



Biomimicking nature for the creation of sustainable supply chains

A practical business guide

Munich, December 2020

SustainNet
CONSULTING

Executive Summary

Our global context is characterized by a VUCA (volatile, uncertain, complex, ambiguous) environment. Challenges that organizations are facing include climate change, political instability, resource depletion, biodiversity loss, rising social inequalities and conflicts as well as the current COVID-19 pandemic. Many of these issues are a consequence of human activities. Hence, mankind needs to seek for new ways of creating sustainable, resilient and regenerative business operations. But while businesses will need to play a vital role in innovating and scaling new solutions, they often face difficulties in knowing where and how to start.

In order to ignite new ideas and concepts for a sustainable future, businesses should look at how nature serves as paradigm ("biomimicking"). The following **10 lessons from nature** can support organizations **to create more sustainable supply chains**.

1. Ground work – analyzing the basis



Strong networks depend on strong foundations, and no matter where on Earth we live, that foundation is based on soil. Healthy soil is based on a huge number of interactions of life between covering plants and microorganisms, which work together in symbiosis. Healthy soil has the power to absorb CO₂, store water, and grow more and better food. Similarly, to unlock the power of sustainability in organizations, we need to analyze their foundation, the diversity of stakeholders involved and their operations' impact on economic, ecologic and social matters.

2. Values – more than the seeds for growth



In nature, value is generated and continuously reproduced through the collaboration of a diverse set of living beings. Our conventional business view of value is however constrained, as it does neither regard the implications of the business operations for its various stakeholders, nor the fact that resources are exhaustible. A comprehensive approach for measuring value differs from the conventional approach by offering a multi-stakeholder perspective and by allowing to map destroyed and missed value along the value chain, thereby identifying new opportunities for value innovations.

3. Balance and circular design – closing the gap



The "nature of nature" is to reuse or repurpose everything in non-human ecosystems, working as a perfect circular economy. While compelling, the manmade world economy is only 8.6% circular today, and disregards huge value opportunities. In order to capture new opportunities for value, organizations should shift their business and operating models from resource consumption to regeneration. Circular approaches for product design and business models are mandatory for making that shift.

4. Innovation – about Green Swans and smart trees



To address the realities of climate change and other overrunning planetary boundaries, we must innovate our mind-sets, technologies, and business models. Nature has inspired mankind to many technological innovations. But it's not only distinct products or mechanisms that need to be innovated, but entire systems. Trees demonstrate how they have systemically innovated the way they transport water, a concept which goes beyond the individual mechanics behind. Similarly, businesses must acknowledge the limitations of incremental changes and recognize the need for more fundamental changes towards business models with "Green Swan" characteristics.

5. Diversity – strengths in differences



Diversity is considered a key determinant of resilience, recovery and adaptability, as well as transformability, innovativeness and collective intelligence. In nature, diversity is the norm, not the exception. Monocultures are unbalanced, vulnerable systems, while permacultures and mixed forests are more resilient and more value-adding. In business environments, the linkage between corporate employee diversity and company performance is well established, and is also valid with regard to supplier diversity. Beyond this corporate view, supply chains consist of a number of diverse internal and external stakeholder groups. This diversity opens up new opportunities for co-innovation and creates portfolios of vendors with different responses to disruptions.

6. Communication – basis for strong communities



Communication allows mankind to bond as communities, to transport (complex) information and to share fictions. In nature, not only animals but also other living beings such as trees communicate with each other. Trees communicate olfactory, optically and electrically, and they use different communication channels for transmitting their distinct messages. Similarly, greater communication facilitates the streamlining of stakeholders and processes along the supply chain. Sharing information builds up trust amongst supply chain partners, is a driver for collaboration and allows them to identify and respond to risks and changes in demand and supply.

7. Multi-tier value chains – integrating across boundaries



Nature depends on the aligned interaction between a multitude of different living beings. Our planet's water supply, for example, is largely dependent on an integrated system of forest ecosystems transporting water from the oceans to the far inland of the continents. In business environments, supply chain integration refers to how aligned processes and activities are across the value chain, both within and between organizations. A common recognition is, that “the whole is greater than the sum of the parts”. The aim of supply chain integration is to drive efficiencies and customer value, eliminate waste and ultimately achieve a common business objective. To achieve this goal, an integrative perspective on performance management and relationship management is required.

8. Managing risk – early warning, joint mitigation



While animals tend to warn their groups by using sound signals, trees spread the news more quietly. They use different means of transportation to warn their fellows about identified risks. They can even adapt their messages depending on the type of risk detected. As a result, trees can protect themselves directly from emerging risks, but also indirectly by preserving the entire forest ecosystem which they need in order to thrive. In business environments, the challenges arising from the VUCA context pose a risk to supply chains and potentially lead to disruptions. Effective risk management can make supply chains more resilient, as risk impacts can be avoided, mitigated or better and faster resolved.

9. Technologies – means of sharing information



Technology and supporting infrastructure are amongst the key factors having the potential to facilitate supply chain transformation. They aim to better integrate supply chains by fostering communication, collaboration and transparency. While the focus of businesses is on digital technologies, trees rather rely on analog means of sharing information. They use their root networks, intermediating “platforms” such as fungi, insects, the wind, but also electrical signals to exchange information. Similarly, there are numerous technologies available to enhance supply chain collaboration, transparency and efficiency. While incorporating these technologies can provide many benefits, it is important to well integrate them by looking at the supply chain holistically.

10. Collaboration & partnerships – “one tree doesn't make a forest”



Resilient supply chains depend on effective collaboration. Supply chain collaboration is not a new idea, but it has conventionally been rather transactional and driven by financial values such as cost savings and growth opportunities. Looking into nature – trees support each other. And they collaborate with an uncountable number of microorganisms and fungi, to achieve a greater, common good. One tree doesn't make a forest, but forests make trees more resilient. In business environments, there are multiple forms of vertical and horizontal, internal and external supply chain collaboration. And it is this multi-stakeholder collaboration, which all previous lessons are predicated upon.

The challenges that we have ahead of us in terms of creating a more sustainable future are certainly daunting. But nature can give us guidance in doing the ground work, in redefining values, and in developing resilient business ecosystems. And nature can encourage us to keep evolving and revolutionizing.



Why nature is a paradigm

The need for a sustainable business environment

Our current global context is characterized by a VUCA (volatile, uncertain, complex, ambiguous) environment. Organizations become increasingly aware that they need to adapt and address the challenges that this unstable climate implies for their operations¹. These challenges include climate change, political instability, resource depletion, biodiversity loss, rising social inequalities and conflicts, technological vulnerabilities and the appearance of black and green swans. And this VUCA environment is currently further destabilized by the ongoing COVID-19 pandemic.

Many of the issues above are a consequence of human activities, particularly as an impact of the industrial development and population growth. The amount of carbon dioxide (CO₂) in the atmosphere, for example, has risen along with human emissions since the beginning of the Industrial Revolution in 1750. While emissions increased slowly to about 5 billion tons per year in the middle of the 20th century, they skyrocketed to more than 35 billion tons a year by the end of the century³.

Humanity currently emits 36 gigatons of CO₂ every year; The available carbon budget of 335 gigatons related to the 2° warming limit will be reached in only 8 years time²

As Albert Einstein had pointed out, “no problem can be solved from the same level of consciousness that created it”. Hence, mankind needs to seek for new ways of creating sustainable, resilient and regenerative business operations and environments.

Speaking about resilience, it always impresses me how non-human ecosystems maintain their natural balance and function in closed loops. There is no overconsumption, everything is reproduced, biologically degraded, reused or repurposed. When I recently read the book “The Hidden Life of Trees” from Peter Wohlleben and watched the documentary “Kiss the Ground”, it struck me that there are multiple lessons that business environments can learn from natural ecosystems.

The smartness of biomimetics

Mankind has addressed a variety of challenges by looking at nature. Living organisms have evolved well-adapted structures, systems and materials over a long period of time through natural selection. Hence, biomimetics as the imitation (ancient Greek: mīmēsis) of life (bios) seems just natural⁴.

¹ Cambridge Institute for Sustainability Leadership (CISL) (n.d.)

² McCandless (2016)

³ Lindsey (2020)

⁴ Wikipedia (n.d.)

“Biomimetics or biomimicry is the emulation of the models, systems, and elements of nature for the purpose of solving complex human problems.”⁵

Nature has solved engineering challenges such as self-healing abilities, environmental exposure resistance, aerodynamic abilities, and hydrophobicity. Examples include the Japanese high speed train Shinkansen, which was remodeled after the beak of kingfisher bird to reduce energy consumption and noise levels. Another, widely known example of biomimicry is Velcro, which is mimicking the small hooks found at the end of the burr needles⁵.

While biomimicking is well known for addressing technological problems, it is rarely used in business and operating models as well as corporate systems. Looking closely at how natural ecosystems prove their resilience by fostering collaboration, innovation and regeneration can therefore provide a paradigm for organizations. This is particularly valid for procurement and supply chain functions, as they are focal points interacting with a diversity of internal and external stakeholders.

10 lessons from nature for creating sustainable supply chains

1. Ground work – analyzing the basis

Relationships aren't just about how we understand each other as people or organizations. In the coming decades, they must include how we cooperate in our environment. Strong networks depend on strong foundations, and no matter where on Earth we live, that foundation is based on soil⁶.

Humanity emits 4.3 gigatons of carbon into the atmosphere each year. The world's soil contains 1,500 gigatons of carbon as fixed stock. The aim of the “4 for 1,000” initiative is to increase the carbon in the soil annually by 0.4% for compensating the human emissions⁷.

Speaking of soil: In every handful of healthy soil are well over 10 billion organisms processing the organic matter. While humankind is searching for innovative technologies to pull CO₂ from the atmosphere, healthy soil already has the power to do so on an enormous scale. The entire system is based on a huge number of interactions of life. Covering plants, through their roots, excrete carbon in the form of root exudates. The latter feed trillions of microbes, which are involved in complex biological and chemical exchanges with the root system. Through a series of handoffs, the carbon excreted from roots is carried from the upper into the lower layer and eventually deposited in the form of organo-mineral complexes deep in the soil, where it can stay for thousands of years. Healthy soil therefore has the power to absorb CO₂, store water, and grow more and better food⁷. Pesticides and synthetic fertilizers

⁵ Wikipedia (n.d.)

⁶ Walworth (2020)

⁷ Tickell (2017)

however diminish these diverse and interacting organisms and lead to unfertile soil, which is ultimately lacking all those capabilities.

But what can we learn from a business point of view apart from the agricultural, wood and food industry?

We need to analyze the foundation that we are working on as organizations. We need to look at the diversity of stakeholders involved. And we need to analyze the impact that our organization has on economic, ecologic and social matters (dynamic resource-based view⁸).

This “ground work” is usually done in form of a [materiality analysis](#). The materiality analysis determines which sustainability aspects (e.g. greenhouse gas emissions, water usage, energy consumption) are of particular importance for the organization and its stakeholders. It can be supported by further analysis and information sources, such as stakeholder analysis, SWOT analysis and lifecycle assessments (LCA)⁹. The materiality analysis helps organizations to get an overview of their most material sustainability issues, and therefore an indication on where to focus their efforts. By mapping the materiality analysis with the organization’s value chain, the material issues and related fields of action can be identified for the different supply chain stages.

Starting from an overarching business perspective, the materiality analysis informs the functional view of supply chain management

2. Values – more than the seeds for growth

It’s Oscar Wilde who pointed out that economists may simultaneously know the “price of everything”, yet understand the “value of nothing”. And while lexicons define the term “value” as the importance or worth of something for someone, independent if monetary or otherwise, it is that “otherwise” that we often forget. According to John Elkington “(c)racking this nut will be a critical factor in determining whether our economies, societies, and natural environment get through the present century in good order.”¹⁰

Our economy, in large parts, is based on the myth of infinite growth, while being based on a planet with finite resources. From a conventional perspective, value in business environments, such as in supply chain functions, is measured according to costs, profitability, production time and product quality. The product value then becomes realized through its sale. This view of value is however constrained, as it does neither regard the implications of the business operations for its various stakeholders, nor the fact that resources are exhaustible. A comprehensive approach for measuring value hence differs from the conventional approach by considering a wide set of stakeholders,

⁸ Helfat (2003)

⁹ Goette (2020)

¹⁰ Elkington (2020)

such as network actors (e.g. suppliers), customers, society and the environment¹¹.

So what can we learn from nature with regard to this holistic view of value?

As already described in lesson 1 about “ground work”, the soil is composed of a variety of microorganisms, and it’s the **collaboration** (10) and **diversity** (5) amongst these living beings and the plants, which enable the absorption of CO₂, the storage of water and the growth of food. In nature, the rapidity of growth is not always considered as the best way for creating value. As science discovered, slowly growing trees are likely to be more stable and reach a higher age. The reason is, that the wooden cells inside those slowly growing trees are small and contain only little air, which makes them more flexible and resilient with regard to storms and decomposing fungi¹².

And what does this expanded view on value imply for businesses and their supply chain functions?

It offers a multi-stakeholder perspective and allows to map also destroyed and missed value along the value chain, thereby identifying new opportunities for value **innovations** (4). In order to recognize uncaptured value, organizations can use the Sustainable Value Analysis Tool (SVAT). It supports them in recognizing value uncaptured and turning it into value opportunities through business model innovations. The tool supports this process by providing organizations with a scheme to systematically identify value uncaptured (i.e. value surplus/ absence/ destroyed/ missed) at the beginning, middle and end of the product life cycle¹³. Examples include destroyed environmental value such as biodiversity, missed economic and ecologic value such as recycling or reusing waste and surplus value such as excess packaging.

There are several tools available in the market to capture the “real” value in supply chains. Besides SVAT, this includes ENCORE and KPMG True Value

3. Balance and circular design – closing the gap

The natural world manages to reproduce, grow and consume while maintaining balance. The “nature of nature” is to reuse or repurpose everything in non-human ecosystems, working as a perfect circular economy¹⁴. While compelling, the manmade world economy is only 8.6% circular today¹⁵. As already learned in lesson 2, our current business models and economic systems disregard huge opportunities for capturing **value**. Circular business models represent a \$4.5 trillion in opportunity over the next decade. Simultaneously, they benefit the

¹¹ Cambridge Institute for Sustainability Leadership (CISL) (n.d.)

¹² Wohlleben (2016)

¹³ Yang (2017)

¹⁴ Long (2020)

¹⁵ CGRI (2020)

society by re-coupling growth with social progress, resulting in new jobs, access to products and services, as well as better health. And they protect our planet from exhaustion, by decoupling economic growth from the use of scarce, natural resources¹⁶.

We have already learned in lesson 1 how healthy soil and ultimately healthy plants are based on a balanced and circular system of carbon extraction, root exudation, microbiologic processes and deposition. Without balanced soils, which have inside them all the microbial life, nature will cull the overgrowing plants. So an unbalanced ecosystem (e.g. monocultures) will, through bugs, weeds, plant disease, et cetera, attempt to restore itself to balance (**diversity**)¹⁷. Plants, like trees, also keep their inner balance by pacing themselves in fulfilling all of their needs. They portion their available energy to support the growth of trunk and leaves, to build up a reserve in case of emergency (e.g. insect attacks), and to allow for reproduction¹⁸.

Transferring this knowledge to businesses and their supply chains: In order to capture new opportunities for **value** (2), organizations should shift their business and operating models from resource consumption to regeneration. Circular approaches for product design and business models are mandatory for making that shift.

Circular design searches for ways to deliver a functional product or service, which is made of optimum materials for delivering high performance while minimizing its negative impact along the whole life cycle. The focus is on mitigating value loss embedded in these products, by keeping them circulating in utmost closed loops¹⁹. Circular product design can be differentiated into strategies to close resource loops and strategies to slow resource loops. The first strategy type focuses on closing the loop between post-use and production through recycling, and includes strategies such as design for the technological cycle, the biological cycle and for dis- and reassembly. The second strategy type focuses on slowing resource loops by extending the products' utilization period, and includes strategies such as design for reliability and durability, design for ease of maintenance and repair, and design for upgradability and adaptability²⁰.

In order to transform the economy from linear to circular, design strategies will need to go hand in hand with business models²¹.

*Useful references
for circular design
and business model
strategies:
Accenture (2014)
Bocken (2016)
Fifield (2016)
Lewandowski (2015)
Smith-Gillespie
(2017)*

*The "Designer's Field
Guide To
Sustainability" offers
an overview of
sustainable product
development and
the product life
cycle*

¹⁶ Long (2020)

¹⁷ Tickell (2017)

¹⁸ Wohlleben (2016)

¹⁹ Fifield (2016)

²⁰ Bocken (2016)

²¹ Bocken (2016)

*A conceptual
process and tool
overview for circular
economy oriented
business model
innovation is
provided by Pieroni
(2019)*

Business models are “the underlying structures of how companies create, deliver and capture value”²². Business model innovations can create opportunities from previously lost or excess value, foster supply chain resilience through systems thinking, and make a positive contribution to business, environment and society. Circular business models include strategies such as “Access and performance models” (providing capabilities without owning the physical products, e.g. car sharing), “Classic long life models” (delivering long-life products designed for durability and repair, e.g. Miele’s white goods), and “Industrial symbiosis” (using residual outputs from one process as input for another process, e.g. [Kalundborg Eco-Industrial Park](#))²³.

Organizations should start with an overall vision before developing their circular business model and design strategies in detail²⁴. Supporting the executive level, it’s the supply chain function with its various stakeholders and network partners, that is in a focal position for driving circular economy approaches. Taking the lifecycle assessment (lesson 1) and value chain analysis (lesson 2) as basis, the supply chain function can identify opportunities for circular pathways.

4. Innovation – about Green Swans and smart trees

“To address the realities of climate change and other ways in which we are increasingly overrunning planetary boundaries, we must now shift our mind-sets, technologies, and business models (...) – ensuring that a growing proportion of our economies operate in (...) the realm of breakthrough innovation.”²⁵ It is the corporate sector as a whole, with its interconnections of different sectors and organizations, which is required to contribute to innovative solutions and demonstrate leadership to let go of the old ways and to create the new²⁶.

As outlined in the introduction, nature has inspired mankind to many technological innovations. But it’s not only distinct products or mechanisms that need to be innovated, but entire systems.

Looking at trees – they transport water from the soil and roots up into their leaves. Sounds like a simple system, which can be explained by mechanisms such as capillary forces, transpiration, cohesion and osmosis. However, science has revealed that none of these mechanisms fully explain the complex processes that are happening in the trees. Their water-transporting system does not seem to be a stringing together of common mechanisms, but a systemic innovation by nature.

²² Clinton (2019)

²³ Bocken (2016)

²⁴ Bocken (2016)

²⁵ Elkington (2020)

²⁶ Elkington (2020)

With reference to the business environment, we have already talked about the importance of innovations in **circular product design and business models** (3). The supply chain and procurement function with their connections to various stakeholders play a key role in unlocking these innovations. It is thereby important to acknowledge the limitations of incremental changes and recognize the need for more fundamental changes towards conscious business model and supply chain design. John Elkington refers to business model innovations with “Green Swan” characteristics. He concluded that, as a minimum, leading-edge business models need to aim for exponential progress in four key areas²⁷:

1. **Social** – delivering financial and extra-financial value through positive present and future value for people.
2. **Lean** – optimizing the use of all types of capital (physical, financial, human, intellectual, social, natural).
3. **Integrated** – managing financial and extra-financial value creation across economic, ecological and social systems.
4. **Circular** – sustaining inputs and outputs in technical and biological cycles.

5. Diversity – strengths in differences

Diversity is considered a key determinant of resilience, recovery and adaptability, as well as transformability, innovativeness and collective intelligence²⁸. Biodiversity in particular is considered one of mankind's top sustainability challenges, as it is an essential part of the solution to climate change (see effect mechanisms of healthy soil and plants described in earlier lessons).

“In nature, diversity is the norm, not the exception”³⁰. Monocultures, such as large areas with only one species of crops or trees, are vulnerable systems, as they are unbalanced (see lesson 3). Permacultures, mixed and selection forests instead, with their richness of different plants, different species, different ages and sizes are more resilient and add more value. Even though not all interconnections are completely explored yet, it is proven that an increase in biodiversity correlates with a stabilization of natural ecosystems³¹.

“A Green Swan is a profound market shift, (...) changing paradigms, values, mind-sets, politics, policies, technologies, business models, and other key factors. A Green Swan delivers exponential progress in the form of economic, social, and environmental wealth creation.”²⁷

75% of all food plants are relying on insects and other animals for their pollination, representing a global annual market value of 500 billion Euro²⁹

²⁷ Elkington (2020)

²⁸ Kahiluoto (2019)

²⁹ WWF (2016)

³⁰ Tickell (2017)

³¹ Wohlleben (2016)

In business environments, the linkage between corporate employee diversity and company performance is already well established³². Perhaps less familiar is supplier diversity, where companies ensure equal opportunities by buying from businesses owned and operated by minority groups, such as women, ethnic minorities, LGBT or disabled people. These suppliers are often more innovative, flexible and efficient than large corporate suppliers, and thereby contribute to supply chain resilience and competitive advantage³³. Supplier diversity programs are also impactful to local, especially disadvantaged communities, as they generate income and educational opportunities³⁴.

Beyond this corporate view, supply chains consist of a number of diverse stakeholder groups, such as the company's internal functions (e.g. Procurement, Sales), suppliers (multi-tier), customers, investors, industry associations, communities, and NGOs³⁵. This diversity opens up new opportunities for [co-innovation](#) (4), such as supplier enabled innovation (SEI). Relative to supplier type diversity, which refers to any diversity of suppliers, scientific studies revealed, that the diversity of responses of vendors to disruptions has a positive impact on supply chain resilience. This response diversity also manages to reduce or avoid the trade-off between efficiency (e.g. supplier consolidation) and redundancy (e.g. avoidance of single source risk), which procurement professionals are often facing. A portfolio of vendors with different supplier responses (reactions) to disruptions ensures, that some vendors maintain the supply despite a certain disruption, whereas other vendors in the portfolio may be able to maintain the supply in the case of another kind of disruption³⁶. This ability has become particularly valuable in context of the COVID-19 pandemic.

Procurement plays a key role in fostering diversity in the supplier base. It is certainly a challenging task to find a balance between managing a complex supplier base, enhancing diversity, ensuring reliability of supply and leveraging efficiencies. But it is also a chance for procurement to step out of the shadow from other functions and take a seat at the decision table.

6. Communication – basis for strong communities

Communication, and language as one of its tools, are amongst the key factors for the rise and dominating role of the homo sapiens. They

³² Whitfield (2010)

³³ Richens (2020)

³⁴ EYGM (2016)

³⁵ BSR (2019)

³⁶ Kahiluoto (2019)

allows us to bond as communities, transport (complex) information and share fictions.

We all know that communication is not exclusive to humans, and that also animals communicate with each other, such as whales, dolphins and chimpanzees.

What many of us are not aware of is, that also other living beings such as trees communicate with each other. Trees communicate olfactory, optically and electrically (via nerve cells at the root tips). For example, oaks pipe bitter and toxic tanning substances into their barks and leaves to put off insects in case of attacks. But those oaks don't just protect themselves. They also use different communication channels to warn their surrounding fellows, transmitting the message by wind, through their root networks or through intermediary fungi. Interestingly, these fungi can also facilitate the communication between trees of different species, which due to competitive reasons don't interact directly. And trees do not only communicate **risks** (8), they also communicate (positive) signals about their conditions, their offerings and their needs³⁷.

Greater communication along the supply chain increases the end-to-end visibility of stakeholders and processes. This oversight has a number of benefits, such as early **risk** identification and prompt mitigation. Communication facilitates the streamlining of processes along the supply chain, and is a driver for **collaboration** (10). Sharing information builds up trust amongst supply chain partners and allows them to identify and respond to changes in demand and supply³⁸.

For effective communication of common objectives across the supply chain, organizations first need to get their internal communication right. The communication within and between company functions is often neglected and taken for granted, but it is not seldom a root cause for wider communication issues. **Technologies** (9) can help to facilitate communication, but should be accompanied by more holistic change management efforts. Examples of how effective supply chain communication can lead to better **collaboration** and ultimately more resilient value chains, are described in lesson 10.

7. Multi-tier value chains – integrating across boundaries

Supply chain integration refers to how aligned processes and activities are across the value chain, both within and between organizations. A common recognition is, that “the whole is greater than the sum of the

Sustainability reporting is a common way for companies to make the risks and efforts related to sustainability matters transparent to their internal and external stakeholders.

³⁷ Wohlleben (2016)

³⁸ Banomyong (2018)

parts". In other words, optimizing subsystems can result in a suboptimal overall system (systems-thinking approach)³⁹.

We have already learned in the previous lessons, that nature depends on the aligned interaction between a multitude of different living beings. It's a complex and well balanced, circular system in which they operate for fulfilling their individual but simultaneously shared needs. A comparability with supply chains also exists when looking at water supply. All living beings depend on the supply of water. But while the oceans contain enormous volumes of water, the continents would be dry without the rain distributing the water. Rain is a result of clouds forming over the oceans and transporting water inland with the aid of wind. However this mechanism works solely up to a few hundred kilometers of distance from the sea. Life, under these circumstances, would only be possible within narrow areas at the outskirts of the continents. Luckily, forest ecosystems reach from the oceans far into the inland of the continents. They have a large surface area, as per square meter of forest 27 square meter of leaves and needles spread out. A part of the rainfall gets caught in those crowns and evaporates straightaway. Additionally, trees consume water, which they respire into the air. As a result, clouds build up from this water vapor, and pass inland releasing rain. This process continues, so that even remote areas are supplied with water – provided that the forest ecosystems are utmost seamlessly integrated and connected with each other.

Supply chain integration works on the principles of [collaboration](#) (10), trust and open [communication](#) (6), shared vision and decision making, as well as shared [technology](#) and information (9)⁴⁰. The aim of supply chain integration is to drive efficiencies and customer value, eliminate waste and ultimately achieve a common business objective across the stakeholders. To achieve this goal, an integrative perspective on performance management and relationship management is required.

*Useful references
for sustainability
and supply chain
analytics:
GRI, SASB, SDG,
SBTi, Morley (2017)*

One of the reasons why many companies have not yet succeeded in tapping the full potential of supply chain integration is that they have failed to develop the performance measures and metrics needed. Fragmented approaches to measurement imply fragmented approaches to management⁴¹. Analytics can offer a systems-thinking perspective and look at the supply chain as a whole. They can gather, transfer, process and combine information along the entire operations, from resource extraction to product consumption. This is

³⁹ Sweeney (2012)

⁴⁰ Sabir (2014)

⁴¹ Sabir (2014)

particularly relevant for measuring and reporting on environmental and social impacts, such as through certifications and labels.

Moving from fragmented to more integrated approaches inevitably requires changes to the ways relationships are created and managed, both with internal and external customers and suppliers. There are various degrees of integration amongst up- and downstream supply chain stakeholders. Hence, also many different possible relationship types exist. A key management decision involves the determination of the appropriate relationship under a given set of circumstances⁴². This is very relevant for procurement professionals, who are responsible for supplier portfolios, supplier relationship management and supplier development. It is also valid for defining the relationships with customers, industry initiatives, local communities and NGOs. And it is crucial for the interaction of internal supply chain partners, such as procurement, production, warehousing and logistics, as without relatively high levels on internal integration, any attempt of external integration will likely be difficult⁴³.

*Useful references
for stakeholder and
sustainable supplier
management: BSR
(2019), BSR & UNGC
(2010), BME (2019),
ISO (2017)*

8. Managing risk – early warning, joint mitigation

The challenges arising from the VUCA context pose a risk to businesses and their supply chains, potentially leading to disruptions. The risks that organizations and their value chains face are manifold, and include environmental issues, like extreme weather events and resource depletion, social issues, like human rights violations or the current COVID-19 pandemic, and technological disruptions, like cyberattacks. These disruptions can result in significant negative impacts for organizations, such as lost revenues, reputational damage and recovery costs. Effective risk management can make supply chains more resilient, as risk impacts can be avoided, mitigated or better and faster resolved.

While animals tend to warn their groups by using sound signals, trees spread the news more quietly. As described in lesson 6, trees use different **means of transportation** (9) to warn their fellows about identified risks. Interestingly, they can even adapt their messages depending on the type of risk detected (e.g. different insect species). They also make use of different “analytics” such as in spring, where trees assess the risk of growing new leaves by “measuring” not only the environmental heat, but also the length of daytime. These early warning procedures require the collaboration amongst different parts of the trees, such as the roots, trunk and bark, buds and leaves. And while trees limit their direct commitment to their own species, they

⁴² Sabir (2014)

⁴³ Sabir (2014)

collaborate with fungi and certain insects as intermediates, which can transfer the risk messages also to other tree species. As a result, trees can protect themselves directly from emerging risks, but also indirectly by preserving the entire forest ecosystem which they need in order to thrive⁴⁴.

So, how can risks be identified, assessed and mitigated earlier in supply chain management? A systems thinking approach is required for understanding how risks in certain parts of the value chain can impact it as a whole. As Lamoureux (2016) discovered, many organizations do not fully exploit the potentials of supply chain risk management due to fragmented processes, particularly referring to the different business functions involved (e.g. procurement, finance, operations)⁴⁵.

A holistic risk management approach starts by getting visibility over the multi-tier supply chain. Supply chain mapping creates an overview of the stakeholders involved and the process steps that the products in scope go through in the supply chain. While this is certainly a resource intensive and difficult task particularly for complex supply chains, it can provide significant value. It's a common approach to start with a selection of products only, e.g. prioritized by revenue, risk proneness of suppliers or regions. Over time, the goal should be to go down as many tiers as possible in the supply chain and to cover more and more products and services⁴⁶. [Technological solutions \(9\)](#) such as [Sourcemap](#), [riskmethods](#) or [resilinc](#) can help organizations to visualize their supply networks and make them traceable.

In a next step, the supply chain risks need to be identified and prioritized (risk register), followed by an evaluation of the selected risks on a supplier basis. These steps should be done in a cross-functional approach, involving departments such as procurement, operations, logistics, CSR, finance and sales. The above mentioned technological solutions can support the process by capturing and visualizing the risk data and by customizing risk scorecards. The risk register usually includes "traditional" risk types such as financial viability and market conditions, and should also consider sustainability related categories such as compliance, human rights and environmental risks. Sustainability related risk registers and evaluations can be integrated from specialized providers such as [IntegrityNext](#) or [EcoVadis](#), which offer supplier sustainability assessments as well as real-time monitoring.

⁴⁴ Wohlleben (2016)

⁴⁵ Lamoureux (2016)

⁴⁶ Choi (2020)

The development of risk mitigation measures again requires the involvement of different stakeholders. Risk mitigation measures and action plans are subject to be jointly developed while monitoring the related progress. The supplier risk management process thereby should be integrated within the overall supplier management process, informing procurement's decisions on supplier selection, evaluation and development.

9. Technologies – means of sharing information

In today's global context, technology and supporting infrastructure are amongst the key factors having the potential to facilitate supply chain transformation⁴⁷. They aim to better **integrate** supply chains (7) by fostering **communication** (6), **collaboration** (10) and transparency of information.

While the focus of businesses is on digital technologies, trees rather rely on analog means of sharing information. They use their root networks, intermediating “platforms” such as fungi, insects, the wind, but also electrical signals to exchange information. This exchange serves to exchange nutrients (see lesson 10), warn against **risks** and prepare joint mitigation strategies (see lesson 8), and attract partners (like insects) for enabling growth, distribution or even symbiosis.

There are numerous technologies available to enhance supply chain integration, transparency and efficiency. Emerging technologies include the Internet of Things (IoT), machine learning and artificial intelligence, advanced analytics and collaboration platforms. With particular focus on supply chain sustainability, technological solutions allow to better plan demand, anchor sustainability criteria in the category and supplier management process, increase resource efficiency in production processes, and extend product lifecycles via sharing platforms⁴⁸. While incorporating these technologies can provide many benefits to supply chains, it is important to well integrate them by looking at the supply chain holistically.

*Useful reference
regarding the
convergence of
digitalization and
sustainability:
Goette (2019)*

10. Collaboration & partnerships – “one tree doesn't make a forest”

As outlined in the introduction, we live in a VUCA world, implying that organizations will increasingly face challenges and supply chain disruptions in the future. Organizations need to respond to these challenges and enhance their supply chain resilience. Resilient supply chains, in turn, depend on effective collaboration⁴⁹.

⁴⁷ Cambridge Institute for Sustainability Leadership (CISL) (n.d.)

⁴⁸ Goette (2019)

⁴⁹ Banomyong (2018)

Supply chain collaboration is not a new idea, but it has conventionally been rather transactional and driven by financial values such as cost savings and growth opportunities⁵⁰.

Looking into nature – trees support each other. And they collaborate with an uncountable number of microorganisms and fungi. In forests you can detect old trunks of trees which are still being alive. They are nurtured from their neighbor trees by means of roots, either through loose connections from the fungus network, or directly through overgrowing roots. This also applies to trees growing in suboptimal locations, such as sparse slopes. They can show the same performance levels in terms of producing sugar and wood than the surrounding trees of the same species with better local natural conditions. Trees obviously synchronize themselves and balance their strengths and weaknesses. But why do they support each other? Similarly as for human societies, working together is better. One tree doesn't make a forest, but forests make trees more resilient. Forests provide a locally balanced climate, protect from wind and weather, store water and improve the air. In such an environment, trees can securely grow old. Collaboration amongst trees is limited to members of the same species. But while beech and oak trees might consider each other as competitors, the "wood-wide-web" in form of the comprehensive fungus network acts intermediary and balancing⁵¹.

There are two main types of collaboration in supply chains, namely vertical and horizontal collaboration. Both types include internal collaboration, which focuses on breaking up functional silos. The difference lies in the external collaboration, as vertical collaboration refers to the same supply chain (e.g. customers, suppliers), while horizontal collaboration refers to the inter-firm relationship within the same supply chain levels (e.g. competitors, NGOs)⁵².

Internal collaboration is often neglected, but is a prerequisite for successful external collaboration. A mechanism for internal collaboration is [Integrated Business Planning](#) (IBP). It combines strategic, financial, sales and operations planning, and harmonizes the economic and operational processes with the customer demand. As a result, the forecast accuracy can be improved, stock-outs and obsolescence avoided, working capital costs reduced, and consumer satisfaction increased. Besides these business benefits, negative environmental impacts through resource consumption can be reduced by manufacturing products only at the demanded quantity.

⁵⁰ Benavides (2012)

⁵¹ Wohlleben (2016)

⁵² Banomyong (2018)

Another mechanism for internal collaboration is category management, where functions such as procurement, engineering, operations and CSR need to work together to define and implement category strategies (incl. supplier portfolio and [risk](#) analysis).

External collaboration mechanisms include Collaborative Planning, Forecasting and Replenishment (CPFR), supplier development and risk management programs, external roundtables, collaboration portals and data exchange via shared platforms (e.g. sustainability data). More formal partnerships include Vendor Managed Inventory (VMI), Collaborative Sourcing, co-[innovation](#) (4) and cooperatives.

An interesting parallel to the intermediary function of fungi in forests exists in terms of industry initiatives and intra-firm platforms. As mentioned earlier, fungi networks connect trees of different species, which would not exchange signals or nutrients otherwise. By participating in industry initiatives, organizations can create a shift towards supply chain sustainability by leveraging their influence and buying power. These initiatives give the industry a common voice and scalable influence through combined power⁵³. An initiative, such as “Together for Sustainability” (chemical industry) can tackle sustainability issues on an industry and government level, while complying with competition regulations. Similarly, cloud-based platforms allow for the exchange of information between organizations, contributing to greater transparency and efficiency. Examples include [IntegrityNext](#) and [EcoVadis](#), which collect standardized supplier compliance and sustainability assessments. Those can be used by customers as input for their sustainability initiatives, such as supplier qualifications and assessments, risk management and sustainability reporting.

In brief, it is this multi-stakeholder collaboration, which all previous lessons are predicated upon.

Bringing it to life

The challenges that we have ahead of us in terms of creating a more sustainable future are daunting. While we are still struggling to manage the current COVID-19 pandemic, the environmental, social and economic impacts resulting from climate change, loss of biodiversity and rising social inequalities will be considerably more severe. We need new solutions for driving transformation and regeneration, and a shift from stakeholder value to system value⁵⁴.

*Useful references
for cross-company
initiatives on
sustainability:
BMUB (2017)
WBCSD
Ecosense
Climate Action 100+*

⁵³ EYGM (2016)

⁵⁴ Elkington (2020)

Businesses will need to play a vital role in innovating and scaling new solutions, models and systems. But they often face difficulties in knowing where to start, in prioritizing their efforts, in igniting new ideas and in expanding and accelerating their work. As a consequence, many businesses focus their sustainability efforts on complying with regulations and minimum requirements.

In order to ignite new ideas and concepts for a sustainable future, organizations should look at how nature serves as paradigm. Evolution has “copied” itself countless times, and has repeated particular characters within and across lineages. Nature can give us guidance in doing the ground work, in redefining values and in developing resilient business ecosystems. And nature can encourage us to keep evolving and revolutionizing.



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