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2021

Document Version:
Publisher's PDF, also known as Version of record

IIM Industry Report Series 2021:22

The Future of the Dairy Industry – 2030 Scenario Analysis

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Published 1st September, 2021

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Introduction

This white paper reports the findings of an three-year research project conducted by researchers at the Institute of Innovation Management at Lund University's School of Economics and Management, Sweden. It should be of interest to anyone concerned with the long-range development of the dairy industry in the coming decade – from farm to retail distribution – and with the economic, technical and social forces that are coming to bear on it.

The purpose of this study is twofold:

- To drive new insights into the long-term evolution of the dairy industry, broadly conceived across the entire value chain – that is, from farms to consumers.
- To help dairy companies and others envision the future and possibly start preparing for taking strategic action.

We are sharing these results with industry players globally, and see this as a platform for exchange and discussion. Data and conclusions have been and will be published in scientific outlets.

We have made a comprehensive and wide-ranging *scenario analysis* of the global dairy industry. Using a methodology based on identifying predetermined factors (knowns) and potential disruptions from critical uncertainties (unknowns), we arrived at four broad and widely differing scenarios that are plausible descriptions of how the dairy industry will transform itself over the next ten years. We have called these four scenarios:

- **Dairy Evolution** – Characterized by "no big surprises", with developments largely following current trends, and a variety of smaller disruptions from uncertain factors.
- **Green Dairy** – Marked by strong socio-environmental restrictions, but little technological transition.
- **New Fusion** – Dominated by innovative technologies and processes, but with only weak incremental socio-environmental restrictions.
- **Brave New Food** – Combining both strong socio-environmental restrictions and high technological transition.

If you would like to skip the methodological sections and go directly to the detailed descriptions of these scenarios, go to page 12. If you would like to see the scenarios compared, go to Summary and comparison of scenarios on page 22. For practical implications and possible next steps that you can use to build on these scenarios, see Practical Implications on page 24.

The Big Questions in Dairy the Coming Decade

The global food industry is facing challenges of a magnitude never seen before. We could start with the challenge of feeding a growing population, which can be the most dominant force in some countries. Then there are increasing demands relating to sustainability, legislation, consumer preferences, food technology advancements, international trade, and more, suggesting that the entire industry faces great changes. But at the same time these forces provide opportunities for those who can act proactively and pre-emptively. For

example, as some researchers frame it, how can innovations within food technology help us increase food production without expanding agricultural land? (Willett et al. 2019, Searchinger et al. 2019).

The global dairy industry, in particular, is at the very heart of this transformation, and the contours of this are taking shape. For example, according to one study, animal factory farming is exposed to at least 28 environmental, social and governance issues that could significantly damage financial value over the short or long term (FAIRR 2016). Greenhouse gas emissions in animal food chains are under particular scrutiny (FAO 2019).

In short, the dairy industry is currently grappling with key questions of product identity, health, sustainability, technological innovation, safety and consumer preferences – all the while simultaneously being steered by government regulations and market forces.

Where will the dairy industry be in ten years, in 2030? How can we ask the right questions in order to get useful, plausible answers regarding the entire dairy value chain: farming, processing, distribution, retailing and consumption?

Let's start with some of the larger strategic questions that we know are on everyone's mind these days:

- What is the scope of the dairy industry? What does the future hold for plant-based or fermentation-based cultured alternatives to animal milk?
- How is each stage of the dairy value chain reacting to industry and regulatory pressures? To technical innovations? To environmental pressures and climate change?
- Which parts of the industry will struggle to meet sustainability and environmental targets?
- How is the industry reacting to consumer trends? Where are consumer preferences for healthier products and clean labels leading us?
- What changes in the value chain will e-commerce lead to?
- Are there expanding opportunities for ambient-distribution products?
- What kinds of new technologies does the food processing industry need?
- What kinds of technologies, processes and ingredients will be acceptable to government regulators?

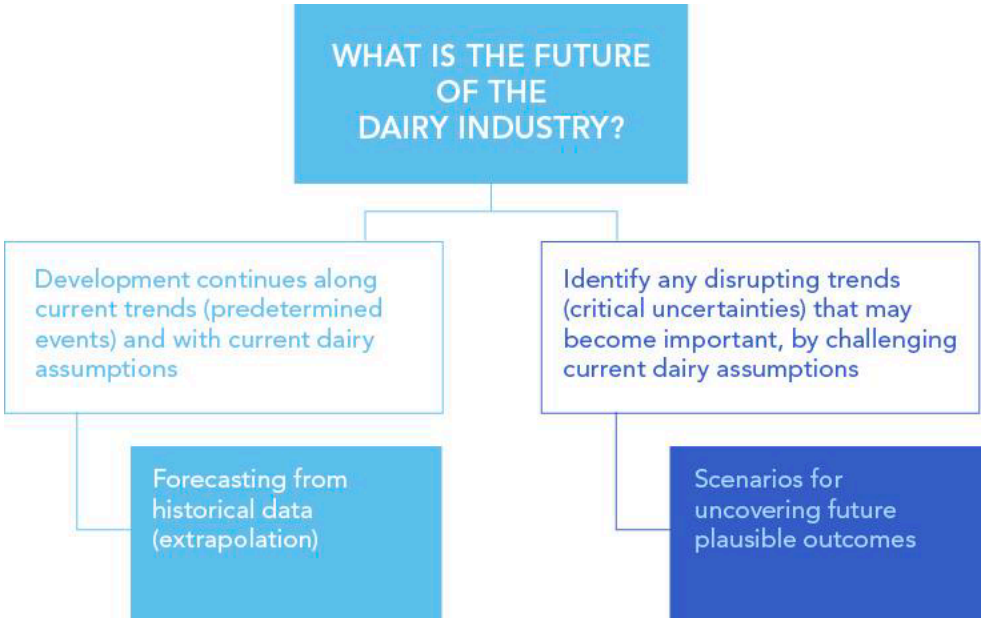
Two Ways of Looking into the Future

There are two fundamental ways of looking into the future, which we can call forecasting and building scenarios.

Forecasting relies on current assumptions and trends continuing on their current paths. In other words, we can know the future by gathering historical data about how things developed in the past, and making extrapolations about how they will develop in the future. We can count on predetermined events (things we already know and can see) unfolding as we move into the future. Predetermined elements are relatively stable or predictable, like demographic shifts. Another way of capturing this would be "no big surprises".

Scenario building, on the other hand, incorporates more dynamic changes (Van der Heijden 2011; Ramirez & Wilkinson 2016). This method is on the lookout for things that change –

and that have the potential to disrupt current assumptions and trends. These critical uncertainties (or unknowns) are unstable or unpredictable, such as consumer tastes, government regulations, or new technologies. The two approaches are outlined below.



Scenario building involves identifying potential change factors, as well as their interactions, and judging which ones might grow in importance. Disruptive forces that change the context for an individual product line, for an ingredient, or for a regional distribution system. Which scenarios are plausible indications of future developments, and how should we use them to monitor the emergence of disruptive trends?

And of course the emphasis is on the plural here – scenarios. There are multiple versions of potential future developments that need to be periodically compared to each other, checked against actual events, and then further refined. We explore how the context of those realities might develop in the future in order to identify potential new strategies to deal with them.

Using scenarios allows us to shift from prediction and forecasting to *strategic reframing* – generating plausible alternatives and new shared knowledge and insights – to reveal, test, and redefine our official company future (Ramirez & Wilkinson 2016). Wide-ranging scenarios also minimize the risk of being blind-sided by unforeseen events.

Effective scenarios are *plausible, relevant to real life, and present challenges to current modes of thinking.*

Project and Method Overview

This research project was conducted by the Institute of Innovation Management at the School of Economics and Management, Lund University in Sweden. The project team consisted of Magnus Johansson, Thomas Kalling, Christian Koch and Matts Kärreman along with more

than 30 students on the International Strategic Management Master programme at Lund University.

Data Collection

This study was conducted over a three-year period in 2018-2021. The geographical scope of the study involved several key global markets: The UK, US, China, India, Nigeria, and Brazil together with smaller markets in Europe. At a later stage, the full project effort focused on the first four of those countries.

Project activities included face-to-face or video interviews across the world, visits to food technology events in Europe and the US, and field trips to all countries included.

In total the scope of the data gathering included:

- More than 200 stakeholder interviews across markets and research topics (see Table 1)
- In excess of 2000 pages of interview transcripts
- In excess of 150 published studies and reports

STAKEHOLDERS	INTERVIEWS (approx.)	EXAMPLES
Dairy Industry	60	- Associations - Cooperatives - Processors
Challengers	20	- Fermentation-based disruptors - Plant-based disruptors - Dairy logistics disruptors
Investors	10	- Food and agri investors - Private equity firms - Accelerators
Consultants	65	- Protein and food experts - E-commerce experts - Sustainability experts
Foundations	15	- Environmental NGOs - Global health NGOs - Cell ag research institutes
Academia	30	- Cornell University - Tufts University - University of California, Davis

Table 1 - 135 widely spread stakeholder interviews

PESTEL Sectors

In conducting interviews and analysing data, we considered the following sectors, which we abbreviate using the acronym PESTEL, standing for Political, Economic, Society, Technology, Environmental, and Legal. One way of defining them is found in Table 2.

A PESTEL analysis is a framework for analysing and monitoring macro-environmental factors that may have a profound impact on an organization's performance. It is often used together with other analytical business tools, such as SWOT analysis and Porter's Five Forces (Porter 1979), to understand a situation and related internal and external factors.

PESTEL was used in a pre-study in key global markets (China, India, US, UK, Nigeria, Brazil) to get a sense of market environments and dairy industry trends. In particular, these categories were used to identify global commonalities and trends in the PESTEL data from the six countries, as a step towards identifying a shortlist of key trends.

POLITICAL	ECONOMIC	SOCIETY	TECHNOLOGY	ENVIRONMENTAL	LEGAL
P	E	S	T	E	L
Goverment policy	Economic growth	Population growth rate	Technology incentives	Weather	Discrimination laws
Political stability	Exchange rates	Age distribution	Level of innovation	Climate	Antitrust laws
Corruption	Interest rates	Career attitudes	Automation	Environmental policies	Employment laws
Foreign trade policy	Inflation rates	Safety emphasis	R&D activity	Climate change	Consumer protection laws
Tax policy	Disposable income	Health consciousness	Technological change	Pressures from NGOs	Copyright and patent laws
Labour law	Unemployment rates	Lifestyle attitudes	Technological awareness		Health and safety laws
Trade restrictions		Cultural barriers			

Table 2 Common factors within PESTEL categories.

Value Chain

Another useful segmentation was the dairy value chain, based on a five-way division of interrelated industries or areas. We found the following key takeaway results in our pre-study data from the six countries.

- *Farming*: Consolidation is underway in most parts of the world
- *Processing*: Differs greatly – large processors dominate in the developed world, small processors in developing world
- *Distribution*: Differs greatly – advanced cold chain logistics in developed world, insufficient cold chain logistics in developing world, due to infrastructure gaps
- *Retailing*: Large retailers and powerful players in the developed world; a fragmented picture in the developing world
- *Consumption*: Milk consumption declining in the developed world, but increasing in the developing world

Key Trends

The nine key trends that we identified in our pre-study data were:

- *Political unpredictability* – including corruption, erratic leadership, changing alliances (such as Brexit in the UK), climate policies, etc.

- *Health consciousness* – consumer-driven awareness of ingredients and sources, chemical additives, etc.
- *Dairy alternatives/food technology* – plant-based dairy alternatives (oats, soy, almond, coconut, etc.) and cultured, animal-free dairy protein
- *Urbanization/middle class growth* – global trend towards urban settlements and rising incomes, rising expectations
- *Environmental sustainability* – climate policies and practices, energy sources and usage, waste and pollution
- *Local food* – community-supported agriculture, avoiding the carbon footprint associated with long transports, increasing traceability
- *Online/e-commerce* – automation, B2B transactions, mobile phone applications, etc.
- *Food safety/traceability* – knowing suppliers and ingredients, monitoring and tracing, quality assurance
- *Organic produce* – farming practices that restrict chemicals and minimize environmental harm

Of these nine key trends, we chose three for further development, since they each displayed *disruption potential, global reach,* and a high degree of *interdependency with other trends*. These qualities were specifically chosen so that we could identify factors that challenge current assumptions about dairy industry developments.

These three prioritized areas we chose for scenario development are:

- Dairy alternatives
- Environmental sustainability
- E-commerce interrelations

To show how interdependent these three trends are, consider first environmental sustainability, which has interdependencies with:

- Developments in food-tech (cultured, animal-free dairy protein) and plant-based dairy alternatives (oat milk, pea milk, etc.)
- Organic dairy products (minimizing environmental harm)
- Local food movements (traceability and community-supported agriculture)
- Political debates and decisions (climate change policies)

Food technology's interdependencies include:

- Environmental sustainability developments (climate change)
- Food safety/traceability concerns (fewer supply chain players)
- Health consciousness trend (free of hormones, lactose, or cholesterol)

E-commerce interrelations have interdependencies that include:

- Food traceability (IoT, Blockchain, etc.)
- Urbanization/Middle-class growth (on the go, instant deliveries)
- Food-tech and plant-based dairy alternatives (better margins)

Data Analysis

As we progressed to the main phase, we reduced the geographical scope by not continuing with Nigeria and Brazil, as these two markets did not meet our criteria for potential impact, relative novelty, pioneering characteristics, feasibility of data access, or consumer buying power. Thus the majority of expert interviews was performed on our three key trends in the US, the UK, China and India, during the spring and summer of 2019.

Qualitative analysis was conducted on interview transcripts as well as industry reports and academic studies. Our goal was to derive a smaller number of higher-level concepts from a seemingly chaotic data set.

On the basis of our stakeholder group interviews within the three overall scenario research topics – food technology, environmental sustainability, and e-commerce – we identified 124 "micro factors". Our group expressed these micro factors from the data as short phrases, writing them on Post-It notes, and then physically clustering them into higher-order groups. We were able to create *12 thematic clusters* based on these micro factors and their contextual interconnections. Our clusters thus each contained a set of elements that could be clearly distinguished from the elements of the other clusters (see below and Appendix D).

Mapping the Clusters

We mapped the clusters against the *value chain* – to show where they would have most impact – and mapped them as well against the three prioritized trends – to show where they fit. This mapping is shown in Figure 1.

As you can see, this graph represents a situation where politics and policies impact the entire chain: farmer's investments, transporting, rules regarding processing, retailing, and taxation – what can be consumed under what names, and which foodstuffs or ingredients will be taxed.

Concerns with health and nutrition mainly affect retailing and consumption. Fermentation factories affect the first half of the value chain… and so on. This analysis resulted in valuable insights for selecting the most critical uncertainties in the contextual environment, the next step in creating scenarios.

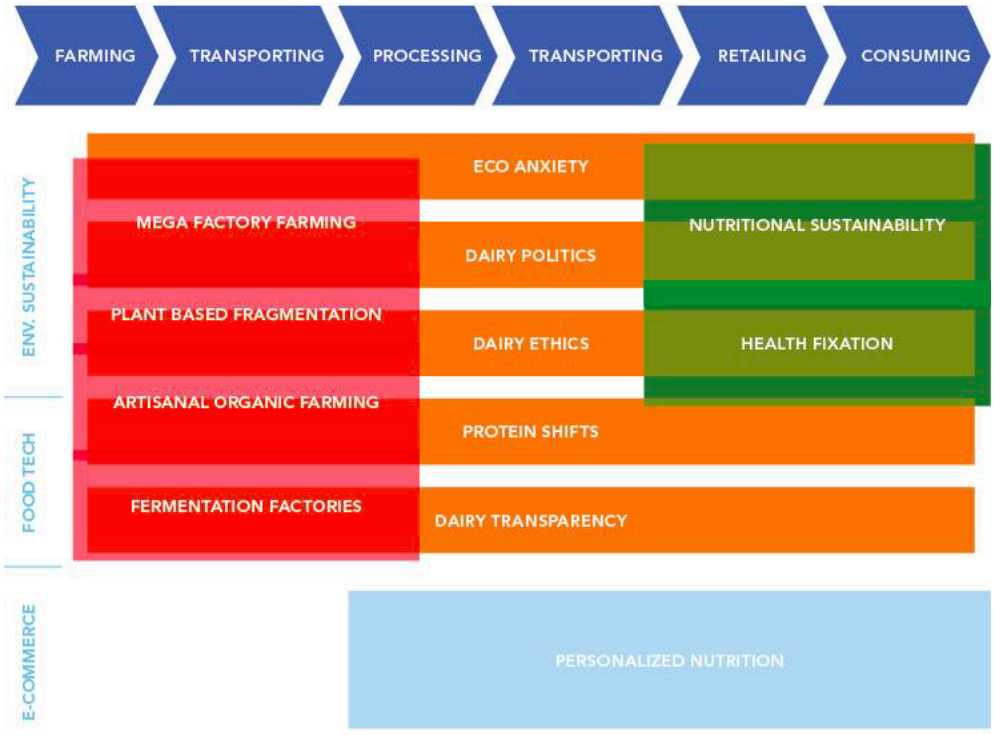


Figure 1 Clusters mapped against the dairy value chain and three priority trends

Developing Scenarios

Overview

Our scenario methodology is based on The Oxford Scenario Planning Approach (OSPA: Ramírez & Wilkinson 2016). General guidelines for creating scenarios – covered in more detail in Appendices A and B – include:

- Create global scenarios that maximize the spread of the thinking within plausible space
- Present tentative scenarios that need to cover the clusters presented in one way or another.

- Don’t complicate scenarios by selecting too many drivers. Predetermined events need to end up in all scenarios, while uncertain events are included in only selected scenarios – usually only one or two.
- Avoid thinking in terms of good and bad futures; only plausibility and internal consistency should be the yardsticks for an effective outcome.

As part of the OSPA tools available, we chose a *deductive scenario method* to develop a scenario matrix, since it ensures most granularity, producing four scenarios that are as different from each other as possible within the limits of plausibility and credibility. You will find the details in Appendix C – The deductive method.

Below we outline our logical progression, starting with predetermined events (knowns) and moving on to our choice of critical uncertainties (unknowns).

Predetermined Events

Predetermined events, as you probably recall, are the given parts of the context – those that are currently unfolding, and will continue to unfold. They will all have an impact on the future development of the dairy industry, regardless of which scenario turns out to match reality. We included the following three in our analysis:

- Demographics – population growth
- Climate change
- Rising global demand for dairy products

Demographics – Population Growth

We know that world population continues to grow, although the growth rate is slowing (UN 2019a).

Growth in the urban population is driven by overall population increase and by migration towards urban areas (UN 2019b).

There is an ongoing generational shift: the next generation is different. In particular, the UN’s Secretary General recently noted that this generation is marked by its commitment and activism – particularly within the areas of environmental sustainability (UN 2019c).

Climate Change

The availability of food, feed and water are all critical to our industry. Climate change creates additional stresses on land, exacerbating existing risks to livelihoods, biodiversity, human and ecosystem health, infrastructure, and food systems. Increasing impacts on land are projected under all future greenhouse gas emission scenarios.

Pathways with higher demand for food, feed, and water, more resource-intensive consumption and production, and more limited technological improvements in agriculture

yields result in higher risks from water scarcity in drylands, land degradation, and food insecurity (IPCC 2019).

Rising Global Demand

Given that one of the "pre-determined" factors was a rise in world population, we also assume a rise in global demand for dairy or "dairy-like" products leading up to our horizon year of 2030. If this dairy demand consists of traditional animal milk, plant milk or cultured/fermentation-based milk is another question, which is directly addressed by the four different scenarios, and visible in their outcomes.

Total demand increase is seen from a global perspective, mainly driven by China and India; in Western regions such as the US and Europe, demand may remain flat or even decrease. These do not vary from scenario to scenario.

Critical Uncertainties

Critical uncertainties in scenario building are *unstable* or *unpredictable*, such as consumer tastes, government regulations, or new technologies

In scenario analysis, the natural choices for critical uncertainty dimensions are *high impact* and *least predictability* within the strategic context that needs to be reframed – the long-term evolution of the dairy industry. Our analysis led us to choose the following two critical uncertainty dimensions as having both the highest potential impact and least predictability in the context of dairy industry development:

- Technological transition (low/high)
- Socio-environmental forces (weak/strong)

The *e-commerce interrelations* category was not selected as an uncertainty dimension, as it was judged to relate to only a single thematic cluster, personalized nutrition.

The technological transition dimension would reflect the following values:

- Alternative (low) versus substitute (high) rationale
- Low-tech (low) versus high-tech (high) plant-based innovation
- Unsuccessful (low) versus successful (high) scaling of cultured dairy protein
- Marginal (low) versus widespread (high) consumer adaptation (propensity of using new technologies)

The socio-environmental forces dimension would reflect the following values:

- Weak versus strong legislative ruling
- Weak versus strong animal-based food taxation
- Weak versus strong application of environmental fines for excessive greenhouse gas emissions
- Weak versus strong animal welfare policies and restrictions
- Weak versus strong societal pressure

Together these two dimensions create a 2 x 2 matrix with four scenarios, as shown in Figure 2. Each scenario provides a different answer to the decision. Each answer presents a myriad of implications that fundamentally change the business environment.

Figure 2 Four scenario directions for the dairy industry

These four scenarios are explained in detail in the following four sections, which devote about 4-5 pages to each one. To interpret the substance of these scenarios, please keep in mind:

- Each scenario needs to be understood on its own
- Treat the content and any quantities in each scenario within the logic of the scenario, not the current reality.
- The goal of a scenario is a "fuzzy fit" – a generalization with enough validity to be useful in understanding underlying structure.

After we present these scenarios, we offer a short summary that compares them, and then conclude with some of the urgent practical questions that these scenarios raise, and how organizations like ours can use scenarios like these to influence their decision-making processes. For additional details about the methodology, see Appendix B – Creating scenarios.

Dairy Evolution Scenario

The first scenario is called "Dairy Evolution" because it is not remarkable in any particular way, but just expresses a slow continuation of the status quo and current trend lines, with

only incremental changes. It could also be called a “business-as-usual” or “world-as-it-is” scenario. Thus it is characterized by the following:

- Weak socio-environmental restrictions and oppositions (only incremental environmental improvements)
- Low technological transition
- Continuation of traditional dairy farming consolidation towards mega factory farming
- Continued, moderate plant-based growth
- Fermentation-based or lab-grown dairy protein remains a niche, since it does not reach scalability and consumer adaptation for mass markets.
- Increased global milk movements to meet demand in dairy deficit countries

Conceptual System

The major drivers in the Dairy Evolution scenario are:

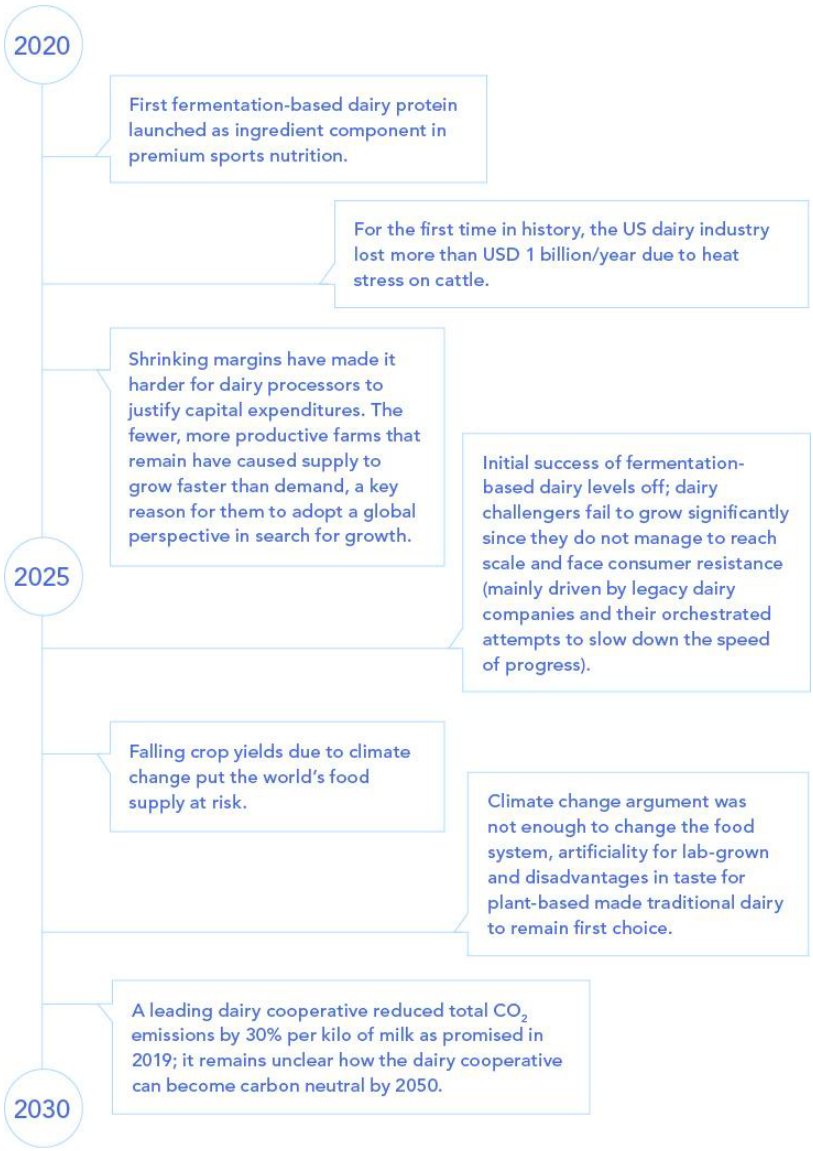
- *Social license* (+): Key stakeholders continue to grant dairy social license to operate (despite occasional scandals and related boycotts of mega factory farming operations)
- *Subsidies* (+): Direct and indirect subsidies remain untouched, which means they persist or even increase to secure jobs
- *Consolidation* (+): Increased consolidation on farm level with increasing mega factory farming approach
- *Margins* (-): A warming climate has made factory farming less financially viable in most parts of the world, which begins to erode margins within the sector – even with continued subsidies
- *Fines & Taxes* (-): Animal-based food taxation and environmental fines remain exceptions
- *Vulnerability* (+): A warming climate and animal welfare issues increases the financial risks of factory farming (the US dairy industry already loses US$ 897 m/year from heat stress on cattle)
- *Milk movements* (+): Increased export capabilities (milk movements) of big dairy producer markets (especially US, Europe and New Zealand) to meet demand in dairy deficit countries (such as China)

Story Map

A story map is a series of connected statements representing plausible events generated out of a given scenario context, and assigned a place on a timeline. Naturally, this type of story line is easy to update as events unfold (or not) in time. The Dairy Evolution story map is outlined below.

Underlying facts and likely implications for the Dairy Evolution story map:

- While recognizing the responsibility of the dairy sector to develop in a sustainable manner, the *mitigation potential* of the sector is limited because, as a biological process, emissions will always be generated.



- Despite only *incremental environmental improvements* and *continued animal welfare scandals*, the dairy industry manages to tell a convincing story that regulators and the majority of consumers buy in to.
- Importantly, the dairy industry manages to *distinguish itself from the meat industry* and is successful in not being lumped together with the heavily polluting red meat industry.
- Environmental constraints on drastic increases of dairy production in exporting countries suggest that *changes in the balance of supply and demand* will shift the global market price of dairy products to *higher levels*.
- Dairy farms around the world need to *relocate* due to changing climate.
- Generational shift and demand increase in dairy alternatives force traditional dairy companies to be more *innovative*.
- Majority of consumers prefer cow-based dairy (or plant-based alternatives) and *reject consuming* initially GMO altered fermentation-based versions; fermentation-based dairy remains a *niche food* (e.g. as source of added protein in packaged food).
- *Niche for local* or small-scale dairy farms remains.
- Farm animal *yields hit diminishing returns* since cow robotization is maxed out.

- Majority of growth in the dairy sector takes place outside Western Europe and North America.
- *Nutritional benefits* will remain dairy's unique selling point with consumers around the world.
- Government dietary recommendations are for dairy to make up 8% of daily food intake, yet actual dairy consumption continues to be twice as much and this *over-consumption* continues, mostly in Western Europe and North America.

Green Dairy Scenario

This scenario is called "Green Dairy" because it most closely mirrors the kinds of changes involved with strong socio-environmental restrictions and oppositions, which push dairy farms and processors to invest massively in improving their carbon footprint. This is the single main driver.

- Technological transition is low
- Only a few mega factory farms are able to remain profitable considering massive changes to subsidy regulations, the introduction of animal-based food taxation, and stricter animal welfare policies
- Cost increases in production lead to higher cow-based dairy prices (especially butter and cheese) for end-consumers (and are consequently increasingly perceived as premium products)
- Strong plant-based growth considering better environmental footprint and increased cost-advantages compared to traditional dairies
- Fermentation-based dairy protein remains niche (e.g. premium sports nutrition segment and versatile ingredient in food production) since it does not reach massive scalability and cost-effectiveness for mass market, as well as facing consumer resistance due to unsolved GMO issues

Conceptual System

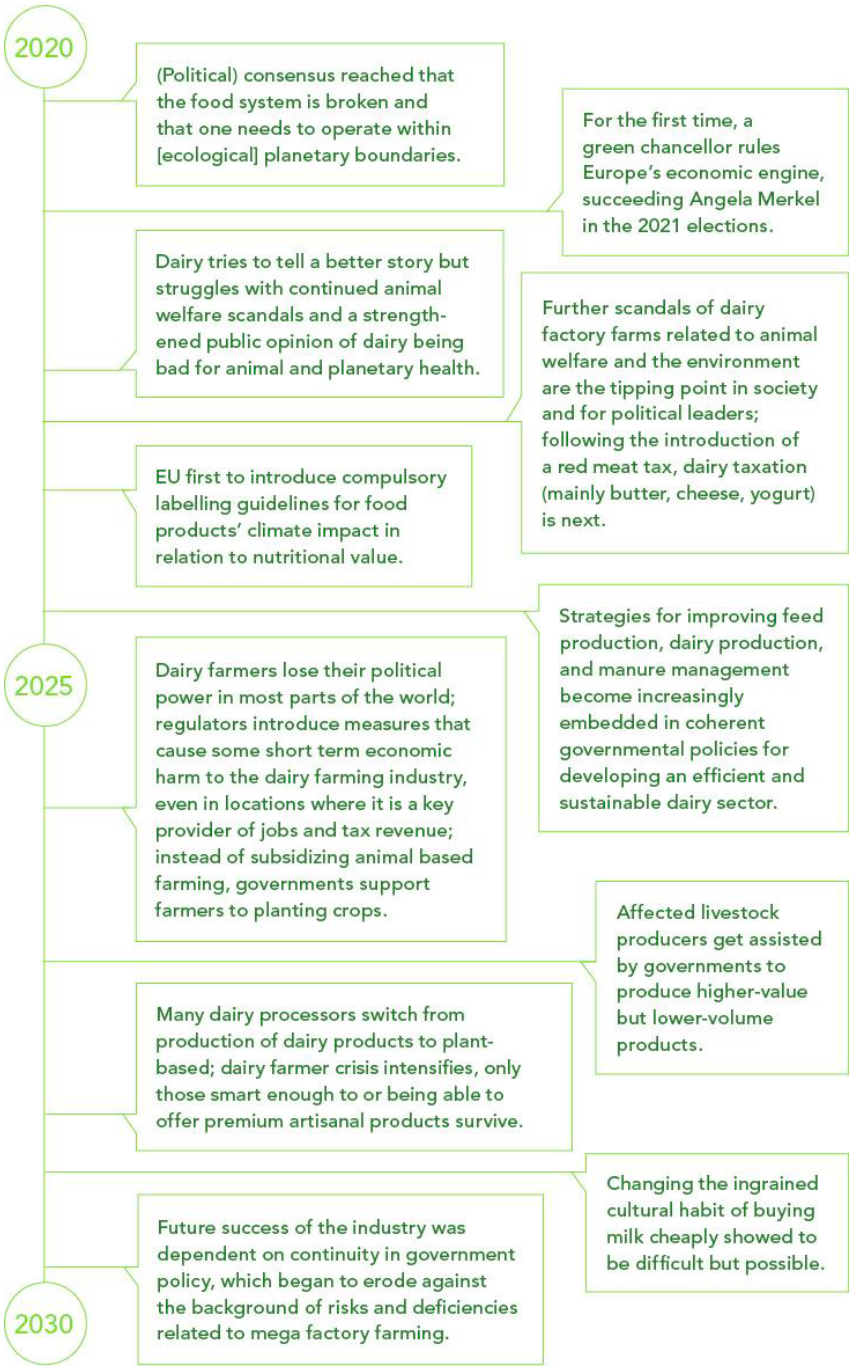
The major drivers in the Green Dairy scenario are:

- *Social license* (-): Key stakeholders such as regulators and consumers stop granting factory-farmed dairy the social license to operate, following a massive increase in disclosed animal welfare scandals and a warming climate, with animal-based agriculture agreed to be a main contributor
- *Subsidies* (-): Direct and indirect dairy subsidies get suspended, which leads to the survival of the fittest dairy farms, short-term unemployment increase, and a shift towards crop-based agriculture
- *Fines & taxes* (+): Animal-based food taxation, environmental fines for polluting dairy farms and stricter animal welfare regulations become the norm
- *Consolidation* (+): Increased consolidation on farm level with only a few mega factory farming operations able to withstand the new regulatory pressures
- *Margins* (-): A warming climate as well as regulatory burdens has made factory farming less financially viable in most parts of the world, which results in eroded margins

- *Transition* (+): Instead of subsidizing animal-based farming, governments encourage the private sector with a range of policy instruments such as supporting farmers to from animal-based to plant-based agriculture
- *Labelling* (+): Labelling guidelines for food products' climate impact in relation to nutritional value become compulsory

Story Map

A story map is series of connected statements representing plausible events generated out of a given scenario context, and assigned a place on a timeline. Naturally, this type of story line is easy to update as events unfold (or not) in time.



Underlying facts and likely implications for the Green Dairy story map:

- *Concerted commitment by leading economies* (agriculture sectors, food companies, government regulators) around the world to make healthy and environmental-friendly foods more available, accessible and affordable
- *Zero-expansion policy* of new agricultural land into natural ecosystems
- *Mega factory farm dairy operations* now *demonized* based on emotion and ideology
- Society and regulators realize that not only the dietary make-up of a product makes it healthy or not; how it is produced becomes increasingly important for assessing if it benefits *human health* and *planetary health*
- Consuming dairy products (especially butter and cheese) becomes a luxury following drastic increase in price (in response to lost subsidies and increased taxation); *dairy consumption declines with side effect of ending over-consumption of dairy products now being closer to recommended levels*
- Dairy products now viewed as a *high-value product* instead of a cheap, subsidized stable product; with higher prices for dairy products, consumers also realize that milk can and does taste differently when sourced from different breeds and regions.
- Hungry for *"ecological public health"*, consumers become more and more adventurous in using *food as a tool for environmental action*
- *Dairy input industry* (soy and corn feed) gets affected and is forced to change strategy

New Fusion Scenario

This scenario is called "New Fusion" because it represents domination by innovative technologies and processes while at the same time experiencing relatively weak socio-environmental restrictions. "Fusion" may also refer to novel combinations of proteins from different sources.

- Only weak incremental environmental improvements
- Technological transition is high
- Fermentation-based dairy companies succeed in producing cost-effectively and reach mass-market scalability (e.g. convenience food, sports & clinical nutrition, bakery & confectionery sources, infant milk formula, butter, staple cheeses, yogurt)
- Fluid milk for consumption remains "last bastion" for the conventional dairy industry
- Moderate plant-based growth despite advances in nutritional profile and texture (reaches natural limit since it does not deliver on taste compared to now-successful cultured dairy)
- Artisanal (premium) dairy and cheese making continues to thrive
- Fusion products are increasing massively where the best of "three worlds" (animal, plant and lab-grown proteins) are mixed and matched to create personalized nutrition

Conceptual System

The major drivers in the New Fusion scenario are:

- *Tech scaling* (+): Wide variety of specialized fermentation start-ups collectively become a force and change the food culture for traditional animal-based foods (which also includes a reframing of the debate around GMOs)

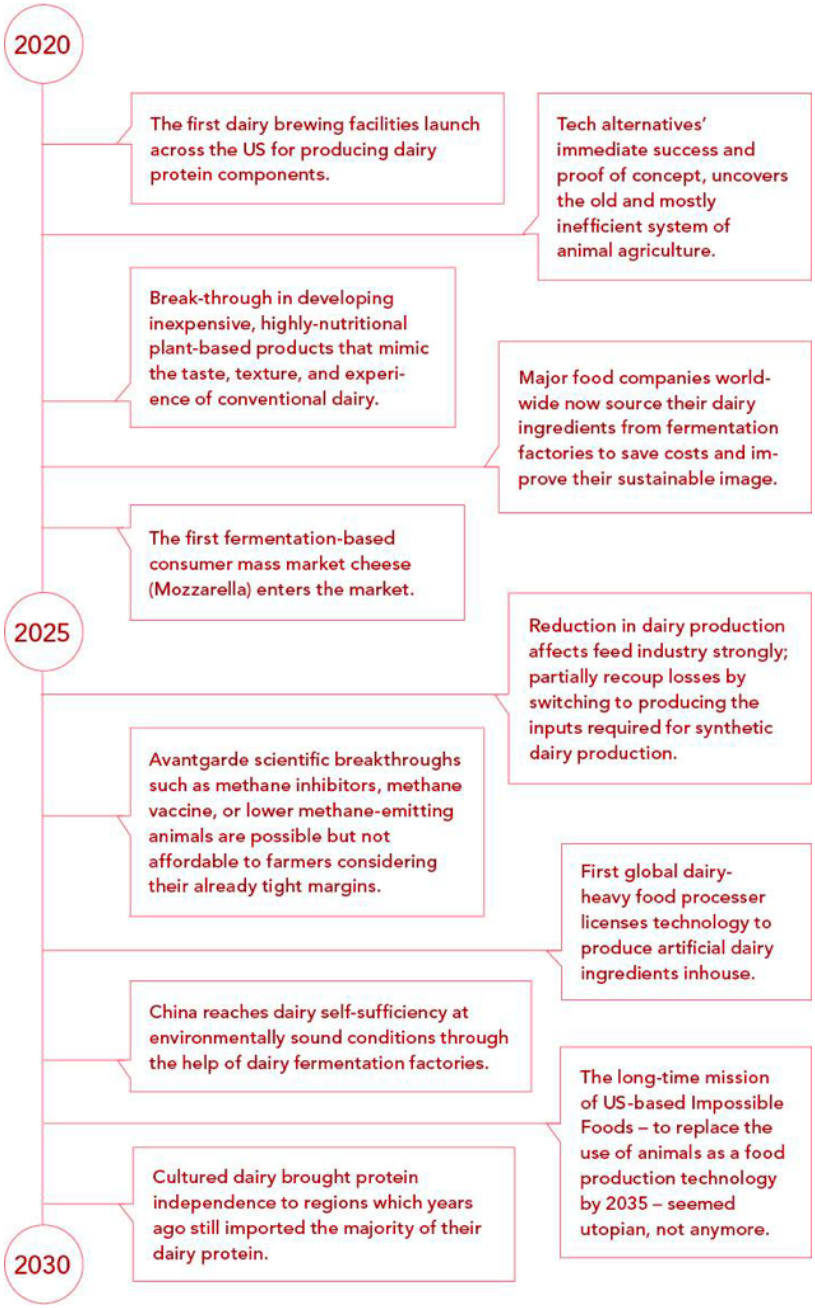
- *Margins* (-): A warming climate as well as successful synthetic dairy substitutes has made traditional dairy factory farming less financially viable in most parts of the world, which results in eroded margins
- *Transparency* (+): Innovation in traceability and labelling for both alternative and traditional protein products, improve transparency and communicate to consumers the multiple impacts of different food types; transparency might involve distributed ledgers or embedded microchips, for example.
- *Vertical integration* (+): Leading food processors vertically integrate dairy fermentation technologies due to cost efficiency and reputational reasons
- *Resilience* (+): Artisanal, organic, local dairy farmers develop resilience and find market opportunities with a variety of craft dairy products
- *Personalized nutrition* (+): DNA-driven nutrition (based on consumers' DNA profile) will take the guesswork out of what is good and not good for individual human health
- *Export market competition* (-): Export market competition for traditional dairy decreases due to decentralized dairy brewing opportunities and associated technological democratization around the world

Story map

A story map is series of connected statements representing plausible events generated out of a given scenario context, and assigned a place on a timeline. Naturally, this type of story line is easy to update as events unfold (or not) in time. Underlying facts and likely implications for the New Fusion story map illustrated below.

- Farming takes many forms now; cow-, plant- and fermentation-based dairy co-exist to *boost nutritional quality*
- Proven success of both plant- and fermentation-based dairy helps low and middle-income countries to *avoid the food-system mistakes* made in the past by today's wealthy nations as they increase in prosperity and move along their own *sustainable development trajectory*
- The cellular agriculture industry succeeds in developing the ability to *use carbon sources as microflora fermentation feedstock* that until now had no appreciable commercial value (e.g. crop residue)
- Fermentation-based dairy brings *protein independence* to regions which used to import the majority of their dairy protein, since dairy brewing is feasible in any climate or geography
- Many consumers highly value the fact that animals are not required to produce *high-quality dairy proteins*, creating a vegan, lactose-free product coupled with the perception that synthetic dairy proteins will have a smaller environmental footprint
- Just as the email or the mobile phone changed how people communicate, society changed over time and now adheres to a *new food identity*; as with all exponential technologies, *change happened at a faster speed than predicted*
- "Crops for the Future", the world's first research centre dedicated to underutilized crops, finds several new *climate-resistant and highly nutritional species* that work well as dairy alternatives
- Regulators seem to be confused by the technology, the speed of change and the ethical implications of new products that do not fit into existing categories; the *market rules* and succeeds to integrate novel products within the current regulatory system

- *Massive investments* by major food and commodity companies in alternative protein startups signals industry's belief in the potential for significant growth in this sector and brings their strengths in production, marketing and distribution



Brave New Food Scenario

The name of this scenario, "Brave New Food", is inspired by Aldous Huxley's 1932 novel "Brave New World", a futuristic vision of a society that is environmentally engineered and based on an intelligence-driven social hierarchy and scientific achievements.

This scenario has both main dimensions operating, combining both:

- Strong socio-environmental restrictions and oppositions (which push dairy farms and processors to invest massively in improving their carbon footprint)
- High technological transition

In other words, both these drivers are present, providing different directions in which a critical uncertainty may play out.

- Only very few mega factory farms are able to remain profitable (considering technological transition and regulatory pressure)
- Artisanal (traditional) dairy and cheese making continue to thrive
- Cultured dairy protein companies produce cost-effectively and reach mass market scalability (dairy ingredients in food production, stable cheeses, sports nutrition, butter, yogurts, etc.)
- Even highly functional cultured liquid milk has been developed considering cost advantages over heavily taxed animal-based products
- Strong plant-based growth considering the many forms of nutritional sustainability and improvements in taste and texture as well as policy nudges

Conceptual System

The major drivers in the Brave New Food scenario are:

- *Tech scaling* (+): Wide variety of specialized fermentation start-ups collectively become a force and change the food culture for traditional animal-based foods (which also includes a reframing of the debate around GMOs)
- *Vertical integration* (+): Leading food processors vertically integrate dairy fermentation technologies due to cost efficiency and reputational reasons
- *Fines & taxes* (+): Animal-based food taxation, environmental fines for polluting dairy farms and stricter animal welfare regulations become the norm, further fuelling the success of plant-based alternatives and synthetic substitutes
- *Consolidation* (+): Increased consolidation on farm level with only a few mega factory farming operations able to withstand the new tech and regulatory pressures
- *Transition* (+): Instead of subsidizing animal-based farming, governments encourage the private sector with a range of policy instruments such as supporting farmers from animal-based to plant-based agriculture
- *Personalized nutrition* (+): DNA-driven nutrition (based on consumers' DNA profile) will take the guesswork out of what is good and not good for individual human health and planetary health

Story Map

A story map is series of connected statements representing plausible events generated out of a given scenario context, and assigned a place on a timeline. Naturally, this type of story line is easy to update as events unfold (or not) in time.

The underlying facts and likely conclusions for the Brave New Food story map:

- *Definitions* of "natural" and "healthy" are *re-written*

"If you can extract protein from grass, why would you give it to a cow first?"
"How natural is it to get milk from cows kept inside all day?"

- Advances in *sustainability-driven tech products get supported by regulations* that cater for a new world of foods
- *Energy supplies* for various fermentation-based protein technologies differ greatly; the most environmentally friendly and nutritionally rich solutions will have advantages in a highly regulated protein tech environment
- *Survival of the fittest* solutions (from both a tech and regulatory perspective)
- Food and pharma become one *(food as medicine)*

Summaries

This research project used established methodologies (Appendices A-D) to develop scenarios for the dairy industry and related food processing and distribution sectors. The geographical scope of the study involved several key global markets in the preliminary stages, among them the UK, the US, China, India, Nigeria, and Brazil. At a later stage, the full project effort focused on the first four of those countries.

Based on the findings from around 200 interviews of key players, the project team carried out the following analyses:

- Identified 124 micro factors that will influence the dairy industry in the coming decade.
- Organized these factors into 12 thematic clusters, along with three key trends to map onto the dairy value chain.
- Identified three predetermined events with wide implications
    - Demographics - population growth
    - Climate change
    - Rising global demand for dairy products
- Developed two critical uncertainty dimensions for dairy industry development
    - Technological transition (low/high)
    - Socio-environmental forces (weak/strong)

The full analysis led to four alternative plausible scenarios for the coming decade, which are well-described using concrete hypothetical events based on each scenario's internal logic.

Summary and Comparison of Scenarios

We must stress once again that each scenario needs to be understood on its own and has its own implications – for all kinds of stakeholders.

The validity of individual assumptions and drivers, and how quickly they play out in one or more markets, or globally, may vary considerably from the portraits we have painted here.

However, all scenarios have a few points in common when it comes to industry attractiveness:

- Large, efficient dairy players without close farming ties (cooperative model) may be more flexible than other players.
- Farsighted food conglomerates may have smart investment strategies that cover more than one technological approach.
- Food entrepreneurs (niche actors) will have opportunities to provide relevant innovations and value propositions.

In our view, the dairy companies that plan strategically – taking known factors into account and showing the flexibility to handle a wave of disruptive changes – will be the ones with thriving businesses in 2030.

We hope that the findings from this white paper contribute to both flexibility and a mindset geared to change in the dairy industry. The next section talks about how to get there.

NOTE: The bulk of the results of this project were completed before the 2020 Covid-19 pandemic. The repercussions of this singular event are still emerging. This presentation has made no attempt to adjust the scenarios or their interpretations based on this recently unfolding pandemic. Whether the consequences of the pandemic have any effect at all, and if so whether they strengthen or weaken our projections remain to be seen.

Practical Implications

So, how can industry players make use of the conclusions of this study? From an "organizational learning" perspective there are several ways to approach this. One is to follow the learning loop approach, outlined by Kolb (1984), illustrated below.

We can map Kolb's learning cycle onto the scenarios by adapting the following steps, which can be carried out through individual work, group exercises, or workshops, as laid out in Table 3.

	RELATION TO SCENARIOS	DESIRED RESULT
CONCRETE EXPERIENCES	Live inside the scenario stories	People learn about, understand and remember the scenarios, and are willing to suspend disbelief and play the scenario game of "living the future in advance"
OBSERVATION AND REFLECTION	Examine the implications of each of the scenarios	People make connections between possible futures and their contextual environment, and the consequences for themselves and their organizations
FORMATION OF ABSTRACT CONCEPTS AND THEORIES	Draw conclusions from each of the scenarios as a set	An integration of the insights obtained from imaginary scenario journeys into the participants' mental models
TESTING THE IMPLICATIONS OF THEORY IN NEW SITUATIONS	Plan next steps	Agreement on how to move from thought to action

Table 3 Kolb's learning cycle applied to scenarios – from Van der Heijden (2011)

Coupling Scenarios to Strategic Directions

A second parallel approach is to couple scenarios to our strategic development, in collaboration with partners at multiple instances along the dairy value chain.

The study offers a framework for inquiry, based on plausible scenarios. These can be questioned, extended, amended and refined, as changing circumstances and new facts emerge. The best approach is to continue to monitor events and choose the most plausible scenarios for follow-up, while continuing to monitor the real world and adjusting these scenarios and their predictive capabilities, where necessary.

The scenarios we developed can help us address both external and internal strategic questions:

External perspective:
- What factors are driving industry performance?
- Where can we add value?
- How can we improve our industry attractiveness and positioning?

Internal perspective:
- Is our organization equipped to survive and flourish in any of the multiple equally plausible future environments we may be facing?
- How can we redirect and strengthen our organizational capability and business portfolio?

Global value-chain questions:
- How will markets grow that have a low dairy tradition?
- Will prices and preferences for basic dairy products towards increasing luxury and indulgence?
- Is ambient distribution achievable with an increasing number of products – with different protein origins – or are there natural limits?
- Will pharma and biotech companies become the new food and ingredient suppliers?
- What are the global trading implications ahead of us?

Dairy Processing Implications:
- How do we combine efficiency and flexibility in processing?
- How can we meet sustainability targets?
- How will the development of specific processing steps – such as extraction, conversion, enzymatic treatment, fermentation, blending and filtration – contribute to overall dairy industry innovation?
- If trends to consolidation and mega factories continue, how will this affect the need for high-capacity equipment? Or automation?
- How important will integrated business ecosystems become?
- What is our innovation agenda? Are we prepared for investment?

Regional Markets and Capabilities

In addition to technology-related questions, one should also apply the scenarios to key regions and markets of interest.

- Which regions are taking a leading role in the production of fermented proteins?
- Which regions will favour product choices on quality and environmental factors?
- Which consumers or processor groups might resist product innovation?
- Which markets will insist on self-sufficiency?
- Which markets might ignore existing industrial traditions and forge ahead with establishing new factories and processing methods?

What's Your Direction?

At the Institute of Innovation Management at Lund University we conduct research on a range of industries in transformation. We study driving forces such as society, policy and technology, but also the actual transformation steps that firms to through as they explore opportunities or mitigate threats, make strategic and subsequent investment decisions, and start building new capabilities and new business models. Please contact us if you want to discuss the challenges associated with the future dairy industry – or other industries.

APPENDIX A – The Oxford Scenario-Planning Approach

The Oxford Scenario Planning Approach (OSPA), based on Ramírez & Wilkinson (2016), is designed to analyse and understand factors involving **turbulence, uncertainty, novelty** and **ambiguity**. These four factors are thus often summarized in the acronym **TUNA**.

The OSPA methodology involves shifting from **prediction** to **reframing**; reframing helps people become mindful of the framework they have been using to make sense of and intervene in the world, as well as what is left out of this framework.

The OSPA is built on seven key premises.

PREMISE	SAMPLE EXPRESSIONS OF THE PREMISE
1. Many organizations are facing unprecedented TUNA conditions.	The level of atmospheric carbon dioxide now exceeds that ever encountered in the human era. Climate change looms large in our collective imagination, and its impacts and their timing remain uncertain.
2. TUNA conditions require new approaches to strategic and policy planning that seek to balance competitive and collaborative opportunities.	Giving more priority to the future in the present day to avoid "missed opportunities". Reconsider assumptions and ask better questions through a process of discovery, interactive and immersive learning and invention.
3. TUNA conditions call for an explicit and flexible sense of future.	Sense of future can be enabled by contrasting plausible, alternative future contexts of a specific situation of a specific person or group of actors through a cyclical process of reframing and re-perception, repeated over multiple iterations.
4. The "aha" moment of impact is only realized after the reframing-reperception cycle has been completed. This might require several iterations.	Reframing occurs though strategic conversations that explore new territory, accommodating disagreement and rendering it into a productive asset. Supported by a combination of rigorous open systems thinking and imaginative storytelling.
5. Learning supported by scenario planning can avoid the extremes of groupthink and fragmentation – pathologies that prevent collective learning in organizational settings.	Learning is enabled through a combination of knowledge exchange (tacit knowledge becomes explicit) and new knowledge generation.
6. Reframing strategy is a distinctive capability that enables learners to identify new opportunities, and more and better options.	More flexible sense of the future enables a shift from being reactive to being proactive. Insights on new relations and new roles become unique strategic options in themselves, increasing adaptive capabilities.
7. Scenario planning can help develop new social capital to renew the license to operate.	Rehearsing new actions in plausible futures An organization's existing license to operate cannot be taken for granted, but can be redesigned, renewed, or regenerated.

The OSPA is thus a process, in which the end result is not as important as how you arrive at it. It is a learner-centric methodology based on iterative, strategic conversations, leading to a reframing/re-perception cycle.

Scenario creation represents a balance between competitive and collaborative strategic action, as defined by a wide range of stakeholders.

The final report detailing a number of scenarios does not represent a final outcome. It is a focus point for continued analysis and strategic conversations among stakeholders.

APPENDIX B – Creating Scenarios

This material is based on Ramírez & Wilkinson (2016) and Van der Hejden (2011). Scenario planning is used as a research methodology in itself. It requires methodological openness and clarity about assumptions, because there is no single method that is "best" or "right" in all circumstances. What is being modelled is not "reality" but a "plausible future" (which currently is fictional). Based on the explicit purposes of the strategic intervention, scenarios can potentially contribute by:

- Improving decision frameworks and judgment processes
- Shifting the strategic vocabulary used
- Clarifying strategic choices
- Generating new questions
- Prototyping of new options

A scenario is a flexible descriptive model, that is, it provides a description of a future context in a way that is considered to be plausible, challenging and relevant/useful for the intended purpose and user group it was designed for.

MAJOR STEPS	**PROCESS**
Defining the purpose, scope, and intended use	Get to know the needs and capabilities of the scenario learners and users. Determine the time horizon of the scenarios. Determine the issues to research.
Deductive method Defining and sketching the scenario drafts [This was in fact the method chosen for this study]	Determine a scenario framework by selecting two uncertainties that are causally independent over the chosen time horizon. Selection criteria: Best support for intended reframing. These two mutually independent uncertainties are then turned into dimensions with contrasting end points (e.g. high-low climate change; strong-weak governmental regulation). This creates a 2x2 matrix that defines four possible conditions.
Inductive method Defining and sketching the scenario drafts	Uncertainties are put together to sketch a large number of scenarios (often over a dozen) that are designed to challenge the current framing and to bring forth possible alternatives that manifest challenging and useful framings. Then a small set of 2-4 draft scenarios is selected; they are chosen to contrast not only with the current framing but also with each other. An optional framework can then be created to compare the scenarios.
Abductive method Defining and sketching the scenario drafts	Repeated alternations of the two approaches above.
Developing the scenario set and each scenario	Using inputs, values and beliefs from a wide range of stakeholders.
Translating and transplanting the scenarios	Interpreting what a global scenario means for a particular set of learners, or a specific context, such as players in a particular place on the value chain.
Embedding the scenarios to enhance their reframing effectiveness.	For example, making scenarios and interpretations a regular feature of internal planning and communication – and in certain cases, shared through external communication with major stakeholders.
Sustaining scenario planning capabilities	For best value and impact, scenarios should be continually questioned, adjusted and put to the test. Their value to the organization should be assessed and measures taken to optimize.

APPENDIX C – The Deductive Method

Key points of the deductive method:

- It aims to first develop an overall structure in the data to be used as a framework for deciding the set of scenarios to be developed.
- It specifies the scenarios in the set, in terms of scoping outcomes of a few (two or three) critical uncertainties, selected as scenario dimensions (sometimes called end-states: states-of-affairs in the horizon year, described in terms of the scenario dimensions).
- Scenarios can then be filled in with available data and supplemented with new data as required.

Choice for critical uncertainty dimensions based on "highest impact" and "least predictability" on the strategic context that needs to be reframed – in this case, the development of the dairy industry.

These four scenarios should have sharply contrasting futures:

- The baseline, business-as-usual, world-as-it-is scenario
- The scenario where one driver alone dominates
- The scenario where the second driver dominates
- One with both drivers present. These drivers are the different directions in which a critical uncertainty may play out.

Each scenario provides a different answer to key decisions. Each answer presents a myriad of implications that fundamentally change the business environment for dairy industry players. Figure 3

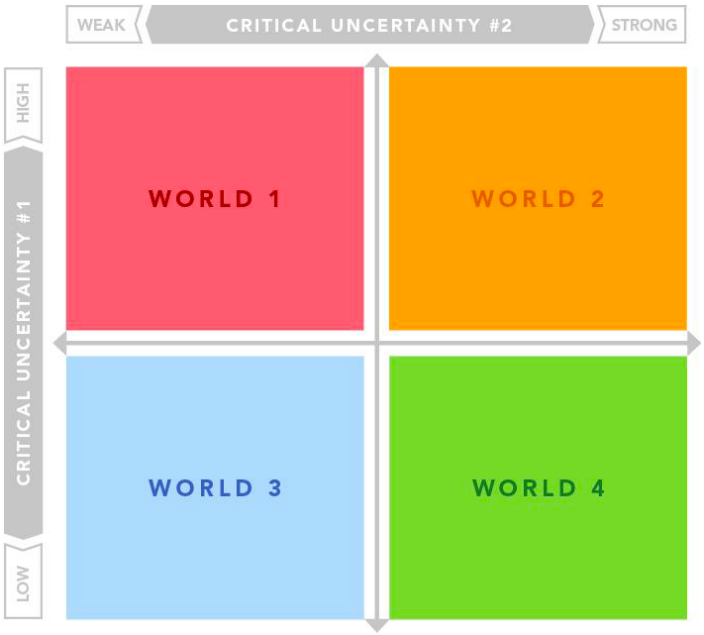


Figure 3 The deductive scenario approach results in a scenario matrix

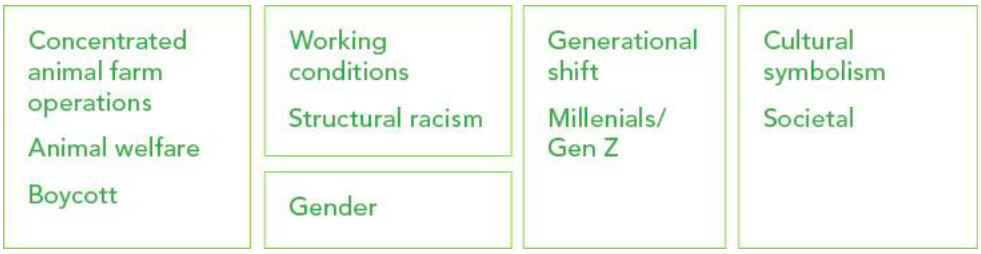
APPENDIX D – Deriving 12 Thematic Clusters from 124 Micro Factors

We were able to identify 124 micro factors within the three topics – food technology, environmental sustainability, and e-commerce. We then clustered these micro factors into higher-order groups. Our limited set of 12 clusters thus each contained a set of elements that could be clearly distinguished from the elements of the other clusters. Below we show the full set of clusters, followed by the contents of each one.

Thematic Cluster Creation:

Dairy Politics:

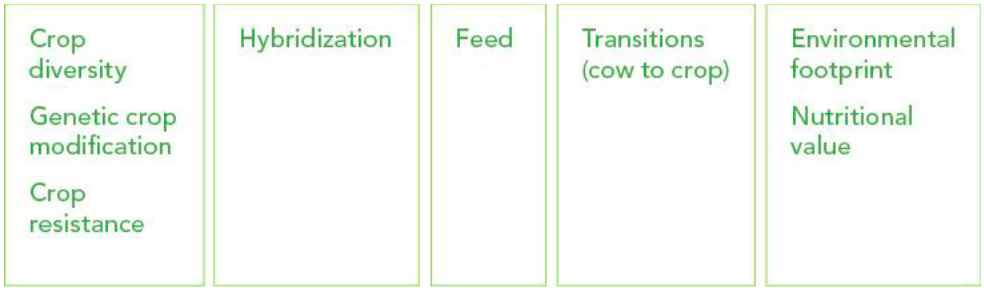
Dairy Ethics:



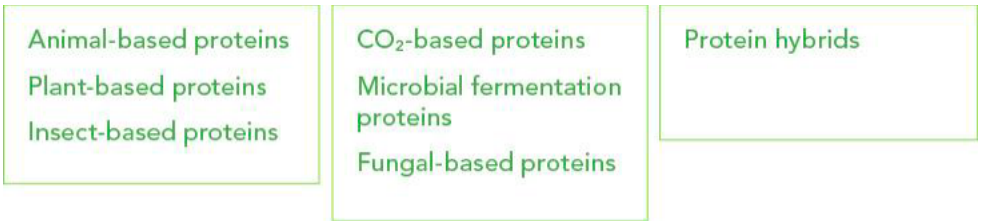
Artisanal Organic Farming:

Eco Anxiety:

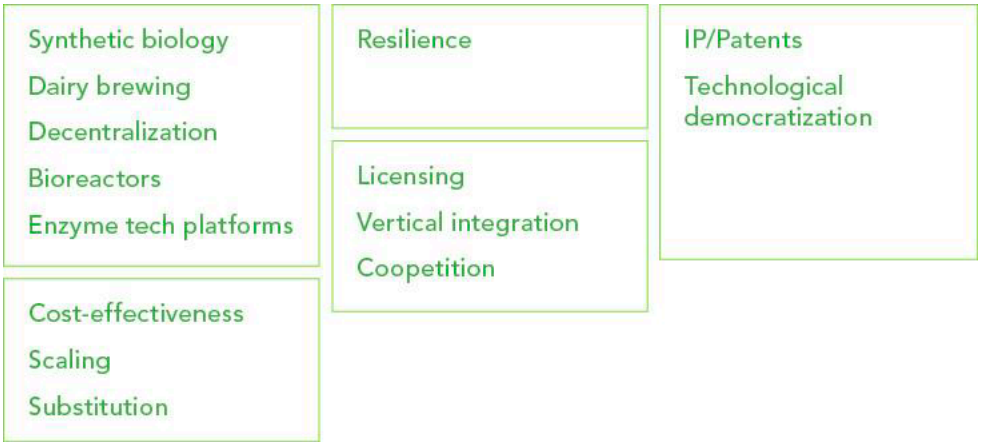
Plant-Based Fermentation:



Protein Shifts:



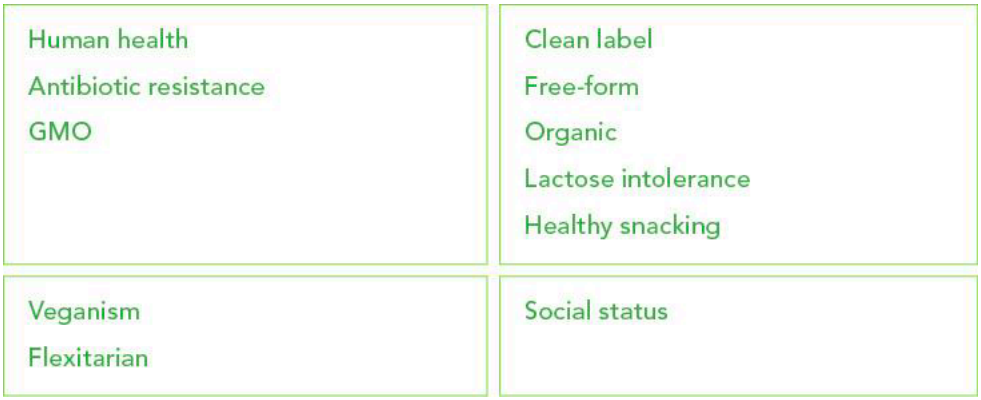
Fermentation Factories:



Dairy Transparency:

Nutritional Sustainability:

Health Fixation:



Personalized Nutrition:

REFERENCES

FAIRR 2016. Factory farming: assessing investment risks https://www.fairr.org/article/factory-farming-assessing-investment-risks/

FAO and GDP 2019. Climate change and the global dairy cattle sector – The role of the dairy sector in a low-carbon future. Rome. 36 pp. Licence: CC BY-NC-SA- 3.0 IGO

IPPC 2019. Intergovernmental Panel on Climate Change. Climate Change and Land. https://www.ipcc.ch/report/SRCCL/

Kolb, D.A. 1984, Experiential Learning: Experience as the Source of Learning and Development, Englewood Cliffs, N.J.: Prentice-Hall.

Porter, M. "How Competitive Forces Shape Strategy", Harvard Business Review, March 1979

Ramirez, R. & Wilkinson, A. 2016. Strategic reframing: The Oxford scenario planning approach. Oxford University Press.

Searchinger, T., Waite, R., Hanson, C., Ranganathan, J., Dumas, P., & Matthews, E. 2019. Creating a sustainable food future: a menu of solutions to feed nearly 10 billion people by 2050. World Resources Institute.

United Nations 2019a. Department of Economic and Social Affairs, Population Division. World Population Prospects 2019: Highlights (ST/ESA/SER.A/423).

United Nations 2019b. Department of Economic and Social Affairs, Population Division. World Urbanization Prospects 2018: Highlights (ST/ESA/SER.A/421).

United Nations 2019c. The climate emergency and the next generation.

https://www.un.org/sg/en/content/sg/articles/2019-03-15/the-climate-emergency-and-the-next-generation

Van der Heijden, K. 2011. Scenarios: the art of strategic conversation. John Wiley & Sons.

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S. Garnett T., Tilman D., DeClerck F., Wood A., Jonell M., Clark M., Gordon LJ., Fanzo J., Hawkes C., Zurayk R., Rivera J.A., De Vries W., Majele Sibanda L., Afshin A., Chaudhary A., Herrero M., Agustina R., Branca F., Lartey A., Fan S., Crona B., Fox E., Bignet V., Troell M., Lindahl T., Singh S., Cornell S.E., Srinath Reddy K., Narain S., Nishtar S., & Murray C.J.L. 2019. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. The Lancet, 393(10170), 447-492.