricultural Organization (FAO) defined food security as "Existing when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2006)

The number of undernourished people in the world has been on the rise since 2014, reaching an estimated 821 million in 2017 (FAO et al, 2018). Severe food insecurity is higher in 2017 than it was in 2014 in every region except Northern America and Europe, with notable increases in Africa and Latin America. Women are more likely than men to be affected by severe food insecurity in Africa, Asia, and Latin America. (FAO et al, 2018)

According to the World Bank, agricultural production is important for food security because it is a source of income for the majority of the rural poor. For low-income countries that are exposed to recurrent food emergencies, increasing and stabilizing domestic production is essential for food security. They emphasize how the food crisis in developing countries pushes governments to use their budgets in direct provision of food instead of investing in infrastructure growth, which would give farmers autonomy and help achieve food security sustainably. Investment channels in agriculture are complex and multiple but are needed in order to achieve food security, as an example, rising productivity increases rural incomes and lowers food prices, making food more accessible to the poor. (The World Bank, 2008)

Recent literature has shown that it is imperative to achieve global food security while reducing environmental impact and achieving a healthy diet for all. Planetary limits are being reached with the current use of natural resources for human consumption and activities, especially food production being the one with the most impact. The human population is expected to grow in the following years, but the main concern is not the number but the eating habits that come with this growth. There is an increasing trend on a more luxurious food consumption which requires an additional amount of resources. As a whole, it can be said that the richer the diet, the higher the environmental impact it has. (Ibarrola-Rivas et al; 2017)

Several studies have shown that food security should be addressed from both the production and the consumption spheres. For example, according to Ranganathan et al (2016), reducing the overconsumption of protein by reducing consumption of animal-based foods is key. This will free up huge areas of land that can be used for crops destined for human consumption instead of for feeding animals. Furthermore, this will ensure that government policies are aligned with promoting sustainable diet choices that can give a shift to current production systems.

In developing countries, giving small farmers the autonomy to create their own channels to sell directly to their customers is important. Linking smallholders to the new domestic food markets supermarkets in particular and creating remunerative jobs is imperative too. Governments can assist in order to train leaders and empower weaker members but providing this assistance without creating dependency is one of the main challenges.

Latin America is a diverse region that can grow a big diversity of food, but it comes with its challenges. The socio-economic situation of farmers is very varied because it ranges from low-income small producers with small-scale farms, to high-income producers with large scale farms that use a substantial number of agricultural inputs. One of Latin America´s current debates is about how technology can help to achieve food security.
Specifically talking about Mexico, this country plays a big role as it remains one of the United States' largest food suppliers with $19.3 billion exports in 2015. (USDA, 2019)

Another important aspect to debate in the relationship between agriculture and achieving food security and autonomy is the change in consumption patterns in the population. These patterns have led to nutritional issues. In the past, the major change has been the influence of switching economic models, the change of the traditional maize and beans rural diet to a highly commercialized and industrialized diet. The new diet includes more animal-oriented products instead of a vegetable-based diet. This has been one of the causes of a rising obesity index in young children. (Van Groenendael, n.d) Agricultural production systems have changed to satisfy consumer demands. To achieve food security, it is imperative to analyze consumption patterns too.

1.13 CONSUMPTION BEHAVIOR

Agriculture as most industries is driven by consumption behavior. It drives production and in order to understand humans' consumption of different types of food, it is crucial to discuss the role of behavior. Consumption behavior varies according to the different regions of the world.

Quantitative studies have shown that there is only a small minority of consumers aware of the meat environmental impact, willing to halt or reduce meat intake for ecological reasons, or who have already stopped or reduced meat consumption because of environmental concerns.

The current reality is that as of February 2020, the estimated worldwide population is 7.8 billion (Worldometer, 2020) and according to Wtvox only 8% are vegetarian, which means that around 7.1 billion people are still eating animal meat.

Taking a closer look at Latin America, the following figure details the percentage of flexitarians, vegetarians and vegans:

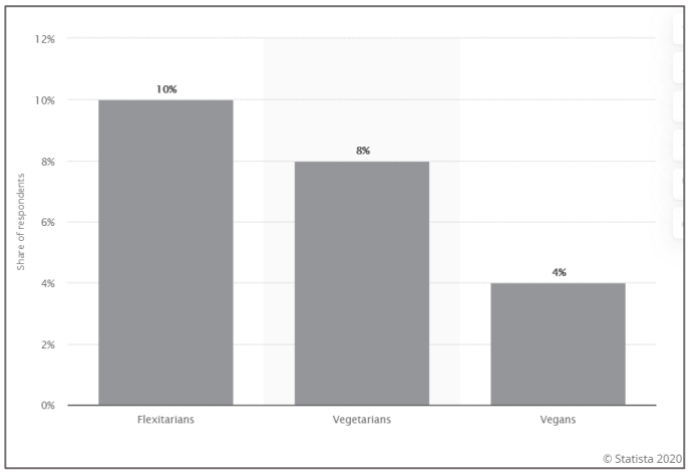


Figure 3: Share of vegetarians, flexitarians, and vegans in Latin America (Statista, 2016)

Eating patterns are affected by a complex set of economic, social, and psychological factors. A study titled: “What is America Eating” (Kenneth et at, 1986) describes consumer behavior as a sum of 5 approaches. The psychological approach shows how researchers have attempted to measure some physiological change that occurs when a subject is exposed to a stimulus, such as an advertisement. The social approach emphasizes the importance of other people in shaping a person's behavior. The third, the economic psychology approach, relates individual behavior to macroeconomic variables. For example, some studies show that when people expect prices to go up they save less and spend more. In contrast, other studies show that people feel pessimistic when they face inflation and delay the purchase of discretionary items so that more money will be available for necessities. In the learning theory approach, theorists viewed complex behaviors as aggregations of much smaller units of behavior for which a person had been reinforced. Reinforcement led to the perseverance of behavior, whereas lack of reinforcement caused the behavior to become extinguished. The last approach is the cognitive approach, which talks about a person's predisposition to behave in a particular way. For example, adopting a strict vegetarian diet is predicted by a person's attitudes toward vegetarianism rather than by attitudes toward vegetables.

A different study on understanding attitudes towards reducing meat consumption for environmental reasons (Ruben et al, 2019) shows that the behavioral change process includes three steps: awareness, willingness, and change.

The study showed that consumer awareness is affected by beliefs about food, meat, and personal behavior. Furthermore, nutrition, health, and taste were found to be both enablers and barriers with regard to willingness. The study (Ruben et al, 2019) also provided some recommendations saying that it is important to prepare consumers to understand that meat has an environmental impact by informing that food, in general, has an environmental dimension. In addition, they say that overcoming consumers’ beliefs and perceptions is key and that consumers need to feel nutritionally safe and enjoy their meals. Nutritional and culinary education on meatless diets may increase consumers’ willingness to reduce their meat consumption. Furthermore, they conclude that quantitative studies have shown that when prior information about the environmental impact of meat is given, willingness to reduce meat consumption increases. At last, they emphasize creating a link between personal

and animal health to planetary health is important since personal health and animal welfare are the most prevalent motives to become vegetarian.

1.14 PLANT-BASED DIET

In recent years, plant-based diets have become more mainstream. An increase in this type of diet has implications in terms of production, health, and sustainability.

According to Harvard Health, plant-based or plant-forward diets focus on food primarily from plants. This includes fruits, vegetables, nuts, seeds, oils, whole grains, legumes, and beans. They emphasize that having a plant-based diet does not mean being vegetarian (no meat or poultry), vegan (no meat, poultry, seafood, eggs, or dairy products) or never trying meat or dairy. It simply means proportionally choosing more food from plant sources (Harvard Health, 2018).

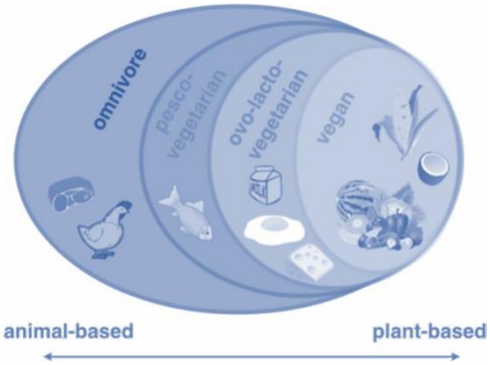


Figure 1.1: The spectrum of diets including all or only certain types of animal-based products. (Medawar et al, 2019)

Plant-based diets in the western world used to be part of a small subculture. It was considered the domain of hippies and activists, rather than large numbers of the population. Currently, plant-based diets have gone mainstream. From prominent public figures like Ellen DeGeneres and Bill Gates to corporations like WeWorks, there is growing support to eat more plant-based foods (Eswaran, 2018).

A debate exists around the benefits of a plant-based diet. Some of the discussed advantages are the following:

Health benefits:

Decades of research have shown that the Mediterranean diet is one of the healthiest in the world. It is characterized by being rich in plant-based foods such as fruits, vegetables, whole grains, legumes, and olive oil, and emphasizes fresh, colorful eating and avoid heavily processed ingredients.

Dietary experts now agree that animal products are unnecessary for optimum health and alternatives like nuts, seeds, legumes, beans, and tofu can provide valuable and affordable sources of protein and different nutrients otherwise found in meats. The vast majority of vegans and vegetarians in these studies meet the recommended daily amount of protein. Contrary to common belief, plant-based diets can contain just as much or more iron than diets containing meat (Eswaran, 2018).

Health professionals are acknowledging that animal products are harmful to health. Studies on diet repeatedly show that body mass index and obesity rates are lowest for people who eat a plant-based diet. Research also shows that a healthy, plant-based diet helps reduce the risk of heart disease, stroke, cancer, obesity, and diabetes, some of the top killers in many western countries. (3) (Eswaran, 2018)

Ethics:

Ethics play an important role because plant-based diets are mainstreaming. The fact that eating meat is no longer an important component of survival and that humanity has evolved to a place where it no longer needs to defend from animals to survive has changed the human perception of food.

Studies show that animals, like us, can experience a wide range of sensations and emotions such as joy, pain, pleasure, fear, hunger, sorrow, boredom, frustration, or contentment. The World Economic Forum (WEF) states that they are conscious and aware of the world around them; because of this fact, self-preservation is important to animals. Humans are increasingly aware of this and consider their lives valuable, and not as simple resources or tools for human use. (World Economic Forum, 2018)

Environmentally Unsustainable

New research suggests that switching to a plant-based diet can reduce your personal environmental footprint. Switching to a more plant-based diet reduces the number of resources required since there are no animals that need to be fed. Water for livestock production is high and producing the food to feed animals already requires additional water consumption. For this, there is a growing concern about climate change and ever-shrinking freshwater resources.

According to Forbes, the efficiency with which various animals convert grain into protein varies widely. With cattle in feedlots, it takes roughly 7 kilograms of grain to produce a 1-kilogram gain in live weight. For pork, the figure is close to 4 kilograms of grain per kilogram of weight gain, for poultry, it is just over 2, and for herbivorous species of farmed fish (such as carp, tilapia, and catfish), it is less than 2 (Earth Policy Institute). This shows the big difference that exists in resource consumption intensity to produce diverse types of meat. Due to this, alternatives like substituting red meat for white meat have shown to potentially positively contribute to reducing GHG emissions from meat production. Eighty percent of starving children live in countries that actually have food surpluses; this is because the extra grains produced are fed to livestock instead of people. (Eswaran, 2018) (3)

On the other hand, The United Nations Food and Agriculture Organization (FAO) estimates that around 30% of land on earth that is not covered by ice is either directly or indirectly used in the production of livestock. (FAO, 2006) This Organisation also states that in the Amazon, almost 70% of forest land has been converted to space that is primarily used as cattle pastureland. Over-grazing has resulted in the loss of biodiversity and the productive capacity of ecosystems, particularly in arid regions. (FAO, 2006).

A report by FAO titled ‘Livestock in a Changing Landscape’ shows important figures like 1.7 billion animals are used in livestock production worldwide and occupy more than one-quarter of the Earth’s land, production of animal feed consumes about one-third of Earth’s total arable land. The animal agriculture industry is responsible for about 18% of all greenhouse gas emissions worldwide (FAO, 2010)

On the other hand, there is a different vision from an alternative group of researchers stating that plan-based diets have created more demand for meat substitutes. An example of meat substitutes is the "Beyond Meat" food brand that manufactures protein-based products with a similar taste than animal-based products. Scientists argue that greenhouse gas emissions on these products can be even higher than for the regular animal-based supply chain.

Economically responsible

The economic benefit of a plant-based diet is fundamental to consider. The value of the additional food that would be produced as a result of this shift would offset the loss from the decrease in livestock production. Economic studies show that animal agriculture in a majority of western economies accounts for less than 2% of the Gross Domestic Product (GDP). Some studies in the US suggest a potential reduction in GDP of about 1% but this would be offset by growth in other plant-based markets. (World Economic Forum, 2018)

In a study published in the Proceedings of the National Academy of Sciences (PNAS), research showed that transitioning toward more plant-based diets that are in line with standard dietary guidelines could reduce global mortality by 6–10% and food-related greenhouse gas emissions by 29–70% compared with a reference scenario in 2050. (PNAS, 2015). The study also found that the monetized value of the improvements in health would be comparable with, or exceed, the value of the environmental benefits although the exact valuation method used considerably affects the estimated amounts.

Overall, they estimate the economic benefits of improving diets to be 1–31 trillion US dollars, which is equivalent to 0.4–13% of global gross domestic product (GDP) in 2050 (PNAS, 2015).

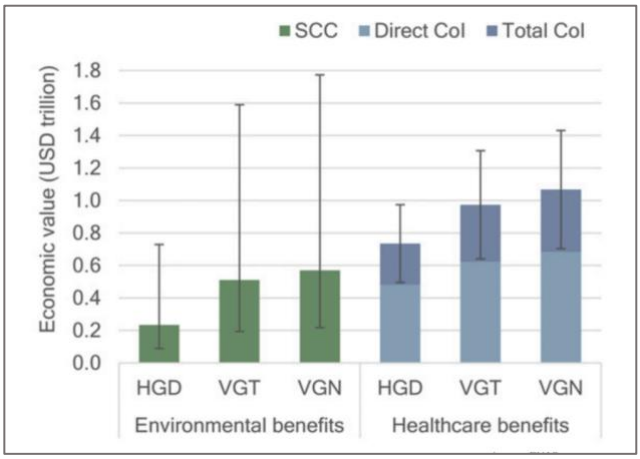


Figure 1.2: Benefits of a shift towards a more plant-based diet (PNAS, 2015)

On the other hand, other studies have reflected that there is a tradeoff in the economic impact; The Vegan Organisation in Australia proposed some critical questions to consider and smoothen the transition. As an example, they talk about employment and what programs can be put in place to help animal farmers transition to plant-based farming. In addition, they question exports since in 2014 the main animal exports were cow meat ($9 billion) (Vegan Australia Corporation, 2019). They believe that new economic wealth will be created from alternative industries derived from this shift in diet, but they emphasize how important it is to take into consideration the impact from different perspectives, so no one is left behind.

1.15 ANIMAL-BASED DIET

An animal-based diet has been part of humankind throughout the evolution process. It is also the diet that is present mostly in the world today. This diet is characterized by consisting mostly of meat coming from animal sources such as poultry, beef, pig, and fish.

Throughout the human evolution process, selective pressures fueled a loop between climate, food availability, and the advantages of a large brain. Furthermore, archaeological and paleontological evidence indicates that increased meat consumption characterized our divergence from our primate ancestors because animal fat powered the brain to expand to four times the size from that of our hominid ancestors (Kevin Stock, 2013).

Internal organs and tissues are evidence for a meat-based diet and so are the adaptations of the outer body. Additionally, humans are the only living primate adapted for endurance running. It is key to mention that the size of our brain is our competitive advantage with other species, but this also means that a larger brain demands more energy and therefore needs more protein-rich food.

Throughout history, plant-based foods were available to indigenous people, but they most commonly chose in favor of meat. Plant-based foods were just a supplement to their meat-based diet. One of the main reasons for this is that humans did not bother to dig a meter deep for a vegetable that provided few calories but took even more calories of work to get to.

There is a current debate on whether the brain needs meat to operate or not. According to Kevin Stock, a strict carnivore and CEO of Muscle Science, besides fat and cholesterol, the brain needs fuel from compounds found mostly or exclusively in meat. He also emphasizes that vitamin B12 is vital to making the DNA, RNA, and blood cells. Moreover, it can only be obtained via animal-based foods.

On the other side of the debate, it is argued that meat is very "inefficient" food because it has a much higher “energy footprint” than any other food. It takes 75 times more energy to produce meat than corn and it takes an area of the vegetation 7 times the size of the EU to produce food for the cattle and other livestock animals in Europe (The World Counts, 2020).

1.2 SUSTAINABILITY

1.21 NEW MODELS OF AGRICULTURE

In previous chapters, it has been stated why agriculture has been a crucial aspect of humans’ evolution but sustainability remains the main question in order for it to keep feeding an increasing population.

Modern agriculture has helped humankind to increase yields in production that have augmented food availability and improved living conditions. As a cause of this, the human population has increased dramatically. Changing food consumption patterns like including

more meat on the daily diet and the rising demand for specific trendy products has created the debate of how agriculture can feed the global population and reduce its impact on the environment and society.

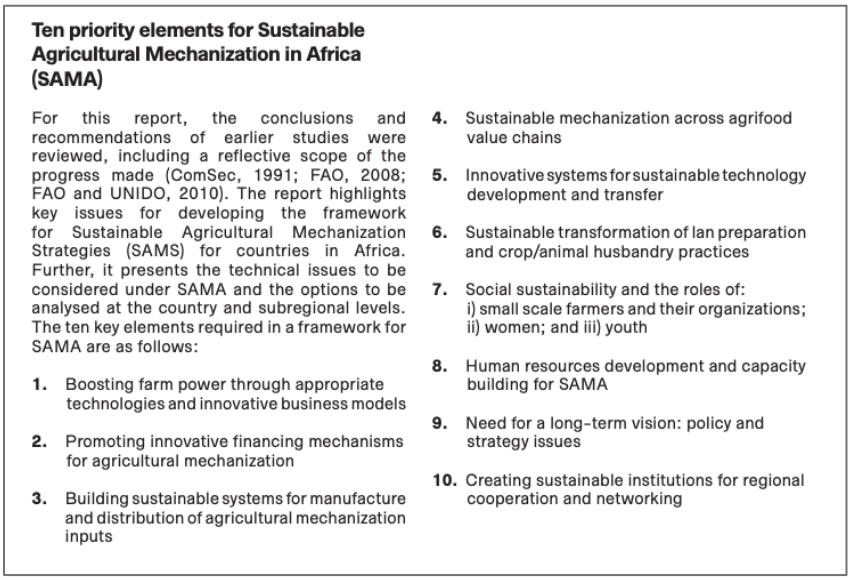
On one side, it is debated that we can still develop technologies to feed an expanding population indefinitely by intensifying the industrial methods of agriculture. They state that industrial disruptions can still be created.

On the other side, it is pointed out that the intensity of current agricultural practices has reduced our potential to feed future generations and that alternative models for agriculture must be developed to achieve both, food security and re-establishment of biodiversity. (Kirschenmann, 2010)

To address the previously mentioned concerns, there is an increasing worldwide trend of a sustainable approach to agriculture, and several frameworks have been created.

The FAO (1988) defines sustainable agriculture development as "The management and conservation of the natural resource base, and the orientation of technological change in such a manner to ensure the attainment of continued satisfaction of human needs for present and future generations. Sustainable agriculture preserves land, water, and plant and animal genetic resources, and is environmentally non-degrading, technically appropriate, economically viable, and socially acceptable".

FAO created a framework specifically tailored for Africa due to the urgent matter of achieving the vision of zero hunger by 2024. It presents the priority elements to be considered by countries while developing their national strategies for sustainable agricultural mechanization. They consider that this mechanization should be built along all the value chain and must be private-sector driven. Since small scale farmers constitute the majority of African farmers, sustainable agriculture should be economically viable and affordable. Women inclusion and targeting the youth to make it more attractive for employment and entrepreneurship are key factors. It is mentioned that it is important to move quickly to get the necessary support for implementation and achieve impact.



Ten priority elements for Sustainable Agricultural Mechanization in Africa (SAMA)

For this report, the conclusions and recommendations of earlier studies were reviewed, including a reflective scope of the progress made (ComSec, 1991; FAO, 2008; FAO and UNIDO, 2010). The report highlights key issues for developing the framework for Sustainable Agricultural Mechanization Strategies (SAMS) for countries in Africa. Further, it presents the technical issues to be considered under SAMA and the options to be analysed at the country and subregional levels. The ten key elements required in a framework for SAMA are as follows:

1. Boosting farm power through appropriate technologies and innovative business models
2. Promoting innovative financing mechanisms for agricultural mechanization
3. Building sustainable systems for manufacture and distribution of agricultural mechanization inputs
4. Sustainable mechanization across agrifood value chains
5. Innovative systems for sustainable technology development and transfer
6. Sustainable transformation of lan preparation and crop/animal husbandry practices
7. Social sustainability and the roles of: i) small scale farmers and their organizations; ii) women; and iii) youth
8. Human resources development and capacity building for SAMA
9. Need for a long-term vision: policy and strategy issues
10. Creating sustainable institutions for regional cooperation and networking

Figure 1.3: Priority Elements for Sustainable Agricultural Mechanization in Africa *(FAO & AUC. 2018)*

The framework focuses on different key elements like implementing appropriate technologies and innovative business models, promoting innovative financing mechanisms, building sustainable systems for manufacture and distribution, social sustainability, human resource development, the need for a long-term vision, and the creation of institutions for regional cooperation and networking. (FAO, 2018)

Circular Economy

The Agricultural Centre for Sustainable Energy Systems (ACSES) at Harper Adams University in England, is more focused on the environment. For them, a circular economy is moving from traditional production models that used natural resources that are transformed into products and then wastes to models that have no effects on the environment with the goal of improving the economic and environmental sustainability. The ultimate goal of a circular economy is to have no effects on the environment and to design a system that creates co-products in order to reduce waste and the use of natural resources. (Toop et al; 2017)

According to the Ellen MacArthur Foundation, society plays a big role in a circular economy too. "A circular economy aims to redefine growth, focusing on positive society-wide benefits. It entails gradually decoupling economic activity from the consumption of finite resources and designing waste out of the system. Underpinned by a transition to renewable energy

sources, the circular model builds economic, natural, and social capital" (The Ellen MacArthur Foundation, 2019) They also put emphasis on how it is important to regenerate natural systems and how the economy needs to work efficiently regardless of the size of the business globally and locally.

Renewable Energies

Alternative sources of energy are required to satisfy the current energy needs from the agriculture sector, especially for the production of meat. There is not a single solution to achieve the replacement of existing energy sources with more sustainable ones, it is a mix of different solutions based on the territory where its development is planned (Pirazzoli, 2013). High productivity in modern agriculture has resulted in the high consumption of energy obtained from fossil fuels. As a result, today agriculture is among the main users of fossil fuels in Western countries. Around 14% of the world's gas emissions are attributed to farming activities, deforestation, and livestock (Bardi et al; 2013).

The question that needs to be addressed is how agriculture can change and adapt to new sources of renewable energy? The new sources of energy should have a similar cost to fossil fuels and the challenge is that renewable energies have a very wide range of forms, efficiency, technology, and footprint.

The different alternatives of renewable energy are photovoltaic, hydroelectric, biomass, and other types of geothermal energy. In order to analyze the effectiveness and viability of the type of technology, several factors need to be included.

First, the Energy Return for Energy Invested EROEI. Currently, the only type of renewable technologies that have reached a level of EROI high enough to compete with fossil fuels are wind and photovoltaic energy. "The EROEI is the ratio of the amount of energy that will be produced by a plant over its lifetime and the amount of energy that needs to be invested to build the plant, operate it, and finally dismantle it" (Bardi et al; 2013).

Second, the area occupied by the plants. As an example, in photovoltaic energy, the land needed for the installation of solar panels is often seen as a major problem.

Permaculture

Permaculture is a growing initiative that has a very natural approach. It focuses on integrating human habits into natural landscapes and to observe how ecosystems work because they are resilient and long-lasting. An example of this is waste, the waste of some species is the food for others. Everything is used, this initiative is linked to the circular economy because it promotes zero waste too. Self-sufficiency is the best word to describe permaculture. it integrates plants, animals, and humans into a closed-loop system where each element supports another.

To better understand this initiative and technique, Permaculture Research Institute Kenya (PRI) is a good reference. It was founded in 2011 to encourage permaculture in Africa.
Seeds from previous harvests are used for new crops, and indigenous species of the region are their main target because they know it will have a higher yield as they are adapted to the area. PRI Kenya also uses intercropping, which refers to multiple species planted together to support one another's growth. Also, they integrate companion plants, where groups of plants that grow well together assist each-other in pollination and pest control.

Permaculture has been growing because it does not only apply to big portions of land, it can be scaled to different sizes of businesses. Permaculture can be summarized as discarding the industrial model of agriculture and focusing on environmental flexibility and rehabilitation by understanding how ecosystems work and are self-sufficient.

1.22 SUSTAINABLE DEVELOPMENT GOALS

According to the United Nations (UN), the Sustainable Development Goals (SDG's) are the guidelines in order to achieve a more sustainable future for everyone. They address the main current global challenges we face as humanity. There are 17 objectives related to poverty, inequality, climate, environmental degradation, prosperity, and peace, and justice. The UN makes emphasis that the Goals interconnect and in order to leave no one behind and that it is important to achieve each goal and target by 2030 (United Nations, 2019).

The goals that have the most direct connection with agriculture are:
SDG 2: End hunger, achieve food security and improved nutrition and promote

sustainable agriculture. The biggest challenge for this goal is to achieve full national food security but if it is done right, agriculture can provide food for all and leave no one behind. Guaranteeing quality nutrition and sustainable agricultural production continues to be major challenges too. A profound change in the global food and agriculture system is needed. Agriculture is the single largest employer in the world and there are around 500 million small farms worldwide. Producing regional products, accessing high-value markets, and improving planning and investment in infrastructure and transportation to increase opportunities for transitioning towards more sustainable agricultural models is key. Some of the goals for 2030 for this goal are to end hunger, ensure access to everyone, and end all forms of malnutrition (United Nations, 2019).

SDG 13: Climate change. Many countries are becoming highly vulnerable to the effects of climate change because of their geographical location. After formalizing its adherence to the Paris Agreement, some countries have started a series of mitigation and adaptation measures. To strengthen the global response to the threat of climate change, countries adopted the Paris Agreement at the COP21 in Paris, which went into force in November of 2016. In the agreement, all countries agreed to work to limit global temperature rise to well below 2 degrees centigrade. Some of the main targets for this goal include strengthening resilience and adaptive capacity, integrating climate change measures into national policies, and awareness-raising for climate change mitigation (United Nations, 2019).

SDG 15: Life on land. Forests cover 30.7 percent of the Earth's surface and, in addition to providing food security and shelter, they are key to combating climate change. Deforestation and desertification caused by human activities and climate change pose major challenges to sustainable development. Slowing the change of land use patterns due to agriculture and ranching is a key aspect along with creating opportunities to attract financing and promoting projects that make sustainable use of biodiversity. Nevertheless, factors such as changes in government, legal and budgetary restrictions, and temporary contingencies can jeopardize continuity. Some of the main targets for this goal include ensuring the conservation, restoration, and sustainable use of terrestrial and inland freshwater ecosystems and promoting the implementation of sustainable management of all types of forests (United Nations, 2019).

1.3 CONCLUSION: SITUATING THE THESIS IN THE LITERATURE

Worldwide food security needs to be achieved and agriculture plays a key role. There is a clear shift towards more sustainable agricultural practices superseding those from conventional practices like circular economy, permaculture, and renewable energies. Nevertheless, it is important to mention that conventional agriculture has fed the human population for the last centuries, but it is not certain that it will continue to do so due to the increase of the human population and climate change.

It is true that agriculture plays a key role, but it is a consumer-driven industry and there is an existing debate with plant and animal-based diet that will continue to influence consumer behavior and drive demand towards one or the other (USDA, 2003). As stated in the literature, there are several views with positive and negative impacts from both diets and the main questions that remain are to what extent do recent trends in South American food-consumption exceed the 2030 SDG goals and how can policymakers close the gap in order to meet the 2030 SDG goals.

This will shape the way the industry evolves and how will it contribute to the SDG goals set by the United Nations. The following chapters of the thesis will aim to analyze historical data and forecasts in order to compare the trends to the SDG goals and will describe relevant scenarios for aligning consumption and with the goals.

CHAPTER 2: METHODOLOGY

The purpose of this study is to reveal what is the difference between current trends of consumption and the SDG goals and to understand how policymakers can create policies that help meet them.

This chapter explains the methodology chosen to answer the research questions and to test the hypotheses. It also explains the choice of research design and strategy, the data collection method, and data analysis for the study.

3.1 RESEARCH DESIGN AND STRATEGY

Out of the three main research designs; exploratory, descriptive, and explanatory (Saunders et al, 2009), this study will use the descriptive.

Descriptive research is defined as a research method that describes the characteristics of the population or phenomenon that is being studied. This methodology focuses more on the "what" of the research subject rather than the "why" of the research subject.

This type of research primarily focuses on describing the nature of a demographic segment and the phenomena should be clear already before collecting the data (Saunders et al, 2009). The descriptive research design aligns the best with the purpose of this study since the aim is to uncover details or patterns on the data used in the analysis. Will describe what are the consumption trends and the alignment to the SDGs and what are the policies that can be implemented to help achieve that.

On the other hand, the research strategy is another key element of the methodology of this study. It should also be guided by the research question and research objectives to allow the researcher to answer the particular research question and meet the research objectives (Saunders et al, 2009).

Saunders et al. (2009) describe 7 different research strategies but the three most widely used are experiment, survey, and case study.

3.2 DATA COLLECTION

The study is limited to the Latin American region and useful and reliable data about consumption patterns are needed. Due to practical and resource constraints, the most accurate data needs to be found in order to address both research questions.

Data has a big impact on the relevance and findings and that is why using existing quantitative data from the OECD (Organisation for Economic Cooperation and Development) was chosen. Data will come from "The Agricultural Outlook" a joint report prepared by the Organisation for Economic Co-operation and Development (OECD) and the Food and Agriculture Organization (FAO) of the United Nations. The report provides thirty years of historical data along with a ten year forward-looking, assessment of trends and prospects in the major temperate-zone agricultural commodity markets of biofuels, cereals, oilseeds and oilseed products, sugar, meat, fish and seafood, dairy products, cotton. Data was collected using a number of monitoring methods for the countries included in the study (OECD/FAO, 2019).

The projections in the data set are influenced both by current market conditions and by assumptions on the macro-economic, demographic, and policy environment (OECD/FAO, 2019) The projections in the Outlook are developed by OECD and FAO in collaboration with experts from member countries and international commodity bodies. In the OECD, Data are collected using a converged reporting system where bilateral and multilateral providers of development co-operation use a single file format called "Creditor Reporting System" to report at item level on all flows of resources to developing countries. Item-level reporting is validated against key aggregates also reported by donors and then serves as the basis for producing various other aggregate statistics. (OECD/FAO, 2019)

There are two types of data that a researcher can use: primary and secondary data. Secondary data is data that has been originally collected for some other purpose, including raw data and published summaries, that can be analyzed to meet own research objectives and to answer the research questions. However, for most research studies primary data is used to fully answer the research question as the new primary data is collected specifically for the research

project that is in process. (Saunders et al, 2009) For the purpose of this research, data will be secondary because no data will be collected specifically for the purpose of this thesis. Convenient and available data exists from trustworthy sources and is enough to cover the needs of the research questions defined in previous sections. In further sections, reliability and validity will be discussed along with the connection of the source of the data.

It is also important to define the time horizon of the study. It is a longitudinal study since it is the research that represents the events over a specific period. The advantage of this time horizon is that it's able to study change and development. The other type that exists is the cross-sectional study, meaning that it studies the phenomenon only at a particular time rather than over a longer period of time (Saunders et al, 2012).

3.3 DATA ANALYSIS

After the data has been collected, it must be processed and analyzed in conformity with the purpose of the research to understand the patterns and the key variables to answer the research questions. In order to do so, summarizing and organizing results so that they answer the research question is important. Research studies often result in a large volume of raw data which must be appropriately reduced in order for the same data to be easily read and to be used for further analysis and, therefore, certain indices or measures to summarize the collected data must be developed. It does not matter if the quality of the data is high until it is used in the appropriate way in order to get the desired results. Furthermore, it is important to have all the relevant data in order to make reflected comparisons and analysis.

The data comes in the form of continuous numerical data, meaning that values can take any value, given that it is measured accurately (Saunders et al, 2012). Since the quantity of data included in the OECD/FAO Agricultural Outlook is high, data will first be categorized and selected to include only relevant information for the analysis.
First, out of the 35 countries listed in the database, we will focus on data from Mexico, Brazil, and Colombia only. Secondly, there are many commodities listed in the database, and only meat and plant-based data from the following categories will be selected:

- Animal-based: beef and veal, pig meat, poultry meat, sheep meat, fish, fresh dairy products, butter, cheese.
- Plant-based: wheat, maize, other grains, rice, soybeans, distiller's dry grains, oilseeds.

The database includes several categories of data per commodity: production, consumption, imports, exports, yield, among others. For the purpose of this research, the focus will be on consumption.

After selecting the data as previously described, it will be analyzed using excel statistical tools in order to understand trends. It is important to mention that the data available comes from 1990 all the way to 2028 and we will use all the time frames.

Ethics will be considered in the thesis, it relates to questions about ”how we formulate and clarify our research topic, design our research and gain access, collect data, process and store our data, analyze data and write the research findings in a moral and responsible way” (Saunders et al, 2009: 184). In order to achieve this, we guarantee that the data comes from sources where the privacy of participants of the monitoring system was assured and data received will be handled with confidentiality. Participation in the monitoring by the OECD and FAO was completely voluntary and they were informed about the objective of the monitoring round (OECD/FAO, 2019).
During the data analysis, special care will be taken in order not to misrepresent the collected data and to have the objectivity to get the right conclusions and recommendations.

To guarantee the quality of the data and the research, the credibility of the research findings needs to be ensured with reliability and validity (Saunders et al, 2009) that will be addressed in the next two sections.

3.3.2 VALIDITY

Validity refers to "the extent to which data collection method or methods accurately measure what they were intended to measure" as well as "the extent to which research findings are really about what they profess to be about" (Saunders et al, 2009: 603).
Data comes from a monitoring round performed by the OECD and FAO, it was conducted on sample groups who have the intention to participate, also, the sample groups include several Latin-American countries (Chile, Mexico, Brazil, Colombia, Argentina, Paraguay, Peru)
We will use the data from the 3 biggest Latin-American countries in terms of population: Mexico, Brazil, and Colombia (World Population Review, 2020) in order to understand consumption trends in the region and for data to be representative.

On the other hand, no major event has happened during the data collection that could have altered the results (such as a catastrophic natural disaster, disease, a disruptive product technology, etc.) or have a dramatic effect on findings. Therefore, we can argue that the samples are both significant and big enough to generalize our research results to the Latin-American market.
Internal validity is important, biased information will be reduced because the information comes from measurement tools to avoid the data to be altered in a certain way that could favor countries that participated in the monitoring round. Furthermore, to assess criterion-related validity, we will compare the findings to the recommendations made by the OECD when they published the summary of the Agricultural Outlook in 2019 to make sure that we give recommendations along similar lines.

Concerning external validity, findings can be applied to other research settings and even in the case that our results may not be generalized, valid over time or applied to other contexts, we believe that the study can produce insights to complement the existing research studies on the matter and provide direction for future researchers. So, there are no high deception issues to thread research ethics but a motivation to do the data analysis with accuracy and honesty.

3.3.1 RELIABILITY

Reliability refers to "the extent to which data collection techniques or analysis procedures will yield consistent findings" (Saunders et al, 2009: 156), "similar observations would be made or conclusions reached by other researchers or there is transparency in how sense was made from the raw data" (Saunders et al, 2009: 600).

We expect that the electronic data collection technique and the analysis procedure will yield consistent findings. Decoding errors can be considered minimum as all the data was decoded electronically through OECD and FAO tools that are reliable.

There can be four types of threats to reliability: participant and observer error, and participant and observer bias. Participant error can be concluded to be minimum as the questionnaire was responded by government agencies that are capable to respond in an appropriate way.

However, participants' bias cannot be completely mitigated as participants have to disclose the country they are representing when reporting the data, and they might feel a certain political pressure when responding.

CHAPTER 3: ANALYSIS

In this chapter, the analysis is presented and discussed. First, the descriptive statistics are presented, detailing the order of thought to analyze the data and subsequently look into the results. 3,393 data from Mexico, Colombia, and Brazil from 15 different types of commodities (wheat, maize, other grains, rice, distillers dry grains, soybean, other oilseeds, beef and veal, pig meat, poultry meat, sheep meat, fish, fresh dairy products, butter, and cheese) both from plant and animal-based food in the time frame of 1990-2028 were used for the analysis.

Some data was used individually and some combined between the three countries to understand trends in the region. Some data was deleted since it was not complete and therefore useful to use in this analysis.

This chapter is divided into two parts in order to answer RQ1: To what extent do recent trends in Latin American food-consumption exceed the 2030 SDG goals? and RQ2: How can policymakers close the gap in order to meet the 2030 SDG goals?

4.1 DO CURRENT TRENDS IN LATIN AMERICAN FOOD-CONSUMPTION ALIGN WITH THE SDG GOALS?

4.1.1. OVERVIEW OF TRENDS IN THE REGION

The first part of the analysis was to get a big picture of the current trends per country and graphs were used to understand the main trends in the three countries. With this, we obtained the following commodities as the ones with the most increase in the time frame of the data (1990-2028).

In Brazil, Maize and Soybean had the biggest increase in consumption in the 37-year timeframe in terms of thousands of tons consumed. Maize had a projected increase of more than 51 thousand tons, a 205% increase whereas soybean had the second-largest increase

with more than 45 thousand tons, representing a 287% increase. The following graphs show the trend. The x-axis shows the year (1-37 representing the time frame of 1990-2028 and the y-axis the quantity of consumption in thousands of tons)

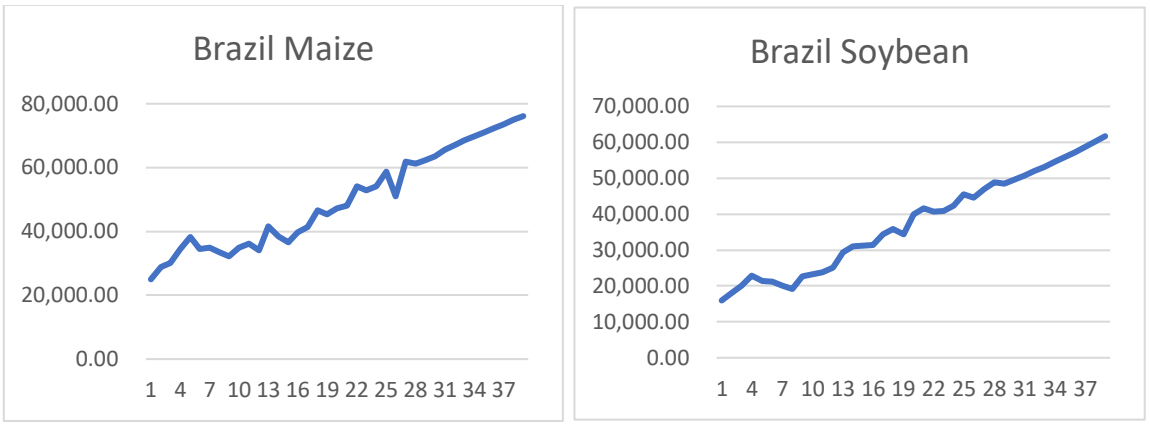


Figure 3.1: Brazil´s Maize and Soybean consumption in thousands of tons (OECD/FAO, 2019)

In Mexico, maize and poultry meat had the biggest increase in the 37-year timeframe in terms of thousands of tons consumed. Maize has a projected increase of more than 31 thousand tons, a 195% increase whereas poultry meat had the second-largest increase with more than 4 thousand tons, representing a 515% increase. The following graphs show the trend:

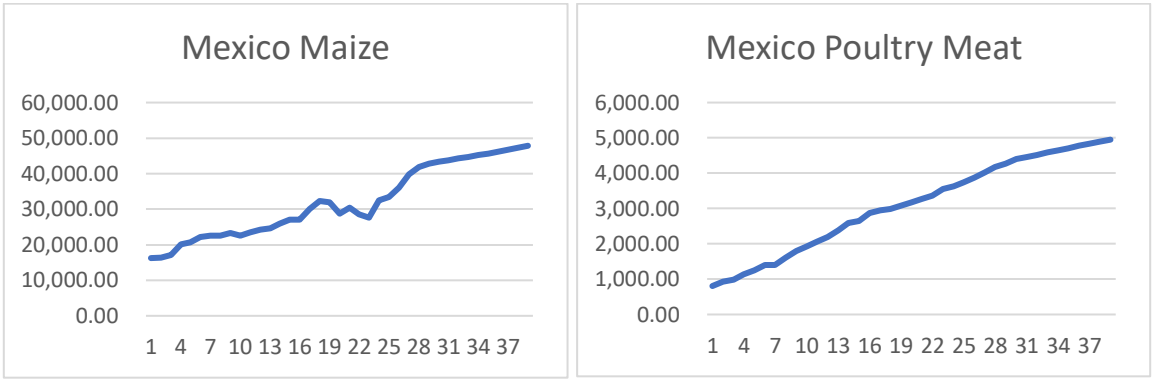


Figure 3.2: Mexico's Maize and Poultry Meat consumption in thousands of tons. (OECD/FAO, 2019)

In Colombia, maize and fresh dairy products had the biggest increase in the 37-year timeframe in terms of thousands of tons consumed. Maize has a projected increase of almost

7 thousand tons, a 600% increase whereas fresh dairy products had the second-largest increase with almost 3 thousand tons, representing an 89% increase. The following graphs show the trend:

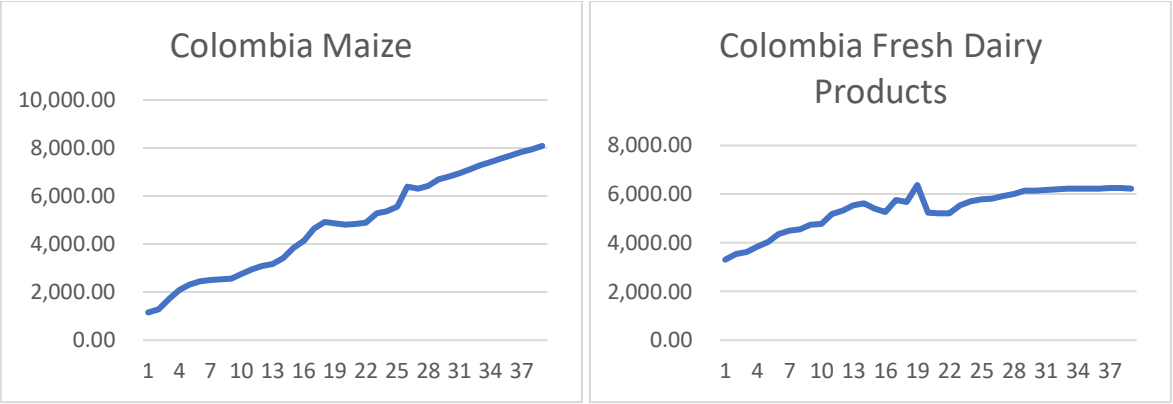


Figure 3.3: Colombia's Maize and Fresh Dairy Products consumption in thousands of tons. (OECD/FAO, 2019)

The biggest increase in the region (Mexico, Brazil, and Colombia), when analyzed together, showed that Maize and Soybean were the highest with an increase of more than 89 and 50 thousand tons respectively in the 37-year time frame. This provides very useful information for the next chapters of the thesis.

4.1.2 EMISSIONS PER COMMODITY AND THE IMPACT ALL THE WAY TO 2028

The second part of the analysis has the objective of quantifying the previously mentioned increases with the emissions per type of commodity. The most challenging aspect of this section, which will be later addressed in the limitations, was that there are many sources of information with different quantities about carbon dioxide emissions per kilogram of the commodity.

The following table shows the values that were assigned to each commodity, the information was taken from several sources:

	Commodity	Emissions per kg (kg of C02 equivalent)
Plant-Based	Wheat	0.4
	Maize	1
	Other grains	NA
	Rice	2.7
	Distiller's dry grains	NA
	Soybean	0.3
	Other oilseeds	NA
Meat-Based	Beef and veal	27
	Pigmeat	12
	Poultry meat	6.9
	Sheepmeat	24
	Fish	5
	Fresh dairy products	NA
	Butter	12.505
	Cheese	13.5

Figure 3.4: kg of CO2 Emissions per Commodity (Visual Capitalist, Bloomberg et al.)

Some values were declared as non-applicable because it is not possible to quantify some commodities like “other grains”, “Distillers dry grains”, “Other oilseeds” and “fresh dairy products” in kg of CO2 emissions since they include subcategories inside that cannot be clearly divided.

In this section of the analysis, the total kg of CO2 (carbon dioxide) emissions were calculated in 1990 and 2028 per commodity to understand the trend. This analysis is useful because the ultimate objective is to know the impact on the SDGs, an increase in consumption does not necessarily mean that the emissions are in the same proportion as different commodities have different CO2 emissions. The following table shows the results:

	Commodity	Average Total emissions in 1990 (kg)	Average Total emissions in 2028 (kg)
Plant-Based	Wheat	1,533,733,385.33	3,126,631,857.49
	Maize	14,129,833,407.40	44,017,610,545.26
	Other grains	NA	NA
	Rice	9,052,884,284.24	10,298,473,875.50
	Distiller's dry grains	NA	NA
	Soybean	1,742,748,757.00	6,800,071,756.17
	Other oilseeds	NA	NA
Meat-Based	Beef and veal	54,560,919,255.44	94,508,456,810.09
	Pigmeat	7,944,565,219.53	28,531,679,665.19
	Poultry meat	7,412,258,934.68	39,819,858,541.04
	Sheepmeat	1,370,577,123.77	1,854,818,942.31
	Fish	3,855,703,934.88	8,825,137,921.67
	Fresh dairy products	NA	NA
	Butter	430,258,086.89	1,604,558,417.01
	Cheese	2,286,400,504.31	7,142,112,733.25

Figure 3.5: Average total CO2 emissions of Mexico, Brazil, and Colombia in kg from 1990 and 2028

In terms of CO2 emissions, we have different results compared to the first section where we had maize as the highest in terms of increase in consumption. This result shows that the highest impact difference from 1990 to 2028 comes from beef and veal and Poultry with CO2 emissions of more than 39 and 32 billion kilograms respectively. In third place is Maize and in fourth pig meat with more than 29 and 20 billion kilograms.

4.1.3 ALIGNMENT WITH THE SDG GOALS

CO2 emissions in 1990, where the study starts, equal to more than 104 billion kg of C02 equivalent. If consumption follows the same trend as shown in the numbers, CO2 emissions are expected to grow to more than 246 billion kg of CO2 equivalent in 2028. This represents an increase of 136%.

According to the United Nations, SDG 13, Climate action aims to mobilize US$100 billion annually by 2020 to address the needs of developing countries to both adapt to climate change and invest in low-carbon development to limit the increase in global mean temperature to two degrees Celsius above pre-industrial levels, aiming at 1.5°C. It emphasized urgent and ambitious collective action and some of the main key facts and figures are that as of 2017 humans are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels. Sea levels have risen by about 20 cm (8 inches) since 1880 and are projected

to rise another 30–122 cm (1 to 4 feet) by 2100. To limit warming to 1.5C, global net CO2 emissions must drop by 45% between 2010 and 2030 and reach net zero around 2050. Climate pledges under The Paris Agreement cover only one-third of the emissions reductions needed to keep the world below 2°C (United Nations, 2019)

The previous analysis shows that food consumption and production will not contribute enough to the goal of reducing CO2 emissions by 45% between 2010 and 2030 and will negatively keep opening the gap by increasing emissions by more than 134% if food consumption patterns stay the same way.

	Commodity	Emissions 1990	Total Emissions 1990	Emissions 2028	Total Emissions 2028	Increase % 1990 vs 2028
Plant-Based	Wheat	26,459,199,833.98	104,319,882,893.48	64,242,788,034.42	246,529,411,064.99	142.80%
	Maize					
	Other grains					
	Rice					
	Distiller's dry grains					
	Soybean					
	Other oilseeds					
Meat-Based	Beef and veal	77,860,683,059.51		182,286,623,030.57		134%
	Pigmeat					
	Poultry meat					
	Sheepmeat					
	Fish					
	Fresh dairy products					
	Butter					
	Cheese					

Figure 3.6: CO2 Emissions in 1990 and 2028

4.2 HOW CAN POLICYMAKERS CLOSE THE GAP IN ORDER TO MEET THE 2030 SDG GOALS?

The question that remains is how policymakers can close the gap in order to meet the SDGs. For this analysis, first emissions will be divided according to plant or animal-based commodities in order to understand the emissions per diet type. Then, several scenarios will be forecasted in order to show different alternatives for how food consumption can evolve for the better in terms of CO2 emissions.

The selection of scenarios was first by selecting the two most extreme scenarios where the global diet is either 100% purely vegetarian or animal-based. These will show the two extremes so then other scenarios can be used in the middle. The next scenarios were chosen given the fact that red meat has the highest emissions of CO2 compared to other commodities, two scenarios are used where red meat is substituted for other types of white meat or fish.

The last scenario is where the diet is 100% plant-based but only from specific commodities that emit the least amount of CO2, this to show how close it would be to meet the SDG goals.

4.2.1 SEPARATING EMISSIONS FROM PLANT AND ANIMAL-BASED COMMODITIES

This section aims at analyzing the impact of CO2 emissions from two groups: plant and animal-based commodities.

The total CO2 emissions in kg were quantified for all commodities and then separated into two subgroups plant-based and animal-based commodities. The following table shows that 25% of the total emissions in 1990 came from plant-based commodities and the rest from animal-based. This clearly shows that the most resource-intensive commodities are the ones that come from meat sources. The total emissions in 1990 were approximately 104 billion tons of CO2 equivalent.

	Commodity	Emissions 1990	Total Emissions 1990	Emissions 1990 %
Plant-Based	Wheat	26,459,199,833.98	104,319,882,893.48	25%
	Maize			
	Other grains			
	Rice			
	Distiller's dry grains			
	Soybean			
	Other oilseeds			
Meat-Based	Beef and veal	77,860,683,059.51		75%
	Pigmeat			
	Poultry meat			
	Sheepmeat			
	Fish			
	Fresh dairy products			
	Butter			
	Cheese			

Figure 3.7: CO2 Emissions in kg from 1990

The previous table shows that the same trend goes all the way to 2028, where animal-based commodities have the highest percentage of emissions with 74% out of the total, animal-based commodities contribute to 24% of the total emissions. Emissions from plant-based commodities show an increase of 143% and meat-based at 134% when compared from 1990. The total emissions in 2028 will be approximately 246 billion tons of CO2 equivalent.

	Commodity	Emissions 2028	Total Emissions 2028	Emissions 2028 %
Plant-Based	Wheat	64,242,788,034.42	246,529,411,064.99	26%
	Maize			
	Other grains			
	Rice			
	Distiller's dry grains			
	Soybean			
	Other oilseeds			
Meat-Based	Beef and veal	182,286,623,030.57		74%
	Pigmeat			
	Poultry meat			
	Sheepmeat			
	Fish			
	Fresh dairy products			
	Butter			
	Cheese			

Figure 3.8: CO2 Emissions in kg from 2028

In the 37-year time frame, the total consumption of all commodities exceeds 8 billion kilograms. Out of this total consumption, 23% was from animal-based commodities and the rest from plant-based. However, the previous section showed that emissions were almost the opposite where animal-based commodities contribute to almost 74% of kg of CO2 emissions.

4.2.2 SCENARIOS

This section aims at showing different scenarios and on how they will contribute to the SDG Goals. The purpose is to create some fictional analysis to understand how different decisions in terms of food align with the SDG goals. The first five scenarios assume that there will be no changes in food production technology while the last one contemplates that change.

- **Scenario 1 and 2: Purely plant-based or animal-based diet**

In order to better understand the magnitude of the impact of these emissions in the decision on whether to buy one commodity or the other we ran a forecast of the number of emissions that would exist if only one type of diet existed in 2028; either fully plant-based or fully animal-based.

In order to do this, an average of emissions was taken for the whole category to calculate the total emissions (meat or plant-based)

Using this calculation, if the diet was only from animal-based commodities, the emissions would be of more than 1.3 trillion kg of CO2. This is an exaggerated scenario but serves the purpose to illustrate the reader on how much CO2 intensive are animal-based products.

If the diet was only from plant-based commodities, the emissions would be of more than 76 million kg of CO2. This would be 20 billion kg of CO2 emissions more than the SDG goal of 56 billion.

The difference between both scenarios is considerable, the emissions from a pure animal-based diet would be almost 17 times higher than the ones from a purely plant-based one.

	Commodity	Emissions if there was only meat-based consumption 2028	Emissions if there was only plant-based consumption 2028
Plant-Based	Wheat	1,311,202,330,235.21	76,708,718,211.77
	Maize		
	Other grains		
	Rice		
	Distiller's dry grains		
	Soybean		
	Other oilseeds		
Meat-Based	Beef and veal		
	Pigmeat		
	Poultry meat		
	Sheepmeat		
	Fish		
	Fresh dairy products		
	Butter		
	Cheese		

Figure 3.9: CO2 Emissions in kg in 2028 if the diet was only purely animal-based or plant-based.

In all the scenarios we will simulate, one dimension that considerably affects the forecasts by 2028 of the data we used is the increase in population and the increase in consumption per capita. The increase in population factor makes emissions grow each year regardless of the diet decision because it is also a matter of the number of humans to feed.

To illustrate this, data about population growth and consumption per capita for the three countries is illustrated in the following figures: from 2005 (the oldest data available for the population from the OECD) and 2028:

	Commodity	Increase in per capita consumption (3 countries in kg)
Plant-Based	Wheat	39.87
	Maize	47.14
	Other grains	- 0.01
	Rice	- 3.61
	Distiller's dry grains	No data available
	Soybean	0.08
	Other oilseeds	- 0.56
Meat-Based	Beef and veal	1.94
	Pigmeat	21.67
	Poultry meat	78.15
	Sheepmeat	- 0.25
	Fish	13.50
	Fresh dairy products	34.72
	Butter	1.45
	Cheese	3.82

Figure 3.10: Increase in per capita consumption

	Commodity	Average Total emissions in 1990 (kg)	Average Total emissions in 2028 (kg)
Plant-Based	Wheat	14.28	19.59
	Maize	55.66	71.37
	Other grains	NA	NA
	Rice	75.56	72.31
	Soybean	0.00	0.01
	Other oilseeds	NA	NA
Meat-Based	Beef and veal	387.82	405.31
	Pigmeat	63.25	149.94
	Poultry meat	65.44	245.19
	Sheepmeat	11.59	9.62
	Fish	35.17	57.67
	Fresh dairy products	NA	NA
	Butter	4.99	11.03
	Cheese	24.59	41.76

Figure 3.11: CO2 emissions in per capita food consumption in 1990 and 2028 (average of the 3 countries)

Country/ Year	Population in Millions	
	2005	**2028**
Mexico	105	130
Colombia	42	53
Brazil	184	222

Figure 3.12: Population in 2005 and forecast for 2028. (OECD, 2020)

- **Scenario 3: Reduction of red meat with an increase of white meat**

In this scenario, the purpose is to simulate a more realistic scenario where red meat will be reduced by 30% and substituted with white meat (poultry and fish).

In order to do the calculations, consumption for beef and veal, pig meat and sheep meat was reduced by 30% and poultry and fish increased by 30% where the result was that this change in diet will have an 11% of reduction in the CO2 emissions when compared to the current trend showed in the data by 2028 (a decrease from 246 billion kg to 216 billion kg).

	Commodity	Average Total emissions in 2028 (kg) regular consumption	Average Total emissions in 2028 (kg) with change in diet
Meat-Based	Beef and veal	94,508,456,810.09	66,155,919,767.06
	Pigmeat	28,531,679,665.19	19,972,175,765.63
	Poultry meat	39,819,858,541.04	39,819,858,541.04
	Sheepmeat	1,854,818,942.31	1,298,373,259.62
	Fish	8,825,137,921.67	8,825,137,921.67
	Fresh dairy products	NA	NA
	Butter	1,604,558,417.01	1,604,558,417.01
	Cheese	7,142,112,733.25	7,142,112,733.25

Figure 3.14: CO2 Emissions per commodity (kg) in 2028 if red meat is reduced by 30% and substituted with white meat

This is an 11% reduction over the forecasted emissions by 2028 but will not contribute significantly to the SDG target of reducing emissions by 45% in 2030 which would need to be a total of 56 billion kg of CO2:

	Commodity	Emissions if there was a 30% reduction in red meat, substituted by white meat
Plant-Based	Wheat	
	Maize	
	Other grains	
	Rice	
	Distiller's dry grains	
	Soybean	
	Other oilseeds	
Meat-Based	Beef and veal	219,691,023,037.85
	Pigmeat	
	Poultry meat	
	Sheepmeat	
	Fish	
	Fresh dairy products	
	Butter	
	Cheese	

Figure 3.15: CO2 Total emissions in kg in 2028 if red meat is reduced by 30% and substituted with white meat

- **Scenario 4: Substitute all red meat for fish**

In this scenario, the purpose is to simulate a scenario where red meat would be substituted for fish. Fish has the lowest emissions out of all types of the white meat types analyzed

The calculations were done in a way that all red meat consumption was calculated with the emissions of fish, which are considerably lower with 5 kg of CO2:

	Commodity	Average Total emissions in 2028 (kg) Regular Consumption	Average Total emissions in 2028 (kg) with change in diet
Meat-Based	Beef and veal	94,508,456,810.09	17,501,566,075.94
	Pigmeat	28,531,679,665.19	11,888,199,860.49
	Poultry meat	39,819,858,541.04	39,819,858,541.04
	Sheepmeat	1,854,818,942.31	386,420,612.98
	Fish	8,825,137,921.67	8,825,137,921.67
	Fresh dairy products	NA	NA
	Butter	1,604,558,417.01	1,604,558,417.01
	Cheese	7,142,112,733.25	7,142,112,733.25

Figure 3.16: CO2 Emissions in kg in 2028 if red meat is completely substituted by fish

The result was that this change in diet will have an 11% reduction in the CO2 emissions when compared to the current trend shown in the data by 2028 (decrease from 246 billion kg to 151 billion kg). This is a 39% reduction over the forecasted emissions by 2028 but will not contribute significantly to the SDG target of reducing emissions by 45% in 2030. Emissions would still be 45% higher in 2028 compared to 1990.

	Commodity	Total Emissions 2028 if red meat is substituted for fish
Plant-Based	Wheat	151,410,642,196.82
	Maize	
	Other grains	
	Rice	
	Distiller's dry grains	
	Soybean	
	Other oilseeds	
Meat-Based	Beef and veal	
	Pigmeat	
	Poultry meat	
	Sheepmeat	
	Fish	
	Fresh dairy products	
	Butter	
	Cheese	

Figure 3.17: CO2 Emissions in kg in 2028 if red meat is completely substituted by fish

- **Scenario 5: Purely wheat and soybean consumption**

Given that all the previous scenarios do not meet the SDGs, it was decided to simulate the last scenario where the human diet was based only on low carbon-emitent commodities like wheat and soybean. Realistically speaking, the human diet cannot be based only on these two types of food as it will not serve the purpose of providing a well-balanced diet that provides enough energy for the human body to survive. It also brings other complications in terms of production and the sustainability of it but for the purpose of this thesis, it illustrates well where emissions stand.

The analysis shows that a pure wheat and soybean diet would reduce CO2 emissions considerably, even below the SDG scenario. Total emissions would be 32 billion kg of CO2, representing a 70% decrease when compared to 1990. This is the only scenario of the ones presented where the SDG goals are met and it shows how challenging it is to achieve that by 2030, the deadline established by the United Nations.

This scenario provides useful insights for the next chapter where recommendations will be made. This might mean that food with emissions similar to the ones of soybean and wheat can be selected.

- **Scenario 6: New technology for food production**

Since beef is the commodity with the highest emissions of CO2 in this study, this scenario contemplates and alternative where technology is used to feeding supplements to livestock that can cut their methane emissions.

By adding a small amount of seaweed to the animals' feed, researchers found, they could cut the cows' methane production by nearly 60% (MIT, 2019). The problem is the digestive process of cattle and other ruminants, known as enteric fermentation. Microbes in their digestive tracts break down and extract energy from the carbohydrates in fibrous grasses. But the same process also generates hydrogen, which a separate set of microorganisms feed on, producing methane.

About 95% of the gas escapes through the mouth and nostrils, while the rest exits in the other direction.

Researchers have explored a number of potential paths to lowering livestock emissions, including selective breeding (some animals are less gaseous than others), vaccines, microbiome transfers, various dietary supplements, and more efficient feeds.

But there's growing momentum behind the seaweed approach, thanks to almost shockingly effective results in initial scientific studies. In 2014, Australian researchers found that low doses of a red algae known as Asparagopsis taxiformis virtually eliminated methane production in lab experiments. Field trials with live sheep cut emissions as much as 80%, while the UC Davis experiment, the first on live cattle, showed a 58% reduction on average when a related seaweed made up 1% of their diet. (MIT, 2019)

The incorporation of new technology in order to feed cows and sheep a different diet that includes seaweed will reduce by 24% the total emissions when compared to current trends:

	Commodity	Emissions 2028	Total Emissions 2028
Plant-Based	Wheat	64,242,788,034.42	188,748,541,992.39
	Maize		
	Other grains		
	Rice		
	Distiller's dry grains		
	Soybean		
	Other oilseeds		
Meat-Based	Beef and veal	124,505,753,957.97	
	Pigmeat		
	Poultry meat		
	Sheepmeat		
	Fish		
	Fresh dairy products		
	Butter		
	Cheese		

Figure 3.18: CO2 Emissions when incorporating new technology to feed cows and sheep a different diet

- **Scenarios comparison and summary:**

The previous scenarios were full of information that cannot be easily compared so the following table shows all the scenarios and where they stand when compared to each other. The color code shows that the redder the scenario is, the farthest away it is to meet the SDG goals. The greener the scenario, the closer it is to the goals.

The worst scenario for CO2 emissions is a pure-meat diet and the best one is a purely plant-based diet which includes only low emitent commodities like wheat and soybean. There are several scenarios in the middle with more or fewer emissions but that does not completely meet the SDG goals.

		Total Emissions 2028 (kg)					Total Emissions in 1990	Total Emissions 2028 (kg)		
Commodity / Scenario		Pure meat consumption	Current Consumption	30% reduction red meat substituted with white meat	New Technology	Red meat substituted for fish		Pure plant-based consumption	SDG Scenario	Pure wheat and soybean consumption
Plant-Based	Wheat	1.3 Trillion	246 Billion	219 Billion	188 Billion	152 Billion	104 Billion	76 Billion	56 Billion	32 Billion
	Maize									
	Other grains									
	Rice									
	Distiller's dry grains									
	Soybean									
	Other oilseeds									
Meat-Based	Beef and veal									
	Pigmeat									
	Poultry meat									
	Sheepmeat									
	Fish									
	Fresh dairy products									
	Butter									
	Cheese									

Figure 3.19: Scenarios Comparison and Summary

CHAPTER 4: DISCUSSION

The purpose of this thesis was to examine food consumption in Latin America and how can it become more sustainable in order to meet the Sustainable Development Goals by 2030. The objective was to develop a broader understanding of what are the consumption patterns and the environmental impact they have. The research questions were: to what extent do recent trends in South American food-consumption exceed with the 2030 SDG goals and how can policymakers close the gap in order to meet the 2030 SDG goals. The two research questions were addressed to a small extent and need to be explored in more detail because it was limited to specific commodities and countries only.

The main objective of this study was to provide new discoveries and insights and to create a foundation for future studies. It is an initial step towards understanding consumption and how consumer behavior changes the environmental impact of this industry. It also provides a basis from which others may build. Moreover, the research findings also enrich the cross-category literature related to sustainability in agriculture. These topics are discussed and elaborated in the following sections, based on established theory together with the results of the conducted study.

4.1 MAIN FINDINGS

The literature review provided various theories and frameworks regarding agricultural production, consumption, and sustainability. This included different new models of agriculture, consumption patterns, and consumer behavior. This was the basis to build the research study which was focused on finding out how aligned is consumption in Latin America to meet the SDG goals where there has not been specific research before under the same context.

In the analysis, the first finding was about finding which commodities had the biggest increase in consumption in the 37-year time frame of the study. Maize had the biggest increase in the three countries (Mexico, Brazil, and Colombia), followed by soybean.

It was also found that some commodities will have a larger impact in terms of CO2 emissions when quantified according to their specific quantity of emissions. This means that if a commodity had a low consumption but the CO2 emissions per kilogram were high, it was going to have a big impact. Moreover, if the consumption was high but the CO2 emissions per kilogram were low, it was still going to have a big impact. To explain this, one of the main results was that the highest impact in terms of CO2 emissions comes from beef and veal and poultry. In third place comes maize and in fourth pig meat. There were other commodities where CO2 emissions were high but the consumption was so low that it does not really have a big overall impact. This is a result of the combination of an increase in consumption and the CO2 emissions per kg of product. These results started to give a direction of where the direction of the study was going to go.

Further in the analysis, it was important to understand the relevance of the previous findings to the overall objective which is aligning it with the SDG goals. As the UN stated, global net CO2 emissions must drop by 45% between 2010 and 2030 and reach net zero around 2050. The analysis showed that following the existing consumption patterns, food consumption, and production will not only not contribute enough to the goal of reducing CO2 emissions by 45% between 2010 and 2030 but will negatively keep opening the gap by increasing emissions by more than 134% if food consumption patterns stay the same way. This section of the analysis answered the research question one. These results also provided further insights on where the study was going to answer the second research question on how policymakers can close the gap in order to meet the 2030 SDG goals.

To answer the second research question, an analysis per type of food (plant or animal-based) was needed. The analysis showed that 25% of the total emissions in 1990 came from plant-based commodities and the rest from animal-based. The analysis also showed that the same trend goes all the way to 2028, where animal-based commodities have the highest percentage

of emissions with 74% out of the total, animal-based commodities contribute to 24% of the total emissions. Emissions from plant-based commodities show an increase of 143% and meat-based of 134% when compared from 1990.

To give additional information on the previously mentioned findings, in the 37-year time frame, the total consumption of all commodities exceeded 8 billion kilograms. Out of this total consumption, 23% was from animal-based commodities and the rest from plant-based. However, the previous section showed that emissions were in the opposite direction where animal-based commodities contributed to almost 74% of kg of CO2 emissions. This provided very useful information that showed that plant-based commodities were consumed more in terms of kilograms but emissions contributed less, the other way around with animal-based commodities.

The last part of the analysis provided very insightful results in terms of how the consumption can be changed in order to meet the SDG goals. This provides hints for further research and for policymakers to close the gap to meet the SDG goals.
The 6 scenarios analyzed included: pure meat-based diet, a purely plant-based diet, a reduction of 30% in red meat substituted by white meat, a substitution of red meat with fish, the adoption of new technology to feed cows and sheep a different diet, and a purely plant-based diet of only wheat and soybean. Ranking them from most negatively impactful (far from the SDGs) to most positively impactful (closer to the SDGs) in terms of total CO2 emissions, the worst scenario was to have a purely meat-based diet because CO2 emissions were the highest. The best scenario resulted in a purely plant-based diet with only wheat and soybean. This scenario was the only one where the SDGs were met because the CO2 emissions of both commodities are low and the overall impact is lower while still satisfying the consumption demand. Their other scenarios stand in the middle with more or fewer emissions but that does not completely meet the SDG goals.

This information is key for policymakers to understand in which direction can they push national regulations to drive change. The previously mentioned scenario where the SDGs are met is hard to meet in the short term, a pure wheat and soybean diet is not completely realistic

in terms of a worldwide diet by 2020 not only in terms of emissions but also in terms of health. The key aspect is that it shows the number of emissions per commodity that the world needs to stop climate change. This can help as a reference for policymakers to make recommendations on other types of food with similar emissions in order to have a more balanced diet that at the same time has low carbon dioxide emissions. Policies have to have a balance between what is realistically achievable in terms of production to feed an increasing global population and what is recommended to stop climate change where technological innovation can play an important role in the future.

The mass production of ruminant animals produces untenable amounts of climate-warming methane. The conversion of large portions of land into feed grain monocultures to raise ever-growing numbers of animals emits the potent greenhouse gas nitrous oxide, as synthetic fertilizers leach into soils and water. Additionally, this land-use change releases precious carbon stocks from soils into the atmosphere. The analysis showed that red meat was the highest in emissions due to the fact that it is very resource-intensive to produce one kilogram of product. New technology plays a key role to reduce emissions, scenario 6 showed how technological innovations can positively contribute to the goals. A question remains on how can different technologies be added to food production to keep emissions to lower levels.

As an example and in order to better illustrate this for policymakers, in order to raise the cow, it needs grains and water. And in order to grow those grains to feed the cow, more water and other resources are needed. If a person eats 75g of beef every day, over an entire year their consumption of beef is contributing 2,820 kg to the annual greenhouse gas emissions. That is the equivalent of driving a regular petrol car 11,581km or the same as heating the average UK home for 447 days or taking 8 return flights from London to Malaga. Their consumption of beef also uses 8,094m² land, equal to the space of 31 tennis courts (BBC, 2020). This shows how resource-intensive can be one type of food compared to another and shows how consumers can drive change.

Policymakers need to find the perfect equilibrium to recommend policies where the least resources are used, where the global demand for food is met, and where the diet is balanced enough for a healthy life.

4.2 IMPLICATIONS

This section discusses the connection between the results, the theory, and the practical application it can have along with future expectations. Furthermore, the effect that this research may have on future research, policy decisions, or the appropriate field of research is discussed.

4.2.1 THEORETICAL IMPLICATIONS

This research contributes to the emerging literature by proposing new topics to be studied further. This study covers research gaps in terms of current consumption trends and future forecasts, establishing a framework to be researched further.

Literature regarding food consumption patterns in Latin America is limited and focuses mainly on a few products on a larger scale. However, not much literature is dedicated to a larger quantity of products that shows information per country. Additionally, not a lot of information is available regarding how far or close is Latin America to meet the Sustainable Development Goals despite the importance of the phenomenon.

There is a strong dependence on new technology, there is almost no way to reach the goals without it. Theory should focus more on new technology and the adoption of it and less on changing consumer habits.

Further research is needed to create new theoretical frameworks to systematically analyze the implications of food consumption in the region.

4.2.2 PRACTICAL IMPLICATIONS

New knowledge about consumption patterns in Latin America is valuable for policymakers worldwide. Understanding these patterns will not only be useful for countries in Latin America but also for other regions in the world which can relate because they have similar contexts.
This study can assist policymakers and governments when deciding whether to facilitate regulations or investments towards specific products that target consumers.

This research suggests that the SDG goals will not be met unless resources are mobilized so consumption patterns change towards a more plant-based diet. As stated before, consumer behavior plays a key role, and governments can use this information and include it in marketing campaigns, national education plans, subsidies, and foreign investment projects so that plant-based food becomes predominant in the diet.

Technology will also play a crucial role in the future to make processes less resource-intense. CO2 emissions of different commodities can drastically change with new technology round more efficient ways to heat, freeze and transport food. Additionally, more productive technology to use less water can potentially change the industry.

Furthermore, the knowledge provided by this study gives different scenarios and possibilities to national decision-makers in order to incorporate tailored strategies for each country. If the proposed recommendations are followed, the gap of CO2 emissions will start to close and ultimately meet the SDG goals.

4.3 LIMITATIONS

Limitations of this thesis need to be considered for future research and for the reader to understand the context and ambition of this research paper.

First of all, this paper was written as a master thesis, with its limitations regarding resources and time, which results in a limited scope of this paper. The study was performed in a 6 month timeframe with one person performing all tasks.

There are limitations considering the data since the dataset was taken from already existing sources from the OECD. This has implications because there was no control in the sampling round or in the way the survey to obtain data was designed, furthermore, there was no control over the sampling size. Additionally, it is not possible to ensure that the respondents were not influenced by internal or external factors at the time of responding. However, it is important to also mention that the methods used to gather data through monitoring rounds by the OECD are recognized internationally and are validated to ensure the quality of the information gathered.

This study is not representative for providing a global picture of the phenomenon, it can only be generalized as Latin America where Mexico, Colombia and Brazil were the countries covered in the scope.

Another limitation is that the was data used on this thesis from 2020 to 2028 that were forecasts. These represent an analysis and vision from the OECD where this study had no control of.

There is a limitation given the fact that this study takes technology as constant in future projections. This means that is that it does not take new technology innovations that can reduce emissions into account.

The last limitation is the quality of the information used for CO2 emissions per type of commodity. There are very diverse sources of data with very different approaches. The selected sources come from respected sources but cannot be taken as the only trustful sources. The way they calculated emissions is not completely public to the reader and would need a deeper analysis and comparison with other sources to judge them thoroughly.

4.4 FUTURE RESEARCH

To produce valid results that can be generalized to a broader target population, a larger scope of countries to create a worldwide analysis is needed. Further research is highly recommended and would provide a second stage of analysis with deeper and valuable insights and to enhance the knowledge and frameworks regarding the phenomenon.

Furthermore, there are plenty of other types of food that were not considered in the analysis and that are very resource-intensive and that are negatively contributing to the SDGs. This currently lacks extensive research and would be useful to perform the same analysis with a broader range of products or commodities.

Additionally, the study could be divided per type of food like animal or plant-based but with many more subcategories including fruits, grains, vegetables, etc. This would provide more specific results and can be used to tailor national programs to different country contexts.

The research method used could also be combined with a qualitative study to get broader insights into the phenomenon and to get more information from policymakers, consumers, and national governments. This would provide the study with a more robust approach where the feasibility of recommendations can be connected better with real cases.

Sustainable food consumption is a growing topic that is getting more traction every year. Achieving the SDGs in the next ten years is critical and this phenomenon has to be further researched to provide more data for decision-makers to change policies and to increase the development of research in the field.

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