

Trends in Technology for Agriculture, Food, Environment and Health

Editors

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AGROBIOS

VISION PAPER

**Meat Alternatives
("Plant-Based Meat")
Will Plow Up Agriculture in
the Future by 2025/2050!?**



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Symbol for "Alternative Meats" (SCET, UC Berkeley, 2018)

**"MEAT OR NO MEAT? – THAT'S THE
QUESTION / IS NOT THE QUESTION!"**

1. INTRODUCTION

There is no argument about the fact that everybody must eat. Nevertheless, this fundamental need was globally addressed by the United Nations in the Universal Declaration of Human Rights in 1948, Article 25: "Everyone has

the right to a standard of living adequate for the health and well-being of themselves and of their family, including food, clothing, housing and medical care and necessary services ...," (*United Nations, 1948*). How this should be done was not outlined at that time.

At the beginning of the Third Millennium, we all know that this human right is not being realized worldwide (*Kern, M., 2012*). Facilitating food and nutrition security by closing the protein gap now (the gap has been exacerbated by *African Swine Fever*) and up to 2050 are ongoing challenges.

Between 2015 and 2050 more than a doubling of crop production, an almost doubling of meat production, a tripling of plant-based protein production (food & feed), and a tripling of fruit and vegetable production will be necessary to feed in a healthy way the 9.7 billion people living on the earth (*Kern, 1998; 2016a; 2016b*).

1.1. Definitions for Clarification

- **'Food'**, is any substance consisting essentially of protein, carbohydrate, fat, vitamins or minerals used in the body of an organism to sustain growth and vital processes and to furnish energy (*Merriam Webster's Dictionary, 2019*).
- **'Food' (or 'Foodstuff')** means any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by humans (*EC Regulation No 178/2002 of the European Parliament and of the Council, January 28, 2002*).
- **'Meat food product'** is human food derived from the carcasses of cattle, sheep, pigs, goats or poultry.
- **'Nutrition'** is the process of taking in food and using it for growth, metabolism, and repair.
- **'Eating'** means to consume food, to express lifestyle, social gathering and culture.

1.2. List of Global Food Types

Today, food is available in such a sheer diversity that the world has never seen before. There are a lot of food types for every letter of the alphabet:

- A.** AB-food, airline food, anti-aging food, anti-allergic food, anti-fat food, anti-anxiety food, antique food, archaic food, artificial food, artisan food, atomic food
- B.** baby food, benefit food, bible food, bio food, blood types food, bowl food, brain food, bush food
- C.** call food, camping food, cell-cultured food, cheap food, chilled food, clean food, climatarian food, comfort food, convenience food, cult food
- D.** dabbawalla food, diet food, diet code food, digital 3D-food, doc food, dog food, dream food, designer food, dorm food, drink food, dry cat food
- E.** e-bay food, eco food, edible food, elite food, e-mail food, enjoyable food, erotic food, ethic food, ethno food, exotic food
- F.** fair food, fast food, fat food, fine food, finger food, fire food, fit food, fortified food, fresh food, frutarian food, frozen food, fun food, functional food, fusion food, futuristic food

- G. gay food, gender food, gene food, genetically modified food, genius food, ghost food, golden ratio food, good food, gourmet food, guy food
- H. hand-held food, happy food, healthy food, halal food, holy food
- I. impulse food, indulgent food, instant food, intergalactic food
- J. junk food, just-in-time food
- K. kern food, kosher food
- L. light food, live food, low-carb food, luxury food
- M. magic food, mac food, media food, medical food, men’s food, mind food, molecular food, mom’s food, mood food, moon food, muscle food
- N. natural food, nature identical flavored food, negative-calorie food, no food, non food, novel food
- O. organic food, on-demand food
- P. patriot food, peace food, peasant food, perfect food, personalized food, pet food, planet health food, power food, premium food, prison food, pure food
- Q. quality food, quick food
- R. raw food, ready food, rejuvenate food, religious food, road food, royal food
- S. safe food, sea food, self-grown food, sentinel food, sex food, simple food, slow food, smart food, smile food, snack food, soldier’s food, soul food, space food, sport food, stone-age food, street food, subsistence food, superhero food
- T. tattooed food, traditional food, toy food,
- U. ugly food, unidentified food, ultimate food, ultra-food, ultra-processed food, utopia food
- V. vegan food, vegetarian food, virtual food, volumetric food
- W. war food, wellness food, whole food, women’s food
- X. x-ray food
- Y. yoga food
- Z. zombie food.

Key characteristics for more or less all the listed types of food containing proteins, carbohydrates, fats, vitamins or minerals are the following: they have to be safe, healthy, sufficient, well tasting and need a well sounding history expressing a specific lifestyle and culture.

1.3. Some Examples of Global Cook Books

Worldwide, there are over 1 billion cookbooks sold every year offering different diets and different histories, *i.e.* 3 million per day – some are real bestsellers. Nevertheless, this does not mean that everyone is utilizing food in the right way. Furthermore, it seems to be that there is no causal relationship between these cook books and public health status.

Some examples of cook books are listed here:

- **Lanzalotta, S.** (2007): “The Diet Code – Revolutionary weight loss secrets from Da Vinci and the Golden Ratio”
- **McLagan, J.** (2008): “Fat: An Appreciation of a Misunderstood Ingredient, with Recipes”

- **Berg, E.** (2013): "I'm cooking so you're dead – no romantic novel" ("Ich koch dich tot – (k)ein Liebes-Roman")
- **Butzek, A.-M.** (2014): "Help, what can I still eat? – The struggle for proper nutrition" ("Hilfe, was darf ich noch essen? – Der Kampf um die richtige Ernährung")
- **Wallner, S.** (2015): "You are not sick, you are only eating the wrong things" ("Du bist nicht krank, du isst nur das Falsche")
- **Goldwyn, M. and Blonder, G.** (2016): "Meathead: The Science of Great Barbecue and Grilling"
- **Greger, M. and Stone, G.** (2017): "How Not To Die: Discover the foods scientifically proven to prevent and reverse disease"
- **Gundry, S.R.** (2017): "The Plant Paradox – The Hidden Dangers in 'Healthy' Foods That Cause Disease and Weight-Gain" ("Böses Gemüse – Wie gesunde Nahrungsmittel krank machen")
- **Lugavere, M. and Grewal, P.** (2018). Genius Foods - Become Smarter, Happier, and More Productive While Protecting Your Brain for Life"
- **Neumann, J.** (2019): "51 Plant-Based High-Protein Recipes: For Athletic Performance and Muscle Growth"
- **Olson, M.** (2019): "Living High off the Hog – Over 100 recipes and techniques to cook pork perfectly"
- **Zacharias, N. and Stone, G.** (2020): "Eat for the Planet Cookbook: 75 Recipes from Leaders of the Plant-Based Movement That Will Help Save the World"
- **Van Mensvoort, K. and Grievink, H.-J.** (2014): "The in Vitro Meat Cookbook". This inspiring cook book was written at a time, when the key ingredient – the cell-cultured meat, was not commercially available. It addresses a broad spectrum of key weak or critical issues in the field of animal production, especially factory farming, in a very serious, bizarre, futuristic and communicative way.

2. PLANT-BASED MEAT ALTERNATIVES

2.1. Plant-Based Protein Overview of Sources

- **SOY:** GMO, non-GMO
- **BEANS, PEAS & PULSES:** black beans, chickpeas, dark red kidney beans, fava beans, great northern beans, green lentils, green peas, light red kidney beans, mayocoba beans, mung beans, navy beans, pea protein, pink beans, pinto beans, red lentils, small red beans, white kidney beans, yellow peas.
- **ANCIENT GRAINS:** amaranth, bulgur, farro, foni, freekeh, kamut, millet, quinoa, rye, sorghum, teff
- **SEEDS & NUTS:** barley, chia, flax, hemp, pumpkin, sesame, spelt, sunflower beans – almonds, Brazil nuts, cashews, hazelnuts, macadamia nuts, peanuts, pecans, pine nuts, pistachio nuts, walnuts (*ADM, 2019*).

2.1.1. The German Pease-Flour Sausage ('Erbswurst')

- Invented in 1867 in Berlin by **Johann Heinrich Grüneberg** who was a cook and food canner. His invention was immediately purchased by the

Prussian Army which introduced the product as the main meal for the soldiers. When the war between France and Prussia broke out in 1870 the factories were producing thousands pounds of '*Erbswurst*' daily

- has been manufactured by the Knorr company since 1889 and sold in Germany
- it may be considered to be the first instant soup in history
- is made from pea flour, pork belly, beef or pork fat, onions, salt and spices
- can be sliced and eaten as a snack or dissolved in hot water to make a nutritious and calorie-rich pea soup
- has almost unlimited shelf life
- is cheap to make and easy to prepare
- is a survival food sausage and has been popular with hikers and expeditions (*Meats and Sausages, 2018*) ...

but UNILEVER discontinued its production (300t/year) and sales of this 129-year old food legend - the *KNORR-Erbswurst* in December 2018. Maybe, a contemporary marketing strategy would have fallen on fertile ground was speculated by Frank (12/2018).

However, it seems more likely that, this product did not fit into the new food product portfolio of KNORR/UNILEVER UK launched under the following headline: "*Plant-based eating: creating a healthy planet through healthy diets.*" (Knorr, 9/2019; Unilever, 10/2019).

2.2. Plant-Based Meat Alternatives from Different Producers

2.2.1. Meat alternatives from meat producing companies

- **Danish Crown** is offering plant-based products, hybrid products by combining minced meat and plant-based products as well as pure meat products.
- **Hormel Foods** in UK is offering protein alternatives containing 20g of non-GMO soy protein, with no preservatives, no cholesterol and is gluten free. The new brand "*Happy Little Plant*"
- **Maple Leaf Foods** (4/2019a) in Canada has launched a plant-based burger named "*Lightlife*". Ingredients are: Water, pea protein, canola oil, modified cellulose, modified corn starch, organic virgin coconut oil, yeast extract, potassium chloride, sea salt, flavoring, beetroot powder, onion powder, ascorbic acid, onion extract, garlic powder, vitamins and a mineral blend, an amino acid blend (i-methionine, i-tryptophan). Allergens: Coconut.
- **Ruegenwalder Muehle** was the first meat producing company in Germany that ventured into the alternative meat market at the end of 2014. "*Mini-Sized Vegetarian Salami*" and "*Mini-sized Vegetarian Sausages*", "*Vegetarian Ham Sausage Salad with 'Herbs'*" and "*Budapest Style*" as well as "*Vegan Ham Sausage with Grilled Vegetables*" were launched in 2018. "*Vegetarian Escalopes*" and "*Vegetarian Nuggets*" were also produced followed by "*Vegan Chicken Filet*", "*Vegan Beef Steak*" and "*Vegan Chicken Strips*". Key marketing focus is on climate protection and responsible consumption. For Rügenwalder Mühle it is not just fleeting hype,

because around one third of its total revenue in 2018/2019 was based on vegetarian/vegan meat-free alternatives (*Vegconomist* 9/2019).

- **Marfrig**, a Brazilian meat company, produces a 100% vegetable burger with a meat-like flavor and taste based on soy protein.
- The **Vion Food Group** in The Netherlands has launched (10/2019) via its start-up for alternative proteins “*ME-AT*” 5 high-quality ‘*Meat-Like*’, 100% vegan products.
- **Tyson Foods** has launched plant-based (“*Nuggets Made from Plants*”) as well as plant-blended burgers (“*The Blend*”). Pea protein isolates and Angus beef with less saturated fat and enriched with omega-3 fatty acids are key characteristics.

For all meat producing companies, alternative meat is about ‘and’, and not ‘or’, because alternative protein could someday be a multi-billion business for them.

2.2.2. Meat alternatives from other multinational companies

- **IKEA** in Sweden famous for selling “*Swedish Meatballs*”, which is an icon product, is developing a plant-based meat alternative by using pea protein, oats, potatoes and apples. Key arguments are to reduce environmental impact and to improve human health.
- **UNILEVER** in the Netherlands has partnered with **Burger King®** in launching the 100% plant-based “*Rebel Whopper®*.” The main ingredients of the plant-based patties are soy, wheat, sunflower and coconut oil, spices, and onions. The major target consumer group is the ‘flexitarian’, who is concerned about environmental issues and sustainability.
- **ALDI** in Germany is selling **Aldi’s “Wonder Burger”**, a soy-based alternative meat burger.
- **Lidl’s “Next Level Burger”** introduced in Germany in 2019 contains water, mushrooms, refined coconut fat, 9.2% pea protein, 5.6% wheat protein, 4% vegetables (onions, chicoree), canola oil, 3.8% soy protein and soymeal, spices, methyl cellulose, salt, flavors, pea starch, yeast extract, bamboo fibers, beetroot, and preservatives, namely potassium sorbate sodium acetate, and smoke flavors (*Open Food Facts*, 12/2019).
- **Nestlé** in Switzerland has introduced its “*Incredible Burger*” (= “*Awesome*” in the U.S.), which is 100% plant-based using soy, wheat, red beetroots, carrots, sweet peppers claiming to reduce the ecological footprint of food consumption. Furthermore, **Nestlé** has developed the first fully plant-based “*triple play*” – a bacon cheeseburger (*Economy*, P. 10/2019).
- **McDonald’s** in Germany has launched the meatless veggie burger “*Big Vegan*” made from quinoa served with mustard, ketchup, onion, tomato, and greens. In Sweden **McDonald’s** has introduced “*McFalafel*”.
- **Sainsbury** in UK is focusing on “*Planet Friendly Food*” outlined in their “*Future of Food Report 2025/2050/2169*” (*Hughes, C. et al., 2019*). **Sainsbury** is selling 8 meat-free burgers “*Plant Pioneers*” mainly based on: rehydrated textured soya protein (56%), water, onion (7%), onion purée (6%), rapeseed oil, soya protein concentrate, yeast extract, chickpea flour, stabilizer, methyl cellulose, tomato purée, garlic purée, parsley,

onion powder, malted barley extract, maltodextrin, garlic powder, salt, dextrose, black pepper, white pepper, tomato powder, and flavoring. The company has opened the UK’s first meat-free butcher shop offering a broad spectrum of meat-free food (Wood, Z., 2019).

2.2.3. Meat alternatives from start-up companies

- **Impossible Foods** “*Impossible Whopper*” has the following ingredients: water, soy protein concentrate, coconut oil, sunflower oil, natural flavors, 2% or less of: potato protein, methyl cellulose, yeast extract, cultured dextrose, modified food starch, soy leghemoglobin, salt, soy protein isolate, mixed tocopherols (vitamin E), zinc gluconate, thiamine hydrochloride (vitamin B1), sodium ascorbate (vitamin C), niacin, pyridoxine hydrochloride (vitamin B6), riboflavin (vitamin B2), vitamin B12 (*Impossible Foods*, 2019).
- “**Beyond Meat**” burger includes 18 ingredients: water, pea protein isolate, expeller-pressed canola oil, refined coconut oil, rice protein, natural flavors, cocoa butter, mung bean protein, methyl cellulose, potato starch, apple extract, salt, potassium chloride, vinegar, lemon juice concentrate, sunflower lecithin, pomegranate fruit powder, and beetroot juice extract (the beetroot juice gives the burger its meat-like “blood”) (*Cohen, M., 9/2019*).
- The Austrian start-up **Rebel Meat** (5/2019) has developed a ‘*hybrid*’ burger made from **50% meat** and **50% plant-based** ingredients. The company claims that this ‘*hybrid*’ burger:
 - ▶ produces ~1.5 kg less carbon emission compared to a 100% meat burger
 - ▶ needs ~1000 liters less water and ~1000 m² less land
 - ▶ has ~55% less cholesterol and 50% less fat
 - ▶ is made mostly from mushrooms
 - ▶ has ingredients which are locally sourced, natural and organic
 - ▶ is without additives
 - ▶ is against highly-processed methods
 - ▶ and a future target is to bring the 50% beef content down to 25%.

It can be assumed that in 2020 nearby 200 different meat-alternative products will have come onto the global market mainly to replace meat burgers based on ground meat. However, step by step, consumers will see more variety of options. They will get hundreds of plant-based sausages, ‘schnitzel’, lasagne, BBQ ribs, nuggets, boulettes, kebabs, crumbles for tacos, burritos, breakfast items, and pizza toppings. Taste, nutrition, acceptable ingredients, functional ingredients and sustainability are key factors for this new food segment. Consumers are focusing on functional and real ingredients, all natural, made fresh, no additives, no artificial colors and ‘whole grains’ (*Kerry Proprietary Consumer Research, 2019a,b*).

A large number of companies have developed new dedicated plant-based brand lines offering a broad spectrum of new foods. For example, Unilever: ‘*The Vegetarian Butcher*’, Nestlé: “*Garden Gourmet*”, Ruegenwalder Muehle: ‘*Veggies*’, Marks & Spencer: ‘*Plant Kitchen*’, Kerry Inc.: ‘*Radicle*’, the first online shop in Europe Eureka: ‘*Future Food*’, and Kroger: ‘*Simple Truth*’.

This upcoming new food production sector has the potential to upend a lot in the meat production business.

2.3. Plant-Based Meat Alternatives and New Cooking Equipment

Meanwhile, there are new technologies under development which will revolutionize the way of cooking in the future.

In Israel, '*3D print veggie meat or burger machines*' have been developed, so it is possible to shape your food and complete a meal within three minutes.

With a "*Jet-Eat Printer*" and by using individual ingredient cartridges of plant proteins, fats and other ingredients, it is possible to print fresh vegan "meat" ready to join the food manufacturing supply chain. Adjusting the fat content and other parameters it is possible to replace ground meat, roasting meat, stewing beef or steak.

Commercial activity will focus for the first five years mainly on restaurants. The long-term goal is to create a home appliance capable of preparing meals tailored for each family member.

With "*GENIE*" – '*the kitchen in a box*' it is possible to cook meals and snacks from freeze-dried pods within three minutes, with no preservatives, artificial flavorings, colorings or additives. The '*kitchen-box*' and pods will be available via lease-or-buy plans similar to office coffee machines. (Klein Leichmann, A., 12/2018).

The simplification of cooking of plant-based meat alternatives will significantly facilitate and promote the consumption of meat-alternatives. This new cooking business domain, just like microwaves, is on the way of being introduced onto the markets.

2.4. Plant-Based Meat Alternatives and Real Meat – Prices

Just to give a glimpse of information about the price range of plant-based meat alternatives and real meat by citing offers made by **METRO AG**, a globally acting wholesaler for gastronomy and retailers in its advertising brochure in Wiesbaden, Germany at the end of December 2019 and the beginning of January 2020 - without further comments:

- Beef tenderloin "*Simmentaler*" from Germany/Austria: 35.30€/kg (Dec. 09-24, 2019)
- Beef tenderloin from Brazil: 21.39€/kg (Dec. 27-31, 2019)
- Beyond Meat: "*The Beyond Burger*": 23.60€/kg (Jan. 02-08, 2020)
- Ruegenwalder Mühle: "*Vegane Muehlen Burger Type Beef*": 7.20€/kg (Jan. 09-15, 2020)

3. MEAT ALTERNATIVES

3.1. Meat Alternatives: Pros and Cons

3.1.1. Impact of Plant-Based Meat on Meat Production

a. Pros

- a new evolving business

- mainly in confrontation with factory farming (beef sector)
- challenging the production methods of conventional animal production
- triggering the restructuring of the livestock industry
- revolutionizing the whole meat sector
- creating new jobs
- pushing improvements in the whole agro-industry
- supported by public and private funds
- promoted by the health sector (plant-based meat)
- pushed by the food industry
- improving the market efficiency (far less time and waste, greater responsiveness)
- an efficient and effective technological innovation of producing protein
- fostering research & development in order to minimize prices for consumers
- intensively promoted by the media
- using simplified consumer messages ('decent food' vs 'lewd food')
- using the positive impact on human health and the whole health sector
- creating health claims
- contributing to 'personalized nutrition'
- using the issue of global climate change problems
- using the fact of reduced utilization of key resources
- using the issue of antibiotics resistance
- using the animal welfare issues
- using the 'no-go' for killing animals
- establishing ethical standards
- developing a well sounding 'story'
- doing more with less – reduced time, less waste ...

b. Cons

- highly processed / ultra-highly processed
- not healthier
- not natural
- not organic
- only technical material
- only functional
- faked
- taste is not the same as real meat
- only a new food market segment
- expensive and only for rich people
- not solving the problem of hunger
- some sustainable, open pasture and other types of livestock farming may be actually better
- proper nutrition - can be questionable
- health effects are mostly unknown
- long term health effects have not been analyzed
- needs a lot of energy
- destroys functioning markets
- eliminates jobs in the livestock sector

- revolutionizes the whole agro-sector
- needs more research & development
- not properly regulated
- not clearly labelled
- mixtures make it easier for more food frauds
- not in line with eating cultures
- there will be “Black Swans”

A rough comparison of key parameters of meat alternatives is given in the three tables below showing that for the time being plant-based products have the highest number of acceptable parameters.

Comparison of Key Parameters of Meat Alternatives, 9/2019 1.

	Convent. Meat	Plant-Based	Cell-Culture	Renew. Electricity	Algae, Bacteria	Insects	Aqua-culture
Agriculture Crop Prod	Green	Green	Red	Red	Green	Cyan	Green
Livestock Industry	Green	Red	Red	Red	Cyan	Cyan	Cyan
Commodity Traders	Green	Green	Red	Red	Cyan	Cyan	Green
Logistics	Green	Green	Cyan	Cyan	Cyan	Cyan	Cyan
Food Processors	Green	Green	Green	Green	Green	Green	Green
Food Distributors	Green	Green	Cyan	Cyan	Cyan	Cyan	Green
Food Ethics	Red	Green	Green	Green	Green	Green	Red
Personal Health	Cyan	Green	Cyan	Cyan	Cyan	Cyan	Green
Public Health Care	Cyan	Green	Cyan	Cyan	Cyan	Cyan	Green
Long-term Health Risk	Cyan	Green	Cyan	Cyan	Cyan	Cyan	Cyan
Food Fraud	Cyan	Green	Cyan	Cyan	Cyan	Cyan	Cyan

Source: Kern, M., 9/2019

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Comparison of Key Parameters of Meat Alternatives, 9/2019 2.

	Convent. Meat	Plant-Based	Cell-Culture	Renew. Electricity	Algae, Bacteria	Insects	Aqua-culture
Contamination Risk	Cyan	Green	Green	Green	Green	Green	Cyan
Animal Health Problems	Red	Green	Green	Green	Green	Green	Green
Antibiotic Resistance	Green	Green	Green	Green	Cyan	Cyan	Red
Policies	Red	Green	Cyan	Cyan	Cyan	Cyan	Green
'Zeitgeist'	Red	Green	Cyan	Cyan	Cyan	Cyan	Green
Climate Change	Red	Green	Green	Green	Green	Green	Green
Environ. Pollution	Red	Green	Green	Green	Green	Green	Red
Environ. Resources	Red	Green	Green	Green	Green	Green	Green
Life Cycle Assessment	Red	Green	Cyan	Cyan	Cyan	Cyan	Cyan
Edible Protein Ratio	Red	Green	Green	Green	Green	Cyan	Green
Original Alternative	Green	Red	Cyan	Red	Red	Red	Green

Source: Kern, M., 9/2019

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Comparison of Key Parameters of Meat Alternatives, 9/2019 3.

	Convent. Meat	Plant-Based	Cell-Culture	Renew. Electricity	Algae, Bacteria	Insects	Aqua-culture
Fresh, Highly Processed	Green	Red	Red	Red	Red	Red	Green
Taste	Green	Red	Red	Red	Red	Red	Green
Affordability	Green	Green	Red	Red	Green	Green	Green
Consumer Acceptance	Green	Green	Red	Red	Green	Green	Green
Developing Countries	Green	Green	Red	Red	Green	Green	Green
Food Aid	Green	Green	Red	Red	Green	Green	Green
Regulation	Green	Green	Red	Red	Green	Green	Green
Labelling	Green	Green	Red	Red	Green	Green	Green
Media	Green	Green	Red	Red	Green	Green	Green

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Source: Kern, M., 9/2019
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Consequently, the question raised by Dao, E. (2019): “Are meat alternatives just a fad or the future of sustainable food production? Can be answered with: Yes, they are! Last, but not least, it is a triple AAA-question: “accessibility?”, “acceptability?”, “affordability?” and will be answered by consumers only.

For consumers, especially young consumers, the traditional four Ps: Product, Price, Place, Promotion have changed to: Purpose, Pride, Propriety, Passion, Partnership, Planet Protection, and Personalization (Kern, M., 2019 modified after Hughes, D., 1/2019).

3.2. Meat Alternative Food Industry – Key Participants

Meanwhile, ~\$16 billion has been invested in plant-based (\$15.3 billion) and cell-cultured (\$73.3 million) meat since 2009 and a broad spectrum of start-up companies have been founded in the field of alternative meat production (*The Good Food Institute*, 6/2019).

For references see:

- “Our Meatless Future: How the \$90bn/\$1.8tn Global Meat Market Gets Disrupted” (CBInsights, 11/2017, 11/2019).
- “Appetite for disruption: How leading food companies are responding to the alternative protein boom” (FAIRR - A Collier Initiative, 7/2019).
- “FAIRR Protein Producer Index 2019” (FAIRR – A Collier Initiative, 9/2019).
- “Meat Alternatives – 2019” (PRESCOUTER, 10/2019).

3.3. Meat Alternatives - Economic Outlook of Future Markets

UBS predicts plant-based alternative meat sales could grow to \$85 billion by 2030 (*Markets Business Insider / Khan, Y., 7/2019*).

A market analysis report from Barclays Investment Bank (8/2019) titled “Carving up the alternative meat market” cites rising meat consumption and a

growing population leading to a forecast increase in meat alternative market share from 1% today to an equivalent of 10% in 2029 of today's \$1.4 trillion meat market.

In a RethinkX-Report: *"Disruption, Implications, and Choices Rethinking Food and Agriculture 2020-2030"* published in 9/2019 the key findings are the following ones (RethinkX, 9/2019):

- by 2030, demand for cow products will have fallen by 70% and before we reach this point, the U.S. cattle industry will be effectively bankrupt.
- by 2035, demand for cow products will have shrunk by 80%-90%.
- farmland values will collapse by 40%-80%.
- other livestock markets such as chicken, pig, and fish will follow a similar trajectory.
- there will be enormous destruction of value for those involved in rearing animals and processing them, and for all the industries that support and supply the sector (fertilizers, machinery, veterinary services, and more).
- we estimate this will total more than \$100bn.
- at the same time, there will be huge opportunities for the producers of modern foods and materials.
- by 2035, about 60% of the land currently being used for livestock and feed production will be freed for other uses. This represents one-quarter of the continental U.S. – almost as much land as was acquired during the Louisiana Purchase of 1803. The opportunity to reimagine the American landscape by repurposing this land is wholly unprecedented.

In a report published by the consulting company A.T. Kearney Inc. (5/2019) titled: *"How Will Cultured Meat and Meat Alternatives Disrupt the Agricultural and Food Industry?"* it is concluded, that *"Meat Alternatives"* are going to disrupt the \$1,000 billion conventional meat industry with all its supplier companies. The report claims, that by 2040, 35% of global meat consumption will be come from cultured meat, and 25% from vegan meat replacements. Individual enthusiasts believe, *"plant-based meat"* and *"clean meat"* will be very close to 100% of the global meat market, maybe by 2100.

In a report from Jefferies Inc. about: *"The Great Protein Shake-up?"* it is pointed out (Jefferies, 9/2019), that by 2040:

- **plant-based** and **cellular** meat consumption will grow at **12% CAGR** over 2018-2040
- **global meat sales will grow at 3% CAGR** over 2018-2040 to reach **US\$2.7tn**, most of which is expected in developing countries
- base case estimates show **plant-based** and **cellular meat** will have a **9%** market share (**US\$240bn**) by 2040.

On November 30, 2019, Jefferies Financial Group Inc. sold their 31% interest in National Beef, U.S. to Marfrig Global Foods, Brasil for a total of \$970 million in cash (Business Wire, 11/2019).

In December 2019, Nestlé sold its 60% stake in its packed meat business Herta to Spanish food company Casa Tarradellas as it continues its focus on the plant-based field (Morrison, O., 12/2019c).

The company AgFunder, founded in San Francisco in 2013 has offered alternative protein funds (*"New Carnivore Alternative Protein Fund"*) to give

investors an opportunity to invest in the next generation of start-ups creating animal-free products for food and other industries (*AgFunder Inc., 2019*).

At the end of 2019, a new company, Purple Orange Ventures an entrepreneur-led impact seed fund was started in Berlin, Germany. They seek early-stage teams leveraging technology to remove animals from the global food system. Obviously, they are in addition to '*plant-based meat*' involved in '*cellular agriculture*'. Concerning '*cell-cultured meat*', '*cellular agriculture*', '*solar food*' or '*decoupling of food production from agriculture*' I refer to the forthcoming paper from Kern, M. (2020 in preparation).

In Germany, Prof. Nick Lin-Hi, *University of Vechta* – a "*Business Ethicist*" recommended that livestock farmers should sell their land as quick as possible, because there will be a paradigm shift to "*Vegan Nutrition*" and "*Meat Substitute Products*" (Lin-Hi, 11/2019).

However, we should be very critical and skeptical about conclusions derived purely from papers prepared for investors only. Papers often describe a positive prospective based on given premises and that most important critical issues tend to be tackled in an over-optimistic way.

Nevertheless, all arguments, facts, figures and questions raised by such papers about this new branch of the food industry should be carefully considered by all members of the meat value chains in order to improve significantly the animal production systems and to be in line with the requirements of our various societies as soon as possible.

3.4. Meat Alternatives - Key Parameters of Future Markets

Fair regulations and an appropriate labeling of "*Meat Alternatives*" will be fundamental for the growth of the new industry.

Key parameters for the future market of "*Meat Alternatives*" among others are the following: quality, taste, flavor, texture, convenience, simplicity, price, profitability, target groups in markets, affordability, availability, authenticity (*Angus, A. and Westbrook, G., 2019*), nature based vs science-based, GMO-debate, natural vs artificial, nutritional profile, long-lasting impact on human health, food safety, fair regulations, appropriate labeling, progress in personalized nutrition (*Kern, M., 5/2006, 1/2007; De Caterina, R. et al., 2019*), general benefits (health, environment, animal welfare), 'free from', CO₂ footprint, not many 'food miles', use of non-fossil energy, bio-based product manufacturing, sustainable utilization of resources, transparency, consumer acceptance, consumer preferences, enjoying living as a single, consumer demand, changing eating habits, respecting religions and cultural levels, social consensus, reactions of the livestock industry, improvements in animal production, innovations in agriculture (*Grieve, B.D. et al., 12/2019*), education, information, media and social media reflections, fake news, image creation, visibility, etc.

Social media are influencing more and more what we cannot eat! Examples are given by Hughes, D. (2019):

- anything with palm oil as an ingredient
- livestock that has been fed soy from Brazil
- shrimps caught by slave labour in Asia

- beef that comes from land obtained by the destruction of the Amazonian rain forest
- anything with GMOs – especially in Europe
- anything in non-recyclable packaging
- ... etc.

3.5. Meat Alternatives - Unprocessed Food and Ultra-Processed Food

In order to improve diets in an area of food market transformation, the **Global Panel on Agriculture and Food Systems for Nutrition (2018)** has published the following:

- Diets are changing rapidly around the world.
- While some of these changes, such as improved supply and diversity of foods in low-income settings, have contributed to on-going global reductions in undernutrition, changes in terms of rising availability and falling relative costs of ultra-processed foods have simultaneously led to unhealthy dietary choices that are associated with overweight and obesity.
- Leaders in almost all low- and middle-income countries (LMICs) today face a complex policy challenge – how to resolve persisting undernutrition and vitamin and mineral deficiencies while simultaneously preventing the global escalation of being overweight and obesity, which together signal a surging health crisis.
- Poor diets underpin all forms of malnutrition (undernutrition, micronutrient deficiencies, and being overweight and obesity).
- **Seventy five percent (75%) of world food sales** comprise processed and ultra-processed foods.

A more specific focus on the impact of ultra-processed food and adverse health effects is given in 2019 by the following authors:

- **Rico-Campà, A. et al.** (4/2019): “Association between Consumption of Ultra-processed Foods and All Cause Mortality: A SUN Prospective Cohort Study.”
- **Johnston, B.C. et al.** (10/2019): “Unprocessed Red Meat and Processed Meat Consumption: Dietary Guideline Recommendations from the Nutritional Recommendations (NutriRECS) Consortium.”
- **Lawrence M.A and Baker P.** (2019): “Ultra-processed food and adverse health outcomes.”
- **Srouf B., Fezeu L.K., Kesse-Guyot E. et al.** (2019): “Ultra-processed food intake and risk of cardiovascular disease: prospective cohort study (NutriNet-Santé).”

Actually, Popkin, B.M. et al. (12/2019), have shown in their paper entitled: “Dynamics of the double burden of malnutrition and the changing nutrition reality” the following facts:

- “The nutrition transition has produced remarkable shifts in physical activity and diets in low-income and middle-income countries (LMICs) and a rapid increase in being overweight, obesity, and nutrition-related non-communicable diseases.

- Increases in overweight are the result of changes in the global food system that make less nutritious food cheaper and more accessible, as well as to the decrease in physical activity due to major technological shifts in the workplace, home, and transportation.
- The growth in retail food and the control of the entire food chain in many countries by agribusinesses, food retailers, food manufacturers, and food service companies have changed markedly. This change has been accompanied by the increased consumption of ultra-processed food purchases in **LMICs**.
- Evidence suggests these ultra-processed foods play a major role in increased obesity and non-communicable diseases.
- The retail revolution, which has led to fresh markets increasingly disappearing and large and small food retailers replacing them, has swept the globe, as a series of studies have shown.
- These studies showed that the global and national public sectors were no longer the major influences of diets in **LMICs**. Rather, food retailers, food agribusinesses, global food companies, and the food service sector and their domestic local counterparts have contracts directly with farmers.
- Furthermore, sales of non-essential foods and beverages are growing rapidly.
- Modern marketing and access to mass media have added to changes in conceptions of the ideal set of foods. Although power is shifting to large-scale food retailers, manufacturers, and food-service companies."

Mindful of the fact that meat consumption in **LIMCs** is certainly below global average and against the background of data published by Popkin *et al.* (2019) as well as the groups of authors listed here, it is important, that the topic of 'red meat' and 'processed meat' within the context of degenerative diseases should be looked at very carefully and if necessary it should be reassessed. 'Processed meat' is highly diversified and has different health impacts shown by Crowe, W. *et al.* (2019).

A generalization or oversimplification published in many media is the wrong basis for correct decisions with regard to people and our planet.

Just recently, Ganeshan, S and Chibbar, R.N. (2019) have specified the challenges and opportunities of plant-based food. Some key issues are listed here:

- Globally, there is a trend towards plant-based food diets due to health benefits.
- However, during food processing the plant foods are often treated with preservatives to enhance the shelf-life or flavor-changing compounds to increase palatability and food acceptance.
- Ultra-/Over-processing can strip away some nutritional components.
- Furthermore, anti-nutrients (phytates, tannins, polyphenols etc., in cereals, legumes and vegetables) and potential allergens in plant-based products have to be eliminated.
- The additives can in the long term have some unintended effects on human health and well-being.

- Therefore, there is also a need to review food processing technologies for the benefit of human health and sustainable food production.

Food is becoming more and more diversified, more specified, more differentiated, more complex, and less transparent, less manageable, not simple to select, not easy to decide, and a lot of people become confused concerning healthy nutrition.

In France, the start-up SIGA has developed a ranking system to classify foods on a scale from unprocessed foods to ultra-processed foods (UPFs) to help the consumers to select the most natural and healthy food (see the Figure below). This is necessary because, *food is more than the sum of its nutrients*, and therefore information about the degree of processing is essential to evaluate its health potential (Southey, F., 2019).



SIGA's ranking system classes foods on a scale from unprocessed foods to ultra-processed foods (UPFs), classified by health potential (2019).

In Germany as an example, to make it easy to choose the right healthy food a NUTRI-SCORE-System was introduced by the German government in November 2019. NUTRI-SCORE is a front-of-pack nutritional label which converts the nutritional value of food and beverages into a simple overall score. It is based on a scale of 5 colors and letters (A is green to represent the best nutritional quality while E is dark orange to show it's the lowest). Such a label should be developed based on solid, independent and transparent scientific evidence, and be free from commercial interests (BEUC, 11/2019).



However, in 2019 the "Beyond Burger" received 3 different NUTRI-SCORE-levels:

- B: by Open Food Facts, France (9/2019)
- C: by Food Watch, Germany (7/2019)
- D: by Supermarket Check (2019).

If the system works like that, then there is no simplification for consumers, but the creation of more confusion.

Let’s see, how the NUTRI-SCORE-System will work in future.

Oeko-Test from the *Oeko-Test Verlag*, in Germany (11/2019) has tested 18 vegan burgers (plant-based and plant-based meat alternative patties). They have analyzed pathogens, content of salt, residues of mineral oil and glyphosate as well as traces of GMOs. Beside this, the burgers were tested by experienced tasters concerning appearance, smell, taste and mouthfeel.

In 6 burgers, they detected parts of GMOs and in more than 50% of all tested burgers they found increased residues of mineral oil.

Four plant-burgers received the description “*very good*”, only one plant-based meat alternative burger was graded with “*good*”, nine burgers with “*satisfactory*”, and four burgers with only “*sufficient*”.

The main problems stemmed from increased quantities of oil residues, contamination by GMOs, of too much salt and disappointing taste.

Food allergies and allergy-related food recalls are increasing. In the UK, for example, more than 170 foods have been identified as allergic and in most cases products were found to contain allergens that were not listed on the label (Morrison, O., 12/2019a). A new Law (Natasha’s Law) was announced in June 2019 which will tighten rules on allergen information on packaging, requiring foods carrying a full list of ingredients from middle of 2021 (Instinctif, 2019).

After succeeding in producing plant-based meat analogues there is a clear focus on making them healthier. There is a need for healthier meat-analogues with a shorter ingredients list (Morrison, O., 12/2019b). And, it is important to keep in mind, that ‘*vegan junk food*’ is still ‘*junk food*’.

3.6. Meat Alternatives - Personalized Nutrition

We all know that we are all different and every person responds differently to the same food. Consequently, there is a need for a personalized nutrition plan made possible by the use of AI (artificial intelligence) and IoT (Internet of Things).

People will receive their personal ‘*Chip Laboratory*’ as a diagnostic or bioanalysis kit in order to obtain a nutrition therapy which will improve their health. Personalized nutrition will be possible, and tailored foods will be offered, providing combinations of nutrients and bio-actives with proven efficacy to mitigate diseases or prevent their onset (Kern, M., 2006, 2007; de Caterina, R. et al., 2019).

For references, three examples are listed here: (Angus, A. and Westbrook, G., 2019).

- In Canada, **TellSpec Inc.** has developed a hand-hold scanner “*TellSpec Enterprise Scanner*” which offers real-time food testing, food safety and food authenticity. Using Raman spectroscopy, details of food can be stored in the app and added to daily food diaries and comparing it with the daily recommended intakes (Angus, A. and Westbrook, G., 2019).

- With the app '*TellSpecopedia*' it is possible to search food label ingredients or food components and learn about their impact on personal health. Consumers will be able to make informed decisions about the food they buy (*TellSpec Inc., 11/2019*).
- In the US, **Amazon/Amazon Go US** has upgraded convenience stores by removing the need for queues. Consumers have to scan the '*Amazon app*' at the entrance of the market. Sensors and cameras enable consumers to select products and these are charged to their virtual shopping list. This can especially be used to purchase the right pre-made meals designed for the lunch-time rush (*Angus, A. and Westbrook, G., 2019*).

Meanwhile, hundreds of nutrition or diet apps are on the market that are recommended by the producers. Logically, the key question arises: *What is the right 'app' for me and what effects will it have for me actually particularly in the long run?*

In addition, it has to be considered, that there are discrepancies in the registries of diet vs drug trials (*Ludwig, D.S. et al., 2019*). In their literature search reviewing 148 drug studies and 343 diet studies, 22% of the drug trials and 86% of the diet trials did not satisfy essential criteria for prospective registration. The authors are recommending high-quality diet trials of the type needed to develop effective prevention and treatment for chronic diseases.

Degenerative diseases, such as heart disease, cancer, Alzheimer's, asthma, bronchitis, diabetes, arthritis, allergies, obesity, and the like, are referred to as '*diseases of modern civilization*' (*Fife, B., 2019*). They are often linked to incorrect nutrition and modern foods.

In fact, nobody really knows, what impacts a significant shift towards '*alternative meat*' will have on the public health level in different countries by 2050. And, how can we avoid unintended consequences or so called '*collateral damage*' in relevant areas? And, what are the known and the unknown risks?

For a better evaluation of the importance of 67 risk parameters of the burden of diseases a reference should be made to the global study published in the *Lancet Journal* (*Lim, S.S. et al., 2012*). High blood pressure was ranked as the number one, followed by smoking, and alcohol use; high total cholesterol was at position number 15, and highly processed meat at number 22.

Let us see, which position '*alternative meat*' products will have in 2030.

3.7. Meat Alternatives - Promoters, Media and Influencers

The international medical community is currently building a case against red meat and for plant protein. The healthcare industry is recommending that we eat less meat, and the wellness industry is promoting more plant-based diets. Professional athletes have started advocating the health benefits of meat alternatives and aspirational influencers are making the discussion attractive and are creating followers (*Beef & Lamb, New Zealand, 2019*).

"Pope Vegan the First?" was a headline in *U.S. Catholic* magazine 4/2019 (*Clarke, K., 2019*). The vegans are well organized! Or, they clearly know how to get media attention at least. People for the Ethical Treatment of Animals (PETA) is well-known for its impressive publicity stunts.

In a personal appeal to Pope Francis that ran in the *New York Times* in spring 2019, the Million Dollar Vegan campaign offered \$1 million to a charity

of the pope's choice should he pledge to follow a *plant-based diet* during *Lent*. The campaign's spokesperson was an endearing 12-year-old vegan activist, Genesis Butler of Long Beach, California. "Farming and slaughtering animals causes a lot of suffering and is also a leading cause of climate change, deforestation, and species loss".

The Pope Francis did send his blessing but no vegan promises to the 12-year-old activist (Roewe, B., 3/2019).

Parallel to this, in the US, a meat-loving professional poker player named Jamie Kerstetter (*Global Poker Index Ranking 2.125th, 2018*) was going vegan for one year for \$10,000 (Webber, J., 2/2019).

As an example, in a paper published by Clonan, A. *et al.* (2015) "*Human Health*" and "*Animal Welfare*" were common motivations to avoid red and processed meat than "*Environmental Sustainability*" in a postal survey made in UK during 2009.

Ten years later, in a literature review published in 2019, consumers were aware of the meat impact on the planet and willing to stop or significantly reduce meat consumption for environmental reasons. However, a real change of their meat intake has happened at a low level only (Sanchez-Sabate and Sabate, 2019).

Eating Better in partnership with WWF (2019): "Eating Better YouGov Survey quick analysis" in UK has documented the following:

- **Animal welfare** remains the principal driver of reducing meat consumption (38%), but climate impact is becoming increasingly important. Meat's carbon footprint (29%) has now overtaken health (24%).
- Providing grants and support for farmers producing meat to higher animal welfare and environmental standards' has risen from 23% to 27%.
- **Natural beats processed for all concerned.** Natural unprocessed products are by far the most popular for proteins eaten in the previous month (52% pulses; 45% nuts and seeds). Meat alternatives are less popular (26%).
- Young people are talking the talk when it comes to healthy eating and sustainably, but are not walking the walk. People 65+ are leading the way despite lower levels of awareness.
- Interestingly the **youngest group** (18-24 years) is most likely to eat meat every day and more meat than a year ago. This is counter to what has been regularly stated that change is coming from younger people.

In industrialized countries, the new upcoming alternative meat industry is using, beside health issues, anxieties surrounding meat to do with animal welfare and environmental issues in order to profile their products. Last, but not least, the companies use cheap materials and charge high prices for their products and make growing profits in saturated markets (*Plusminus, German TV, 07.08.2019*). Companies have almost unlimited combinations of different ingredients and can sell new highly diversified products promoted by a marketing using specific '**PROteine-STORies**' ('**PRO-STOs**'). "*Storytelling: Winning with Words*", leads Innova Market Insights' *Top Trends for 2020* (10/2019).

For marketing strategists, “*Planet Food*” is the new keyword, the new bingo, the new bonanza, the new cash word, the new gold mine.

Recently, the Hollywood Foreign Press Association has decided, that the “*Golden Globes Go Green*” with a plant-based menu for 2020. Driven by climate concerns, at the Golden Globes presentation mushrooms will be featured instead of meat, and the U.S. Beef Group is not happy that Golden Globes are going vegan (Almeida, I. and Gilblom, K., 2020). Incidentally, the bottled water served was imported from Iceland, and the floral decoration was made with flowers from Ecuador.

This leads to a key question: Is the Golden Globe event a carbon neutral / fossil-fuel free event or will it become so in future – and until when?

“Go green. Go clean. Go plant based. Do it for your health. Do it to save the planet. Do it to save the animals.” are key credos of the new viewpoints in agriculture and food production (Radke, A., 3/2019). Key words such as: “Fourth Agricultural Revolution”, “Second Domestication” or “2nd Red Revolution”, are intensively propagated in various media to promote “Meat Alternatives” and alternative meat production methods. It cumulates in a headline from Burton (2019) published in the Journal of Rural Studies: “The potential impact of synthetic animal protein on livestock production: The new “war against agriculture”?”

4. LIVESTOCK AND MEAT PRODUCTION

4.1. Livestock and Meat Production - Animal Welfare

Animal welfare issues are not outlined in more detail here, but for reference see the detailed report which was published by the **Food and Agriculture Organization of the United Nations** (FAO, 2014) titled: “*Review of animal welfare legislation in the beef, pork, and poultry industries*”. In the executive summary it is written the following:

“Overall, the public’s expectations for animal products that adhere to higher animal welfare standards have put the issue of animal welfare firmly on the political and development agendas of many countries. Such concern is now shared by consumers, governments and food business, in particular retailers, but also by food service operators and food manufacturers. Moreover, compliance with animal welfare standards is increasingly important in trade agreements and national laws and policies.”

The FAO is convinced that improvements to animal welfare in food production systems can play a significant role in improving the welfare of people by such means as improving access to food of animal origin and reducing risks to human health through improved food safety and animal health.

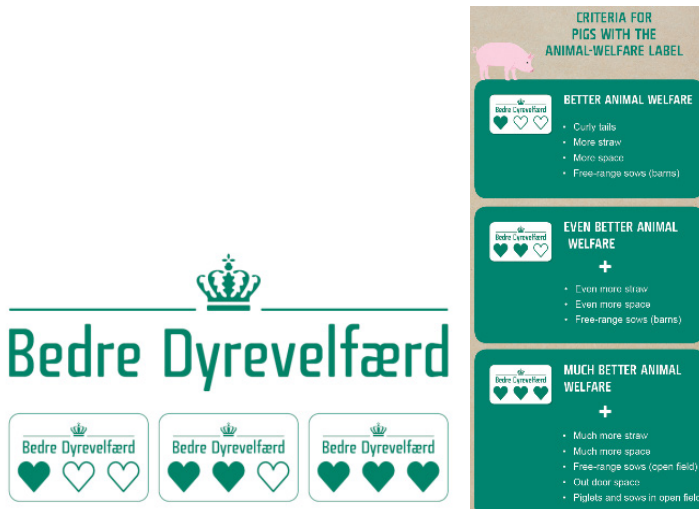
Priority areas are described as such: transportation, slaughter (including pre-slaughter management), food and water, handling/herding methods, culling and disposition of animals that are sick or of low commercial value, and the keeping of animals under conditions for which they are not genetically suitable.

Farmers and the livestock industry have to accept the public animal welfare debate and use the discussions as an opportunity. A proactive

improvement in animal welfare is necessary in order to improve the situation for the animals, the farmers and to provide consumers with products that are produced according to shared common values. By doing this, animal protection and economic success has to go hand in hand as shown by Danish Crown Company in 2017.

- In 2017, the **Danish Government** has introduced an animal welfare label – named “**Better Animal Welfare**” – in order to improve the animal welfare of as many pigs and broilers as possible through consumer purchasing. The three-tier animal welfare label makes it possible for consumers to identify which products meet requirements for better animal welfare. Under the scheme, one heart indicates the following: One heart guarantees, that the basic requirements of the label have been met such as free-range sows with curly tails (no tail docking or tail biting) have more space and daily fresh straw. Two hearts means that, in addition, the pigs have more space and three hearts indicate that pigs have also access to outdoor areas.

By selecting products with better animal welfare at a slightly higher cost the consumer is helping ensure that more animals are produced under improved conditions. It is market-driven animal welfare (Ministry of Environment and Food of Denmark, 2018).



4.2. Livestock and Meat Production - Emissions and Climate Change

Pimentel, D. and Pimentel, M. in their ground-breaking paper entitled: *'Sustainability of meat-based and plant-based diets and the environment'* in 2003, showed that the heavy dependency on fossil energy systems in the US food system is not sustainable, whether meat-based or plant-based. To produce 1 kcal of plant protein requires an input of about 2.2 kcal of fossil energy. Nevertheless, meat-based food systems require more energy, land and water resources than a lacto-ovo-vegetarian diet. On average, for 1 kcal of animal protein 25 kcal fossil energy is needed (lamb: 57:1; beef:

40:1; pasture beef: 20:1; swine: 14:1; broilers: 4:1) (Pimentel, D. and Pimentel, M., 2003). The authors underlined that the food systems in the US are not sustainable in the long run. However, unfortunately, alternative options were not recommended.

Meanwhile in the area of crop production, there are alternative tools and technologies available or are under development, for us to encourage and aim for:

- fossil-fuel-free crop protection (Kern, M., 2010; Kern M., et., 2012)
- fossil-fuel-free fertilization by smart plant breeding (Kern, M., 2015a), microbiomes
- fossil-fuel-free irrigation systems driven by solar or wind energy
- fossil-fuel-free digital agro-management systems (Kern, M., 2015b)
- fossil-free-free mechanical agricultural production systems powered by renewable energy (New Holland NH₂-tractor, Styr biogas tractor, Deutz-Fahr Agrotion biodiesel tractor, John Deere electro tractor, robots)

Similar fossil-fuel-free options are available or under development and have to be implemented in the livestock area as well, e.g. such as renewable energy powered barns, air condition or feeding systems, etc. This is necessary, because the primary production sector has to tackle on-farm emissions – including those produced by smallholders and family farms as well as ‘factory farms’. Referring to COP25 in Madrid 12/2019, there is a clear call for a ‘radical transformational change’ in the food system: ‘Nobody should feel any comfort’ (Askew, K., 2019).

Nevertheless, by having an oil price of \$60 per barrel the speed to implement fossil-fuel-free food production systems by using alternatives will be slow, but if the price increases to more than \$100/barrel the available technologies will be used very quickly.

However, the minimization or elimination of emissions is relevant for all food production systems, for conventional production, for plant-based or cellular food production. The key question will be ultimately, what amount of fossil-fuel based energy is used in which product. Life cycle-assessments will characterize and qualify the level of environmental impact.

IRENA (International Renewable Energy Agency, 2019) in its report 2019 titled: *Gobal Energy Transformation – A Roadmap to 2050*” emphasized that the global energy transformation from fossil-based energy to renewable energy is necessary and is happening. To meet the global climate change objectives, the development of renewables must increase at least six-fold compared to current government plans by 2050. Renewables will have to make up two-thirds of energy consumption. The agro-sector will play an active part in this area.

4.3. Livestock and Meat Production - Mega Feedlots and Industrial Farming of Cattle and Beef and the Environment

For environmental reasons, mega feedlots and industrial farming of cattle are heavily under attack by the alternative meat industry. Product marketing is increasingly focusing on this type of production.

The world cattle inventory in 2018 was 1.002 billion head. India has the largest cattle inventory (305 million, including water buffalo) in the world in 2018 followed by Brazil (232 million) and China (96.8 million). Roughly 63% of the world’s cattle are in India, Brazil & China.

More than 90% of the world’s cattle are NOT in the United States. The United States had the 4th largest cattle inventory (94.399 million) in the world in 2018 (*Cook, R., 12/2019*). In comparison, the US had 132 million cattle and calves in 1975 (*USDA, 8/2019a*).

About 2000 registered cattle feedlots with a capacity of less than 1,000 head compose the vast majority of U.S. feedlot operations, but they market a relatively small share of the fed cattle. In contrast, lots with 1,000-head or greater capacity compose less than 5 percent of total feedlots, but market 80 to 85 percent of fed cattle. Feedlots with a capacity of 32,000 head or more market around 40 percent of fed cattle. The industry continues to shift toward a small number of very large specialized feedlots focused on raising a high-quality product for a particular market like conventional, natural, hormone-free, etc. (*USDA, 9/2019b*).

McDonald’s has 34,000 restaurants in 118 countries and territories across the world, serving more than 69 million people every day worldwide (*McDonalds, 2019*) and sells 70 hamburgers per second worldwide. Furthermore, globally McDonald’s is one of the largest purchasers of beef.

McDonald’s will reduce greenhouse gas emissions related to their restaurants and offices by 36% by 2030 from a 2015 base year.

Furthermore, McDonald’s is convinced that on farms, sustainability and efficiency are interconnected. Via carbon footprints on farms they are trying to improve the sustainability of food supply around the world. One of the tools is their *“Flagship Farmers Initiative”*, *“which profiles progressive farmers who have developed innovative solutions to key sustainability challenges like soil health, animal welfare, ecosystem protection and reducing beef’s carbon footprint, while also demonstrating that sustainable farming practices go hand-in-hand with a sustainable farm business”*.

For example, McDonald’s purchases approximately 2.5% of all beef produced in the EU – from around 470.000 farms. In Ireland, McDonald’s works closely with the Irish Food Board on *‘Origin Green’*, the only sustainable program in the world which operates on a national scale uniting government, food producers and farmers. Some 49.000 farms, with 90% of Irish beef output, are currently certified und this program and more than 117.000 carbon assessments have been conducted and published in their report: *“Helping lead a global movement for better beef sustainability”* (*McDonalds, 2019*).

5. WILL ALTERNATIVE MEAT PLOW UP ...?

5.1. Will Alternative Meat Plow Up Livestock Farming in Future by 2025/2050?

Yes, it will!

Key parameters which shape future livestock industry by 2025/2050 are listed in five different sections:

1. **Innovation:** Plant based protein, Algae/Bacteria, Nutrigenomics, Artificial lab-meat / "Super-meat", "Cellular agriculture", 3D-printer, Meat wending machine, e-meat-commerce, Proactive precision feeding (e.g. FeedLINK) (GlobalVetLINK.), Solid state fermentation (SSF), Smart livestock farming by digitalization (Artificial Intelligence (AI), Cyber-Physical Systems (CPS) and Internet of Things (IoT) e-system, Platforms, Information & Communication Technologies (ICT), Big Data Analytics, Cloud Computing, Crowdsourcing, Transparent supply chains, Flexible production systems (*Deloitte, 11/2017*)
2. **New Game Changers / Actors / Markets:** New trade agreements / Argentina, Russia, Ukraine, USA / 'Turkey' / Pet food market, Mergers and acquisitions / New meat alternative industry
3. **Actual Issues:** Moderate price of oil, High commodity stocks, Low price of commodities, Increasing demand & supply, Decreased investment, Increasing production costs, New agro-inputs, Transportation costs, Infrastructure costs, Critical profitability, Value generation, Quality, Safety, Reliability, Fully integrated value chains, Feed lots, Public debate, African Swine Fever
4. **Future Challenges:** Pandemic Bird Flu, Animal welfare, Factory farming, Transparency, Public perception, Antimicrobial resistance, Reduction of antibiotics, Veterinary standards, Trade agreements, Veganism, Climate change, Fossil fuel-free production, Emission free production
5. **Black Swans:** Scandals, Epidemics, Pandemics, Trade wars, Exchange rates, Military conflicts, Agro-terrorism (*Kern, M., 2016c*).

Very specifically, the livestock industry is being challenged more and more by the upcoming new plant-based protein and cellular-cultured meat industry.

The meat industry has to tackle all the mentioned challenges in a positive way as quickly as possible, otherwise they will not get the permit to produce from their societies, especially in rich and developed countries.

Nevertheless, considering the significant increase in meat demand in developing countries within the next 30 years, it is of significant value, that plant-based protein alternatives are on their way in order to help to close the protein gap by 2050. Nevertheless, Livestock and meat will be the key source of protein in developing countries, because it is the culture there, and safeguards food security at a local level.

For meat/sausage producing companies 'alternative meat' is about 'and', and not 'or'. For some of them it is a 'hybrid' or a 'blend', for others it is only an 'or'.

However, if we go for a *"war against agriculture"* - all of us will be losers. Therefore, we have to look for the best practices to feed people in the most sustainable way in an appropriate time. In doing this, apocalyptic scenarios are not helpful at all.

At this point, it is of great relevance to refer to the book written by Rosling *et al.* (2019) entitled: *"Factfulness – Ten reasons we're wrong about the world – and why things are better than you think."* It is an excellent guide to improve the world, full of positive recommendations and an inspiring eye opener for everyone!

New Zealand's 'beef+lamb' report titled: *"Future of Meat: How Should New Zealand's Red Meat Sector Respond to Alternative Protein Advancements?"*, is a very important and for the time being the best reflection and description of the disruptive potential of the new upcoming food industry (*Beef and Lamb, 2019*). They have developed 4 different plausible scenarios describing the future of red meat:

- Red meat is **pushed to the side** of the table
- Red meat is the **specialty choice**
- Red meat is the **reluctant choice**
- Red meat is the **everyday choice**

Key characteristics of new restructured markets as well as modified attitudes of consumers are well described and nicely visualized. The key question finally is: *"Will consumers reduce red meat consumption – or not?"*

Four strategic responses are given related to the four scenarios for the government, livestock associations, farmers, and meat companies:

- **DIVERSIFY** their portfolio beyond red meat and protect the current volume
- **INNOVATE** beyond red meat using funding from short-term revenue growth
- **PREMIUMIZE** by building tiers of value and investing in product development
- **EXPAND** and increase their share in red meat via differentiation and speed to market.

Within these scenarios, all stakeholders of the red meat value chain have to reflect the significant changes and to reshape their own actions and businesses. To wait and see, seems to be not a future-proof solution. Within this context, we can quote an African Proverb: *"Not to know is bad; not to wish to know is worse."*

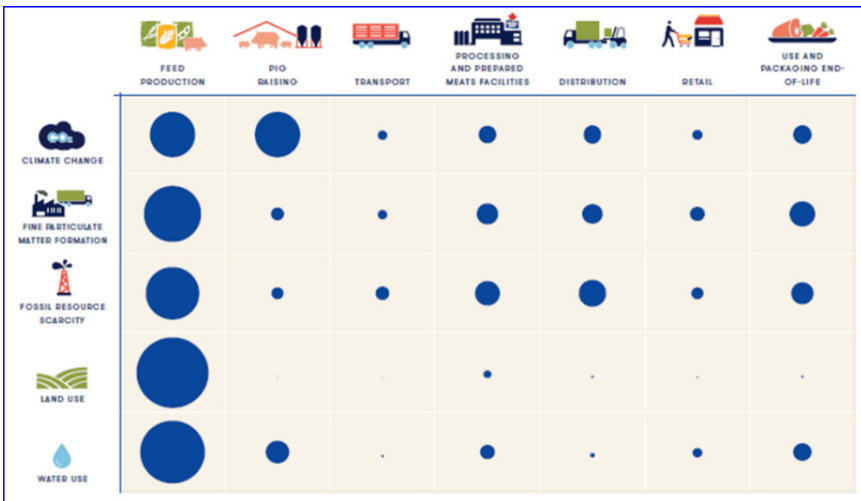
Meat has always been a part of the human diet, and it will continue to be so in future. However, no one can live in a comfort zone any longer and the whole meat production industry has to *'find its own narrative'*, has to be innovative, and has to improve the whole value chain in a sustainable way.

Future oriented stakeholders within the livestock industry are demonstrating that it is possible to be in line with the necessary changes requested by societies. Some examples are highlighted:

- In 2019, **Maple Leaf Foods**, a leading American producer of meat and plant proteins became the first major food company in the world to be

carbon neutral. They have achieved carbon neutrality by aggressively reducing their greenhouse gas emissions and are investing in high impact environmental projects to neutralize the any emissions that remain. The company has the vision to be the most sustainable protein company in the world (*Maple Leaf Foods, 11/2019b*). Consequently, they are carrying out *Life Cycle Assessments* along the value chain.

Permanent Life Cycle Assessments will be done in order to improve the production processes and to reach the targets. They are focusing on the optimization of feed composition, considering different transportation modes and investigating ways for further reductions in methane emissions from cowsheds and pigsties.



*Life Cycle Assessment of Maple Leaf bacon prepared by Ecofys, a Navigant company, finalized in 2018. In the graphic above, the size of the circle is proportional to the magnitude of the impact.

- Concerning the reduction of emissions from the slurry of barns, there was a brand new technology provided by the Quebec Company **Développement Solugen Inc.** at the end of 2019. Pig producers can recover up to 84% of the pig slurry in the form of clean water and eliminate up to 95% of the greenhouse gases and orders associated with pig slurry storage and spreading. Furthermore, there is the recovery of three important fertilizers in agriculture: phosphorus, nitrogen and potassium. These recycled fertilizers will be reused as natural fertilizers (*National Hog Farmer, 10/2019*).
- Danish Crown** which is owned by **farmers** is aiming at a climate neutral production by 2050. They intend to reduce the carbon footprint from farm to fork by 50 percent by 2030 and by 100 percent by 2050. **Danish Crown's** meat production should be completely climate-neutral in 2050. To underline this, they have created a new brand identity in 2019 (*Danish Crown, 9/2019a*).

- Furthermore, **Danish Crown** is raising pigs without antibiotics or growth promoters and they give a guarantee of full traceability from ‘*Farm to Fork*’. The company gives a guarantee, that the production principles are used for pig breeding, animal health procedures, for handling of pigs, minimal transportation time to the slaughterhouse, for the butchering process and for product packaging (*Danish Crown, 9/2019b*).
- In Germany, the **German Butcher Association** (5/2019) announced that they will reduce energy consumption in the production of all meat products and to be carbon neutral as soon as possible. And, consequently, they will ask animal producers to provide them with carbon-neutral raised animals in order to offer carbon-neutral produced meat products.
- In Australia, the **Asia Pacific Agri-Corp** is building the ‘*first of its kind*’ solar-powered abattoir in Gladstone, Queensland with a capacity to process 2.400 head cattle per day (*Williams, A., 10/2018*). **Southern Meats** built an abattoir that turns waste into power.
- **Hormel Foods Corporation** in the US has started the construction of a solar array at its Swiss American Sausage Company in California with the emphasis on minimizing significantly their environmental impacts (*Fortune, A., 4/2019a*).
- US processor **Smithfield Foods** and **Dominion Energy** are investing in renewable natural gas projects across the US to \$500m through 2028. **Smithfield’s** company-owned and **contract hog farms** capture methane from covered lagoons or digesters and transport it by a low-pressure biogas transmission to a central conditioning facility. The gas is processed there and delivered to end users. By this ‘*manure-to-energy*’ approach they are not only reducing greenhouse gas emissions on the farms, but also turning a waste product into a clean renewable energy resource (*Fortune, A., 10/2019b*).

Companies, farmers or livestock associations should create a new function named: ‘Eco-Tec Scouts’. They should check technical innovations along the different national meat value chains (from fossil-free crop production, via livestock production, meat processing, packaging, to transport and distribution) which can be integrated in order to produce the ‘first fossil-free and emission-free meat’! This would definitely be, ‘The 4th revolution in agriculture’ and improve our lives and those of future generations in the most sustainable way. I estimate that this type of ‘*real clean meat*’ will be possible earlier than by 2030. Let us see which company will come up first.

5.2. Will Alternative Meat Plow Up Agriculture in the Future by 2025/2050?

Yes, it will!

Triggered by the involvement of hundreds of stakeholders and new start-up companies within the food industry by implementing a new plant-based (in future: cellular-agriculture) new meat alternative food segment more or less all agricultural production systems from agro-inputs, specific seed developments, implementation of new crops, smart pest control methods, new fertilization methods, smart agro-machineries, smart agro-technologies,

artificial intelligence, cyber-physical systems (CPS), and IoT will be significantly changed.

It is obvious, that this will shape the whole landscape in a lot of agricultural areas of the world.

The change is fully in line with the key slogan of agriExcellence: “Do more with less, do it better, and do it with less waste and fewer emissions in an appropriate time”.

The two following examples show that the world is moving from carbohydrate crops more and more to protein crops:

5.2.1. Canada

- By implementing the **Canadian Agricultural Partnership Program**, which is a five-year, \$3 billion investment program launched by the federal government, Canada is looking to initiate new agricultural innovations such as new crop varieties, livestock breeds, nutrient management practices, tilling methods and farm machinery, as well as advancements in biotechnology, precision agriculture, communication and information technologies (Schmaltz, R., *AgFunder*, 2019).
- The Vision of **Protein Innovations Canada** is the following one: “To make the Canadian Prairies, a leading global source of high-quality plant proteins and related food ingredients, developed by carbon neutral production while contributing substantially to Canada’s economic growth and an improved trade balance” (Protein Innovations Canada, 3/2017; Greuel, B., 5/2019).
- With regard to the **Innovation Superclusters Initiative of the Canadian Government**, the **Plant Protein Alliance of Alberta Ltd.** has received CAD250 million for linking companies, growers, investors and researchers to make Alberta a global leader in **plant-based** ingredient processing (*Government of Canada*, 10/2017).

The implementation process is already running in the Canadian Prairies!

5.2.2. Europe

The new roadmap of the **European Commission** titled: “The ‘**European Green Deal**’ sets out how to make Europe the first climate-neutral continent by 2050, boosting the economy, improving people’s health and quality of life, caring for nature, and leaving no one behind” (European Commission, 12/2019a). The ‘**European Green Deal**’ covers all sectors of the economy, notably transport, energy, **agriculture**, buildings, and industries such as steel, cement, ICT, textiles and chemicals.

A final ‘*Farm to Fork Strategy for Sustainable Food*’ will be presented in spring 2020. However, some key issues of this strategy are documented in the actual European Commission paper on the “*The European Green Deal*” (European Commission, 12/2019b).

Some issues are listed below:

- “European food is famous for being safe, nutritious and of high quality.

- It should now also become the global standard for sustainability. Although the transition to more sustainable systems has started, feeding a fast-growing world population remains a challenge with current production patterns.
- Food production still results in air, water and soil pollution, contributes to the loss of biodiversity and climate change, and consumes excessive amounts of natural resources, while an important part of food is wasted. At the same time, low quality diets contribute to obesity and diseases such as cancer.
- European farmers and fishermen are keys to managing the transition. ‘*The Farm to Fork Strategy*’ will strengthen their efforts to tackle climate change, protect the environment and preserve biodiversity. The common agricultural and common fisheries policies will remain key tools for supporting these efforts while ensuring a decent living for farmers, fishermen and their families. The Commission’s proposals for the common agricultural policy for 2021 to 2027 stipulate that at least 40% of the common agricultural policy’s overall budget and at least 30% of the Maritime Fisheries Fund would contribute to climate action.
- The strategic plans will need to reflect an increased level of intention to reduce significantly the use and risk of chemical pesticides, as well as the use of fertilizers and antibiotics.
- ‘*The Farm to Fork Strategy*’ will also contribute to achieving a circular economy.
- Lastly, ‘*the Farm to Fork Strategy*’ will strive to stimulate sustainable food consumption and promote affordable healthy food for all. Imported food that does not comply with relevant EU environmental standards is not allowed on EU markets. The Commission will propose actions to help consumers choose healthy and sustainable diets and reduce food waste. The Commission will explore new ways of giving consumers better information, including by digital means, on details such as where the food comes from, its nutritional value, and its environmental footprint.
- ‘*The Farm to Fork*’ strategy will also contain proposals to improve the position of farmers in the value chain.”
- ..., and on page 19, position: 2.2.5.: *A green oath: ‘do no harm’ is the key objective of all activities.*

The strategic paper is going in the right direction, but planning the future up to 2050 and not solving the existential problems of farmers actually have in 2020 – means: a lot of them will have no future! For farmers it will be not possible ‘*to go greener*’ when many of them are already ‘*in the red*’ and forced to give up their farms. Thousands of farmers in Ireland, the Netherlands or in Germany are demonstrating by carrying out the following:

- “*Green Crosses*” were placed in farmers’ fields as a **silent protest** by thousands of farmers in Germany during 2019 and is ongoing in 2020.



- German farmers blocked streets with **convoys of thousands of tractors** in Berlin, Hamburg, Wiesbaden, Mainz and a lot of other big cities in a **Nationwide Protest** against Government Plans and to draw attention to their current critical situation during October/November/December 2019, (Kern, M., November 19, 2019).



- **Open fires were lit** for a signal by farmers region-wide as a **visual protest** to draw attention to their current critical situation (e.g. Rheinhessen, near the city of Mainz, Germany), (Kern, M., November 19, 2019).



Without farmers, there is no food!

it may be, by cellular agriculture some people will be convinced it should be possible to do without farmers, others are convinced, that that is utopia.

However, if farmers’ lives are not improved immediately, “The ‘European Green Deal’ which sets out how to make Europe the first climate-neutral continent by 2050, by boosting the economy, by improving people’s health and quality of life, by caring for nature, and by leaving no one behind” is impossible, simply untrue and a bitter end for many farmers.

The European Commission top priority should be in line with the following statement: “As for the future, your task is not to foresee, but to enable it” (*The Wisdom of the Sands, Saint-Exupéry, 1948*).

6. CONCLUSIONS

Overall, key factors, which have to be considered, are the following: loss of arable land caused by urbanization, industrialization, desertification, water shortages, shrinking resources, climate change, pollution, species extinction, economic disparities, political instabilities, migration, global trade, new cutting edge technologies in agriculture and digital information systems.

For orientation a tripartite Bio-Vision - 2050 is presented here:

Part 1 (*Kern, 2018a*): A Bio-Vision: “F⁴: Fossil-Fuel Free Farming - 2050” focusing on:

- **Fossil-fuel-free** biomass production (*Kern, M., 2006*)
- **Fossil-fuel-free** fertilization of crops by seed improvements (*Kern, M., 2015a*), microbiomes
- **Fossil-fuel-free** crop protection (*Kern, M., 2010; Kern, M. et al., 2012*)
- **Fossil-fuel-free** irrigation (solar and wind energy)
- **Fossil-fuel-free** land management practices (“*Soil - is more valuable than gold!*”) (*Kern, M., 2009*)
- **Fossil-fuel-free** powered mechanical agricultural production systems (*New Holland NH₂-tractor, Styr biogas tractor, Deutz-Fahr Agroton biodiesel tractor, John Deere electro tractors, robots, no-tillage*)
- **Fossil-fuel-free** smart farming (AI, GPS, Deuterium, drones, apps), (*Kern, M., 2015b*)
- **Fossil-fuel-free** new added-value chains on farms (decentralized, fully integrated hybrid systems, aquaponics, aeroponics)
- **Fossil-fuel-free** cross functional functions on farms and bio-refineries (biogas, biodiesel, bioethanol, solar, wind, water, power-to-gas)
- **Fossil-fuel-free** transportation systems
- **Fossil-fuel-free** food/goods processing
- **Fossil-fuel-free** supermarkets/distribution centers/outlets
- **Fossil-fuel-free** cooking
- **Fossil-fuel-free** bio-economy/industrial ecology

Part 2: “A Mostly Emission-Free Farming – 2050” (CO₂, CH₄, NO₃, NO_x, NH₄NO₃, SO₂, Cu²⁺, P_v, micro-plastic, etc.) going for an:

- Almost emission-free crop production
- Almost emission-free crop protection

- Almost emission-free fertilization of crops
- Almost emission-free smart farming
- Almost emission-free meat production
- Almost emission-free meat processing
- Almost emission-free product packaging
- Almost emission-free transportation
- Almost emission-free distribution systems
- Almost emission-free bio-economy/industrial ecology

Part 3 (Kern, 2018b): A Bio-Vision: “Sustainable Bio-economy - 2050” – Bio-economy is a new concept for the use of natural resources. Bio-economy is the knowledge-based production and utilization of biological resources, innovative biological processes and principles to provide goods and services sustainably across all economic sectors, especially relevant for crop production and crop improvement. The following five areas are recommended:

- **De-Materialization:** “Do more with less!” Save resources by digital farming.
- **De-Carbonization:** “Do it better!” Replace fossil fuels in agriculture with renewable energy.
- **Re-Cycling:** “Do it without waste!” Establish bio-refinery systems.
- **Re-Generation of Natural Resources:** “Do it in order to safeguard bio-capacity!” Save rare and essential factors by implementing smart processing systems.
- **Re-Arrangement of Resources:** “Do it by creating values!” Use modern biotechnology and microbiome methods in crop improvement.
- **And:** “Do it at an appropriate time!” Authorize/regulate necessary methods that are future oriented.

All this is only feasible, if farmers:

- have access to affordable and appropriate new agro-technologies
- are fully compensated for relevant additional requirements
- are getting satisfactory prices for their products
- are protected against products not having these quality standards of sustainable production
- are fully supported by consumers and politicians.

6.1. Vision 2025/2050

Agriculture will be a new global mega-trend in the coming decades and will be triggered by sustainable food and feed, fiber and energy production. Urbanization, globalization, planetarization, increasing aging of societies, changing eating patterns, new cutting-edge technologies and climate change will shape the whole of agriculture – from cellular agriculture, field agriculture, green house agriculture, agro-robotic agriculture via urban agriculture and vertical agriculture to space agriculture.

The agribusiness sector has to reflect all these parameters and generate the capability to reach the following targets by 2050 (modified after Kern, M., 2019):

- Decoupling of greenhouse gas emissions from global agricultural production
- Setting up Fossil Fuel Free Farming (F⁴) systems
- Setting up carbon neutral agro-production systems
- Setting up mostly emission-free agro-production systems
- Setting up emission free livestock systems fully integrated within protein and food clusters
- Vaccination against all key animal diseases will be established safeguarding the highest level of bio-security
- Implementation of biotech/cellular/robot/digital farming systems
- N₂-fixation from the atmosphere by all key crops
- Drought resistance of all key crops
- Doubling of crop production
- An almost doubling of meat production (especially for the 2 to 3 billion ‘new consumers’ in developing countries)
- Tripling of plant-based protein production (food & feed)
- Tripling of greenhouse production systems
- Tripling of fruit and vegetable production
- Tripling of pollination services
- A functioning personalized nutrition system
- Installation of space agriculture
- “Zero” hunger in 2060.

Last, but not least, we need a spiritual guide (Kern, 2018c):

- The world needs people looking ahead and not reacting superficially, who are inspired and not only about what is feasible but who think long term for future generations of which we have only borrowed the present.
- The world needs people who are empowered by a vision, inspired by ethical considerations and possess the courage to look beyond the box.
- The world needs people who make accountable and responsible decisions, although there is discontinuity, instability, uncertainty, incalculability and unpredictability in order to avoid chaos, anxiety and to safeguard a positive future.

As a take home message let me reiterate: “As for the future, your task is not to foresee, but to enable it” (*The Wisdom of the Sands*, Saint-Exupéry, 1948).

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8. APPENDIX

Some Food for Thought to Avoid Oversimplification:

- ~30% of food is wasted by consumers in developed countries
- ~10% of income is spent on food in developed countries
- ~10% of arable land is used for cat and dog food in developed countries
- ~0.18-0.36 ha arable land/year is necessary to provide a dog with 200g/day or 400g/day (Kern, M., 2017)
- ~18% of global calories (kcal) comes from animal resources (FAOSTAT, 2016)
- ~25% of global protein consumption comes from animal resources (FAOSTAT, 2016)

- ~7-18 g of animal protein/person/day would come from livestock, which are exclusively reared on grassland (*Garnett, T. et al., 2017*)
- ~21 g of animal protein/person/day comes from the additional use of non-foods as feed (food waste and crop byproducts) (*Garnett, T. et al., 2017*)
- ~26 g of animal protein/person/day is the current global average of which ruminants provide just under a half (*Garnett, T. et al., 2017*)
- ~50-60 g protein/person/day is available in high income countries (*Garnett, T. et al., 2017*)
- ~5.1 billion ha is global agricultural land (*Wirsenius, S. et al., 2010*)
- ~2.5 billion ha of land is used for livestock production (*Mottet, A. et al., 2017*)
- ~560 million ha are used to feed livestock
- ~40% of arable land is used to feed livestock
- ~30% of livestock feed comes from crop residues as well as co- and by-products
- ~4% of global livestock feed intake comes from soybeans
- ~7-13% of global beef production is done via feedlots (*Mottet, A. et al., 2017*)
- ~8% of global beef production is grass-fed-only (*Godfray, H.C.J. et al., 2018*)
- ~14.5% of global greenhouse emissions are from the livestock industry
- ~45% of livestock GHG emissions are caused by feed production and processing (*FeedCompass, 2019*)
- ~200 million pastoralists rely on keeping animals for their living and a source of income (*Garnett, T. et al., 2017*)
- Farm animals can convert biomass that humans cannot eat into food that we can, provide income, livelihoods and in some parts of the world keeping livestock constitutes a survival strategy (*Garnett, T. et al., 2017*)
- Bushfires in Australia, which have burnt through more than 5 million hectares across the country spew two-thirds (350 million tonnes) of national carbon emissions (523 million tonnes) in one season 2019/2020, (*Foley, M., 1/2020*)
- ~72 million ha of prime agricultural land will be lost to urbanization between 2000 and 2030 (*UNCCD, 2017*); +100-200 million ha between 2010 and 2050 (*UNCCD, 2017*)
- The C40 Cities Climate Leadership Group (C40) is a group of 94 cities around the world that is focused on tackling climate change and driving urban action that reduces greenhouse gas emissions and climate risks, while improving the food system, increasing the health, wellbeing and economic opportunities of urban citizens (*C40 Cities, 2019*)
- The CO₂-PawPrint of a dog in western countries is 30 times higher than the CO₂-FootPrint of a child living in Bangladesh (*Kern, M., 2017*)