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WHITE PAPER

A design framework for sustainable, commercially-sound consumer packaged goods

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Improving the environmental sustainability of formulated consumer packaged goods (CPG) is complex. It requires analysis and potential overhaul across the entire product lifecycle, from ingredients and their raw materials to formulations, manufacturing processes, distribution, consumption, and disposal. However, it doesn't have to necessitate an entirely new system or come at an insurmountable cost. This white paper offers a practical framework to help you design and develop sustainable ingredients or formulations that deliver commercial benefits.

With sustainability now a focal point of CPG business strategy, formulations are under the spotlight. This will intensify as requirements linked to the EU Chemicals Strategy for Sustainability 'safe and sustainable by design' ethos and the US Environmental Protection Agency (EPA) '12 principles of green chemistry' gain momentum.

It's also increasingly clear that the creation of sustainable products is a solid business decision. While the financial costs of sustainable innovation do require consideration, we are rapidly approaching a time where products will only be commercially viable if they are sustainable. A recent study undertaken by McKinsey and NielsenIQ reveals that products making Environmental, Social and Governance (ESG) related claims averaged 28 percent cumulative growth over the past five years. This compares to 20 percent for products that made no such claims.[1]

Here, we look at sustainable design in the cosmetics, personal care, and home hygiene categories. The value chain for these products is long and intricate, with many interdependent and interconnecting elements. It's hard to obtain a balanced, holistic perspective and harder still to make tangible, sweeping improvements to sustainability. Historically, packaging has dominated the sustainability agenda for these goods, but it's only one part of the equation. The entire value chain must be analysed, from raw materials and ingredients to production, consumption, and end-of-life processes.

In this white paper we describe a framework for the sustainable design and development of formulated products and the ingredients they contain.

Managing cost and creating value

Many organisations resist changing their R&D methods to incorporate sustainability. There is a view that sustainable design will compromise performance or cost, or both. However, there can be great synergy between serving consumer needs and innovating sustainably. Tactical innovators can identify and leverage these synergies from the ideation and value proposition development stage onwards.

Cost management must be included in the process, with trade-offs between value and costs carefully considered. Nevertheless, there needs to be a consistent focus on improving (or at least maintaining) the consumer journey to avoid any detrimental impact on the final product perception.

Alignment with overall organisational strategy and long-term planning is another important consideration. Being ahead of the game with a sustainable CPG portfolio that enables delivery of ESG goals unlocks competitive advantage and fosters a successful market position. Lastly, sustainable products are becoming more important to consumers. Until recently, a performing product and brand identity were enough. Now, consumers are demanding more transparency. This applies not just to the mode of action of a product or ingredient but also how it is sourced and produced.

Managing conflict in sustainable design

Sustainability is not a binary issue, it's fraught with grey areas and nuance. So, sustainable CPG development inevitably involves compromise. Trade-offs need to be identified carefully, managed strategically, then communicated clearly. One aspect of this is avoiding the tendency for a single sustainability theme to monopolise attention and resource. As Figure 1 illustrates, a single-issue approach risks solving one problem while ignoring others which may be causing greater harm elsewhere. For instance, replacing a petrochemical-derived ingredient with a natural alternative might appear to be a sustainable move, but the natural ingredient's production may have repercussions for biodiversity or water stewardship. So how can you determine the most sustainable option?

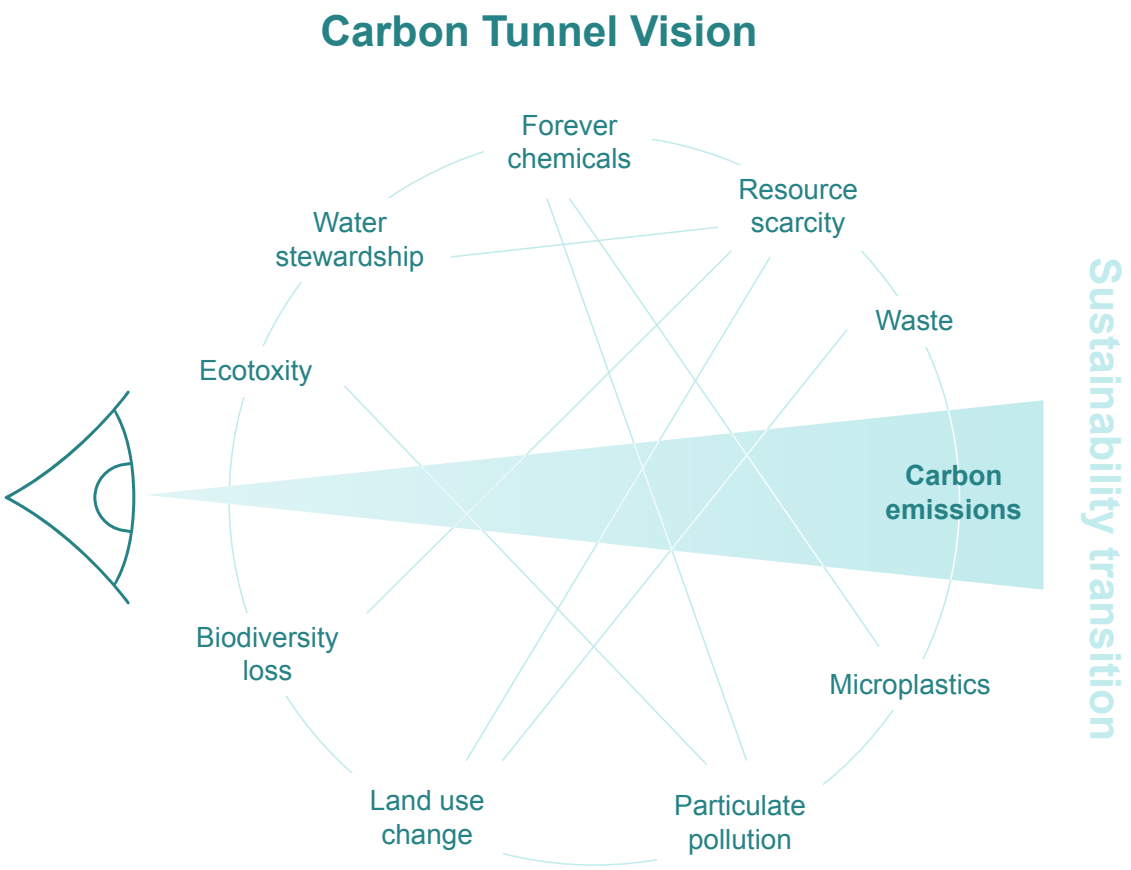


Figure 1: Carbon Tunnel Vision (adapted from a graphic designed by Dr Jan Konietzko[2])

To help navigate this complex territory, Sagentia Innovation has developed a framework for critical evaluation and decision-making processes (summarised in Figure 2). Sustainable value creation is supported by three pillars: product performance, ingredient science, and regulatory strategy. Together the pillars facilitate a pragmatic approach that makes best use of the available data, science, and technologies. There can be a great deal of tension between the three areas, and interactions between them may be complicated. However, managing this conflict in a productive way can generate commercially viable sustainable products which satisfy consumer needs.

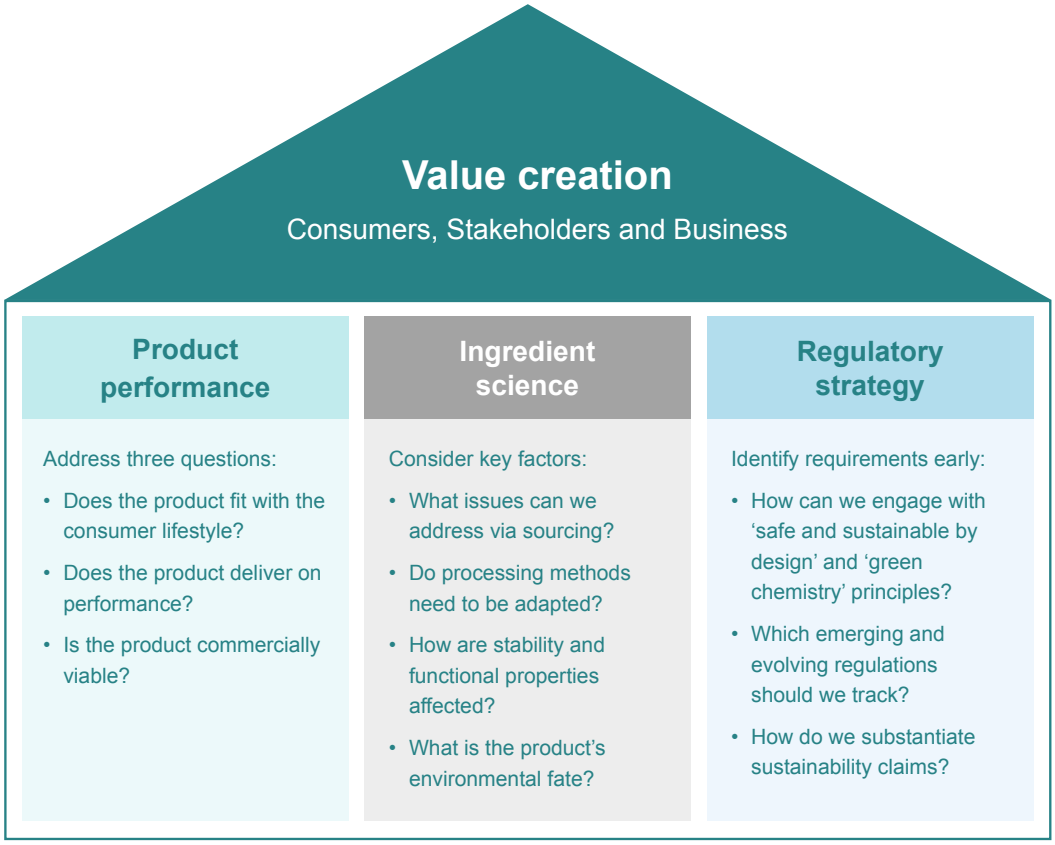


Figure 2: A design framework for sustainable value creation.

Product performance

Balancing sustainability with usability and efficacy

Much research has been done to profile what eco-conscious consumers want, what they care about, and how much they're willing to spend on products with better sustainability credentials. However, there can be a significant disconnect between how people intend to act and how they behave. Home and personal care formulations need to deliver a good experience, fit with consumer lifestyle, and come at an acceptable price point. Achieving all this while improving on sustainability is quite the balancing act. Three key questions should be addressed at the front-end innovation point to help ensure sustainable products are fit for purpose.

Does the product fit with the consumer lifestyle?

Some sustainable product ideas may be disruptive, changing the way consumers interact with them or perform an everyday task. That's OK, but any change must be easy to adopt. This applies to the way the product is used, and how it is stored, dispensed, and disposed of.

An example widely adopted in recent years is the use of refillable packaging to avoid single use. This is often encouraged via a price saving which is well received by the consumer. However, if refilling requires a trip to specialist stores it may be inconvenient. Concentrated products for personal care and hygiene applications make refilling easier, but reconstitution must be simple as it involves an additional step for consumers. This can be achieved using tablets (such as Dazz or Smol) or concentrated liquids (such as Cif from Unilever).

Evaluation at point of use plays a critical role in the development of sustainable solutions. This encompasses any additional elements required for consumers to activate or use the product.

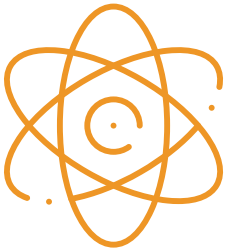
Aspects of consumer use that typically have the greatest bearing on sustainability are energy and water. Innovating to reduce the temperature that clothes are washed at, or the amount of water needed to rinse shampoo, can make a significant difference to factors such as scope 3 carbon emissions and water stewardship. However, this links back to the above points. If the changes reduce convenience or consumers associate the enabling factors with efficacy, they may not feel satisfied with the product.

Does the product deliver on performance?

Whether it's shampoo and skincare products or floor cleaner and dishwasher detergent, consumers have standards that products need to meet. Defining what good looks like, and identifying where compromise may be acceptable, is a useful exercise.

In some use cases, sensory experience holds a near equal weighting to efficacy. Understanding this can help shape design decisions, resulting in products that continue to delight consumers even if certain performance factors must be conceded due to a change of ingredients or formulation.

Take sodium lauryl sulphate, a common surfactant that helps remove oil and dirt from hair, skin, clothes, or surfaces. It's often manufactured from palm oil or petroleum, which can pose sustainability concerns, and it can also be an irritant for some people. However, consumers tend to associate the lather it creates with cleanliness. It may be necessary to find alternative sensorial means to indicate effectiveness, or to educate consumers that a product can perform well without a foamy lather.



Ingredient choices are the cornerstone of sustainable CPG design, and decision-making must be supported with scientific validation.

Is the product (or product mix) commercially viable?

Sustainable design might create additional costs from a materials and supply chain perspective. But it could also unlock new avenues that lead to economies of scale or alternative business models. Ventures rooted in emerging sustainability requirements pose great opportunity. An ingredient manufacturer might look at the commercial prospects of upcycled waste materials, while a premium skincare brand might explore an omnichannel at-home testing model for semi-personalised formulations.

Finding ways to achieve effective interaction and balance between cost, performance, and sustainable design is important too. The consumer experience doesn't have to be the same as it's always been, but it does still have to deliver on performance. Consumers might well buy a single-use, biodegradable, all natural and slightly more expensive shampoo capsule due to its novelty and green credentials. However, if it doesn't clean the hair as well as a classic shampoo they will soon return to traditional bottled versions. Sustainable design needs to add to the consumer experience, not detract from it.

Ingredient science

Understanding the implications of ingredient changes

Ingredient choices are the cornerstone of sustainable CPG design, and decision-making must be supported with scientific validation.

An objective approach to ingredient selection ensures products meet consumer needs while improving on sustainability. Natural and synthetic ingredients alike must be subject to a thorough evaluation that encompasses sourcing, processing, stability, functional properties, and environmental fate. This can be complicated by the fact that some sustainability properties conflict with each other. What is good for water consumption is not necessarily good for carbon footprint and vice versa. Many factors have to be accounted for and informed decision-making requires consideration of the full lifecycle of the ingredient. There is no place for generalised assumptions about ingredients' sustainability properties.

What issues can we address via sourcing?

Ingredients don't fall neatly into 'natural' and 'synthetic' categories. There's a spectrum encompassing natural extracts, natural but modified, nature-identical, biosynthetic, and synthetic ingredients. Any ingredient can present sustainability benefits and concerns. It's too simplistic to label natural as good and synthetic as bad.

Detailed evaluation of synthetic ingredients involves looking at their building blocks, the energy and water used in their formation, and whether they are readily available. In some cases, it may be possible to synthesise an ingredient using more sustainable processes. Croda made a significant development in this vein with a process to manufacture ethylene oxide, a precursor for a range of ethoxylate surfactants, from bio-derived ethanol rather than ethylene[4]. Switching to renewable, plant-based raw materials for widely used surfactants was hailed as a 'milestone in renewable manufacturing'.

To evaluate the sourcing of natural ingredients, it's useful to calculate how much resource is needed to produce a defined quantity. Producing 0.5kg of lavender oil requires around 110kg of the raw material whereas the same amount of rose oil requires around 4,500kg[5]. With plant-derived ingredients, it's important to understand the space and water requirements for cultivation, use of herbicides and pesticides, and the impact all these factors have on the environment and biodiversity. Consider wastage too, looking at the percentage of the raw material used, whether more can be incorporated, or whether waste might be used for a different purpose or in an adjacent industry.

Do processing methods need to be adapted?

Converting any raw material, synthetic or natural, into a functional ingredient involves various processes which usually require energy and often require water. With synthetic ingredients, including those that are nature-identical, it's also important to build an understanding of any processing materials or solvents used, and to establish how they are sourced.

Natural ingredients often require multiple processing steps which may include filtration, extraction, drying, distillation, pressing, milling, lyophilising, or sieving. Again, any additional resources used in these processes must be considered to establish the overall impact on sustainability.

How are stability and functional properties affected?

Benefits associated with synthetic ingredients include high levels of stability, reliable performance, and long shelf-life. Natural ingredients can be more challenging from a technical perspective, presenting limitations in stability, functionality, and aesthetics.

When deliberating between ingredients, consider the fundamental physiochemical properties and molecular interactions within your base formulation.

What is the product's environmental fate?

The impact of home and personal care products extends beyond their use. Ingredients frequently enter our wastewater and can be found in rivers and seas. Environmental harm is a key consideration, complicated by the fact that we are discovering more about ingredients previously thought benign. Intentionally added microplastics are already being phased out in Europe and per- and polyfluoroalkyl substances (PFAS) are now in the spotlight.

The ability of a formulation to biodegrade, and the speed at which it happens, is a central consideration of sustainable design. On the face of it, naturally sourced ingredients would appear to have the advantage here. However, naturally sourced can mean many things: natural extracts are likely to biodegrade but modified natural ingredients may not. The situation becomes more even complex when naturally sourced ingredients are blended into a formulation and layered with synthetic ingredients. Clarity is needed on the biodegradability of full formulations, including the conditions and timeline under which biodegradation is achieved.

A matrix for ingredient assessment

Our ingredient assessment matrix (Figure 4) outlines factors to consider when interrogating ingredients' sustainability credentials.

	Factors to consider	
Sourcing 	• Water use throughout production (including irrigation of plant-based ingredients). • Environmental impact of production (pesticide/fertiliser use or wastewater from production or extraction of petrochemicals). • Raw material purity (e.g. heavy metal contamination).	• Local community impacts. • Pre-production requirements (e.g. water, energy, solvents). • Wastage and potential re-use or upcycling. • Consistency of supply. • Raw material costs. • Availability of alternatives.
Processing 	• Complexity of processing, the number of steps involved. • Energy use during processing. • Water use during processing. • Processing aids (e.g. additional ingredients which may bring their own sustainability considerations).	• Likelihood of process contamination. • Safety considerations (e.g. for irritant or sensitising ingredients).
Product stability 	• Requirements for formulation stability (e.g. preservatives). • Availability / effectiveness of sustainable stabilisers.	• Physiochemical properties of all ingredients.
Functional properties 	• Ingredients' ability to facilitate functional performance. • Consumer expectations surrounding physical and rheological properties. • Potential to achieve functional properties at lower concentrations.	• Potential to achieve functional performance under low energy use conditions (e.g. 20°C wash for laundry detergent). • Consumer acceptance of deviations from existing product performance or aesthetics.
Environmental fate 	• Negative environmental impacts when present in wastewater. • Potential for build-up when released into the environment. • Biodegradability, and biodegradation timeline and conditions (e.g. land, water treatment, freshwater, marine water, temperature).	• Residue from biodegradation. • Product removal (e.g. rinsed with water or removed with a wipe). • Impacts on the recyclability of packaging.

Figure 4: Sagentia Innovation's matrix for ingredient assessment

Building a sustainable product chassis: spotlight on laundry detergent

A product's major ingredients can be likened to a chassis, providing a structural framework for factors like stability, functionality, and performance. Sustainable design should innovate around these ingredients. Let's take laundry detergent as an example:

Unconcentrated formats (powder and liquid)

Powdered laundry detergent is largely made up of filler. Sodium sulphate is commonly used since it modifies and alters the powder's physical properties. Similarly non-concentrated liquid laundry detergent is largely water. More concentrated solid and liquid formats enable lower volume and weight and benefit carbon emissions in transport. Alternatively, it may be possible to replace fillers with an ingredient that benefits the washing machine, drains, or wastewater system.

Concentrated Liquid format

Concentrated liquid formulations and pods can reduce the water content to 15-50 percent. Ultra-concentrated polyvinyl alcohol (PVOH) capsules can further reduce water content. Analysis of existing and potential dewatering technologies could determine whether both water reduction and energy efficiency can be improved. Food and beverage applications might provide inspiration, e.g., membrane technology used in the concentration of juice and beer.

Tablets

Tablets reduce the need for a solid filler and are compact for easier storage and transport. A tablet format can allow incompatible ingredients to be separated into different layers but needs to dissolve readily, including at lower temperatures.

Detergent sheets

While the weight and water concentration of detergent sheets is low, a lot of water is needed to dissolve the PVOH used to make them. What's more, the drying process involves a high level of energy. Sustainable design might consider ways to avoid the need for high temperatures and reduce the water required, or discover better alternatives to PVOH.

Cold wash formulations

Much of the energy associated with laundry products come from the use phase so enabling lower impact during use is an important aspect of design. There has been much innovation in cold wash formulation, delivering the same performance on stain removal but at 30 degrees.

Regulatory strategy

Rapid change at a global level, combined with lack of harmony, creates a challenging environment for industry. Think very carefully about how your business adapts to the requirements of different markets. Harness regulatory insights, along with expert analysis and interpretation of requirements, at an early stage to inform the design process.

Navigating volatile and inconsistent global regulations

The regulatory landscape for sustainability is developing fast, bringing implications for products and their ingredients. Evolving, and often conflicting, regulatory requirements are at play in most supply chains. Various frameworks are also under development within government bodies and industry groups. The UN Environment Program is developing a green and sustainable chemistry framework which could provide a central pillar of chemicals regulation or good practice. The European Union (EU) is also proactive on this matter.

How can we engage with 'safe and sustainable by design' and 'green chemistry' principles?

The European Commission's safe and sustainable by design framework seeks to make a profound impact on the composition of products sold in the region. It aims to encourage commercialisation of new chemicals, optimisation or redesign of production processes, and reconsideration of existing substances. The Commission describes the concept as a holistic approach integrating "safety, circularity, energy efficiency and functionality of chemicals, materials, products, and processes throughout their life cycle and minimising the environmental footprint." Meanwhile, in the US, green and sustainable chemistry is the core focus. An example of engagement with this is Walmart's Sustainable Chemistry Commitment, embracing the 12 principles of green chemistry and laying out what is expected from suppliers.

Which emerging and evolving requirements should we track?

The road to safer, cleaner, more sustainable products relies on good information about the impact of those products and their constituents on human health and the environment. This is a potential minefield, requiring extensive knowledge across hundreds or even thousands of substances and processes, as well as tools to synthesise the data.

Use of some substances has been declining for years, often due to the introduction of regulations restricting their use. However, new matters can surface with little forewarning, requiring urgent attention.

Plastics pollution is one such area. Whilst concern has been building for some time, recent regulations encouraging reuse are accelerating change, forcing innovation and the need for engagement. Regulatory restriction on intentionally added microplastics is affecting many home and personal care products. In the EU there's a timeline for the removal of these ingredients which can cover a wide range of functions such as opacification, rheology modification and emulsification.

Another critical area of focus is PFAS, so-called 'forever chemicals', used in numerous applications and technologies across sectors. A new EU restriction for some PFAS types is imminent, and while requirements haven't yet been fully defined, they need to be considered in product design.

Sagentia Innovation's sister company TSG Consulting published an insight piece on this matter, Forever chemicals: how to get ready for the new PFAS restrictions[6]. It suggests analysing existing PFAS regulations to understand how the new requirements might manifest.

How do we substantiate sustainability claims?

In addition to regulations that impact ingredients, CPG companies need to be aware of restrictions and requirements related to environmental claims. This is a volatile area, with authorities mounting efforts to address greenwashing and check the authenticity of claims. In March 2023, the European Commission adopted a proposal for a Directive on Green Claims to address greenwashing and protect and empower consumers[7]. The UK's Competition and Markets Authority (CMA) has also announced its intention to scrutinise household products for potential greenwashing and is already enforcing its Green Claims Code[8]. Meanwhile, in the US, 'Green Guides' for the use of environmental marketing claims are being updated to help companies avoid misleading statements.

It's advisable to document the rationale for sustainability-led design decisions and make certain that claims can be fully substantiated. This can also be advantageous when it comes to involvement in certification programmes like the US Environmental Protection Agency (EPA) Design for the Environment initiative.

What about sustainable packaging?

Packaging strategies need to look at the circular economy to consider the reduction of materials, the source of materials, reuse models and recycling. The role of packaging in the protection and preservation of sustainable products (which may have different requirements to their predecessors) also requires attention. We've published a separate white paper on the evolution of packaging, available for download on our website[9]

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Summary: applying the sustainable design framework

Some business leaders remain reluctant. They fear sustainable design will involve an overhaul of R&D processes, compromise product performance and/or cost, and negatively impact brand equity. But this does not have to be the case. In a CPG context, the objective of sustainable design is to find and address synergies to deliver on cost, performance and sustainability.

Sustainable design and development is becoming fundamental to value creation (see Figure 5). Evaluating and managing tensions between product performance, ingredient science, and regulatory strategy is a critical success factor for CPG companies and ingredient manufacturers. A tactical approach can resolve friction and ensure strategies are modified to deliver maximum commercial benefits, for instance via new business models or product portfolios.

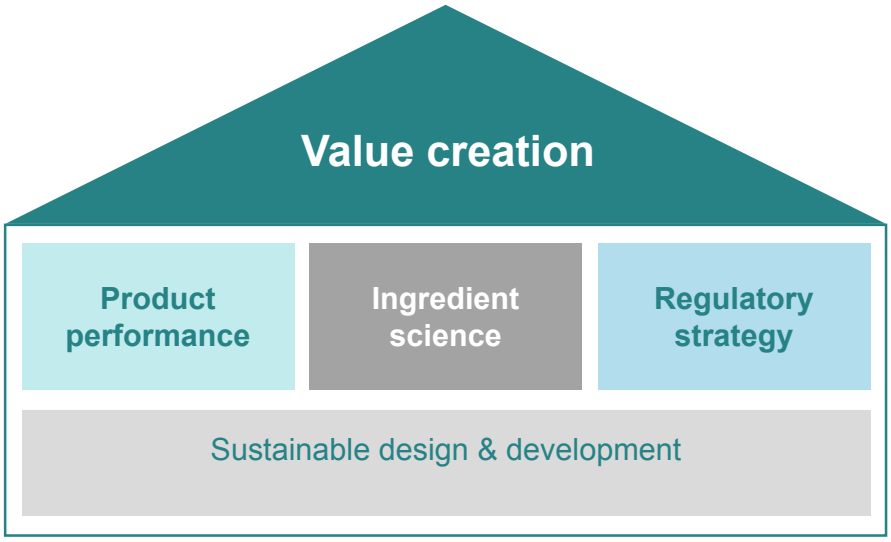

Figure 5: Three pillars of sustainable design and development underpin value creation.

This is not a linear process. It requires ongoing attention as sustainability parameters often conflict and may evolve due to wider changes such as regulatory developments. Ingredient manufacturers and CPG companies need to strive for the best possible outcomes, while acknowledging that there are no perfect solutions. Ongoing appraisal of the framework pillars will help drive effective, commercially viable progress by identifying and leveraging new opportunities for value creation.

Sustainable design can and should fit with systems and processes that are already in place.

Asking the right questions from the start, then focusing on synergies between consumer needs and sustainable innovation, delivers value to consumers, stakeholders, and the business. This is the key to commercial success for CPG in the sustainable age.

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Sagentia Innovation provides independent advisory and leading-edge product development services focused on science and technology initiatives. Working across industrial, chemical, energy, food and beverage, and consumer markets, Sagentia Innovation works with start-up disruptors through to world leading brands to extract maximum value from R&D and innovation investments.

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