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<<Material Scarcity Toward 2040 and the need for Circular products White Paper>>

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1. Introduction

This paper examines material scarcity risks toward 2040 across food, beverage, packaging, construction, textiles, electronics, and agriculture. It also documents real-world product and system examples achieving 80–100% circularity through reuse, remanufacturing, and closed-loop models highlining the need for taking immediate actions towards more circular products in all sectors

This paper provides:

- **A sector-by-sector brief reference to material scarcity risks toward 2040**
- **Quantitative scarcity drivers across food, packaging, construction, textiles, electronics, and water systems**
- **A catalogue of current circular products and systems achieving 80–100% material reuse or recovery**

Material scarcity refers to structural constraints in accessing materials at scale due to demand growth, ecological limits, long supply lead times, and geopolitical concentration. By 2040, scarcity pressures will extend beyond critical minerals into packaging, food systems, construction, and water resources

2. Trends in key Sectors

Industrial and Critical Materials Scarcity

The International Energy Agency projects that demand for key energy transition minerals will rise sharply by 2040. Lithium demand is expected to grow approximately fivefold, while graphite and nickel demand will double under stated policy scenarios . Copper demand is projected to increase by roughly 30%, yet supply constraints may create a deficit of up to 10 million tonnes by 2040

Energy-Transition Materials

Critical minerals are central to electrification, renewable energy, digital infrastructure, and transport. The International Energy Agency projects that by 2040 lithium demand will increase around fivefold, graphite and nickel demand will approximately double, and copper demand will rise by at least 30%. Copper faces particular risk, with potential supply deficits approaching 10 million tonnes by 2040 if new mining capacity does not scale sufficiently . Long development timelines, often exceeding 15 years from discovery to production, constrain supply response.

Packaging and Consumer Goods Materials

Packaging represents one of the fastest-growing material uses globally. Plastics account for roughly 40% of total plastic demand, and global production could double by 2040 under current trends . Paper and cardboard demand is projected to grow approximately 30%, constrained by forest availability and fiber degradation after repeated recycling cycles. Aluminum and glass are highly recyclable but face energy-related scarcity due to their dependence on high-temperature processing and stable power supply.

Food, Agriculture, and Biological Resources

Food systems are among the most material-intensive sectors, consuming land, water, nutrients, and biomass. Agriculture accounts for around 70% of global freshwater withdrawals. Phosphorus, an essential and non-substitutable nutrient, is expected to see demand growth of 30–40% by 2040, with reserves concentrated in a limited number of regions. Soil degradation affects approximately one-third of global agricultural land, reducing productivity and resilience

Construction, Infrastructure, and Urban Systems

The construction sector consumes nearly half of all extracted materials globally. Scarcity risks are particularly acute for cement, steel, copper, aluminum, and sand. Global sand demand exceeds 40 billion tonnes per year, with shortages of construction-grade sand emerging in multiple regions. Once embedded in buildings and infrastructure, materials are locked in for decades, amplifying the long-term impact of inefficient design and linear consumption models.

Textiles, Electronics, and Other Sectors

Textiles face scarcity risks linked to water-intensive cotton production, fossil-based synthetic fibers, and low recycling rates. Global textile fiber demand is projected to increase by 25–30% by 2040. Electronics and electrical equipment rely on copper, aluminum, plastics, and rare earth elements, yet global e-waste recycling rates remain below 20%. Increasing product complexity further constrains material recovery.

3. Examples of Circular Products and Systems

The biggest near term wins for “80% reused material” typically come from remanufacturing and reuse, not from recycling alone. Recycling often faces collection, contamination, and yield losses. Remanufacturing preserves embodied material at high rates, because much of the product mass is kept intact.

The most defensible " reused materials" examples are products where the business model is literally built around reusing the physical core: cartridges, retread tires, remanufactured machines, remanufactured industrial components.

Example 1 : Remanufactured toner cartridges (often 90% reused)

Xerox documentation states remanufactured cartridges contain an average of 90% reused or recycled parts. That comfortably clears an 80% threshold.

Why it matters for scarcity:

- Cartridges are plastics and engineered components that would otherwise be discarded
- The model is scalable because it is tied to reverse logistics and take back programs

Example 2 : Remanufactured office devices (70 to 90% reused by weight, commonly above 80%)

A print industry analysis describing Xerox's approach reports reuse of 70 to 90% of machine components by weight in remanufacturing. The upper part of that range exceeds 80%, so you can cite it as a proven route to 80% reused materials when programs are mature and designs support disassembly.

Why it matters:

- High complexity products concentrate many materials, including metals and plastics
- Reusing large subassemblies avoids both material extraction and precision manufacturing impacts

Example 3 : Retread truck and bus tires (about 90% of material preserved)

Retread tires are a classic example of circularity where the casing is reused and only the tread is replaced. A summary description of retreading notes that about 90% of the original tire by weight is retained.

Examples from other sectors include :

Food and Beverage:

- Refillable glass bottles reused 20–50 times, achieving over 90% material reuse
- Stainless steel beverage kegs with 30+ year lifespans retain over 95% material value.

- Reusable produce crates designed for 100+ cycles retain over 95% of material by weight.

Packaging and Industry:
- Industrial IBC containers and drums reused dozens of times, exceeding 90% circularity.
- Remanufactured printers and machinery reuse 80–90% of original components (Xerox, 2023).

Construction:
- Reclaimed structural steel retains over 90% material value.
- Modular building components designed for disassembly achieve 80–95% reuse.

4. Strategic Implications and next steps

Material scarcity will increasingly influence pricing, supply security, ESG performance, and regulatory compliance. Circular economy models provide a critical mitigation pathway by reducing dependence on primary material extraction while increasing resilience.

Circularity reduces scarcity by lowering primary demand and by decreasing exposure to mining and refining bottlenecks.

There are three "circularity pathways" that matter most for 2040:

1. **Life extension: repair, upgrade, maintenance, modular replacement**
2. **Reuse and remanufacturing: keep product shells and components in service across multiple lifecycles**
3. **High yield recycling: recover metals and materials at end of life and feed them back into manufacturing**

5. The Solution

Material scarcity by 2040 is no longer a distant or theoretical concern. It is a **structural reality** shaping costs, availability, and resilience across food systems, packaging, construction, textiles, electronics, and infrastructure. The facts and examples presented in this paper shows that scarcity is driven not only by physical resource limits, but by slow supply expansion, energy constraints, geopolitical concentration, declining material quality, and increasing competition across sectors.

Crucially, scarcity will not affect all organizations equally. Companies and sectors that remain dependent on **linear, virgin-material-intensive models** will face higher price volatility, supply disruptions, regulatory exposure, and reputational risk. By contrast, those that redesign products and systems around **reuse, remanufacturing, and closed-loop circulation** can significantly reduce their exposure to material constraints.

The examples documented across food, beverage, packaging, logistics, construction, and industry demonstrate that **80–100% circularity range is already achievable** where products are designed for durability, standardization, and return.

From a strategic perspective, material scarcity should therefore be treated as:

- A **financial risk**, affecting input costs and margins
- A **supply-chain risk**, affecting continuity and reliability
- A **regulatory risk**
- And increasingly, a **competitive differentiator**

The most effective response is not incremental recycling alone, but **high-circularity business models and strategies** . This includes:

- Assessing the circularity of all products against standardized criteria and frameworks (e.g CSE's Product Circularity Rating and Assurance)
- Designing products for disassembly and multiple life cycles
- Embedding material scarcity into Sustainability, and enterprise risk frameworks and policies

By 2040, access to materials will increasingly determine who can grow, who can comply, and who can remain resilient. Organizations that act early to decouple value creation from virgin material use will not only reduce environmental impact, but also gain **cost stability, supply security, and strategic flexibility** in an increasingly resource-constrained global economy.

References

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