Reflow

Circular Principles for Cities

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Introduction

TOWARDS A REGENERATIVE CIRCULAR ECONOMY

In this publication we present a set of Circular Principles and Indicators that can help guide cities in the transition toward a regenerative circular economy. The circular economy has been widely employed to mean an economy where materials flow in loops or cycles, human activity runs on renewable energy, economic growth is decoupled from resource use, and natural capital is invested in.

With the term regenerative circular economy, we aim to emphasize three main themes. First, we use the term regenerative to place emphasis on net-positive outcomes, and expand beyond the narrow focus of system optimization towards more generative, creative system outcomes. Second, our vision of a regenerative circular economy also foregrounds the importance of place-based and context-specific analysis and action. Rather than a one-size-fits-all approach to circular economy principles, we emphasize principles that frame the economy as a nested system spanning local, regional, national, and global scales of production and consumption. In particular, local and regional scales are where latent regenerative potential can be found. Third, we take inspiration from living systems by foregrounding change and adaptive management of socio-ecological systems. We propose learning from the way resources in natural ecosystems flow. This leads us away from a mindset of engineering tightly controlled closed loops of materials that are isolated from living systems, to designing our products to be nutrients for living systems at local and regional scales.

We also acknowledge key barriers to a regenerative circular economy, some of which are particularly critical when focusing on local and regional scales. Any development of local and regional material supply chains, particularly those relying on sources of biomass, must avoid over-exploiting source ecosystems. Careful attention must be paid to understanding the carrying capacity of local ecosystems; with volume of resource extraction, rate of nutrient return, and interdependencies between human and ecosystem needs being of primary concern. A regenerative circular economy must avoid competition with food production. This means sourcing material feedstock in ways that are complementary to agricultural demands, such as developing materials from waste biomass. A regenerative circular economy must also avoid putting increased pressure on scarce water sources. There is a clear need for circular economic development to be tailored to the relave abundance and competing demand for resources, including biomass and water, in addition to the availability of renewable energy sources.

A barrier that cuts across all these challenges is knowledge about resource flows, particularly locality-specific knowledge about the volume and rate of resource availability, the composition and quality of resources, and the spatial dynamics of how resources move from one place to another overtime. For us to achieve truly regenerative circular cities, it will be essential to open up knowledge about urban resources - how they are (and can be) sourced, used, and recovered - as well as the means to measure the social, environmental, and economic value and impacts generated across the life-cycle.

If a regenerative circular economy is to take root in localities and regions worldwide, this knowledge must become widely accessible. This challenge relates to the need to scale a regenerative circular economy horizontally, rather than vertically. Instead of perpetuating an economic model where 'scale' means privatization and centralization of resources and productive capacity, we envision 'getting to scale' by propagating solutions through open loops of exchange powered by decentralized infrastructure.

If ideas and learning are shared openly and effectively, circular solutions can be replicated and scaled across localities and regions by adapting them to the local technical, cultural and environmental conditions.

The REFLOW project is perfectly situated to accelerate the transition to a regenerative circular economy. Driven by pilot cities, there is a unique opportunity for place-based circular economy initiatives to take root. The following set of Circular Principles, indicators, and case studies are developed to support this effort.

The Circular Principles serve to distill the aims of a regenerative circular economy and provide meaningful guidance for its pursuit. For each principle a set of KPIs is offered so to make progress towards the principle measurable and therefore more achievable. Case studies are included for illustrative purposes and to make tangible the key concepts put forward within each principle.

The principles will be further co-developed in close collaboration with REFLOW pilots and project partners to ensure they sufficiently reflect and contribute towards the REFLOW shared vision as it evolves over the course of the project.

CIRCULAR PRINCIPLES OVERVIEW

Reflow

SCALE 1: URBAN RESOURCES

1. Use life-friendly chemistry	A regenerative circular economy is one where materials and products are produced using chemical processes that are 'life-friendly', that is, they promote human and ecosystem health.
2. Pursue efficient use of materials, energy, and water	To reduce the pressure put on natural ecosystems and keep within planetary boundaries, there is a need to enhance the material, energy, and water efficiency of products and processes.
3. Design for biological or technical loops	All materials should be designed to either cycle openly within the biosphere as biological nutrients, or be cycled within a technical closed loop by human systems. Waste and pollution is designed out, and instead, 'waste equals food' for the system.
4. Pursue efficient use of materials, energy, and water	Materials and products should be produced and consumed at scales most effective for their cycling within biological or technical loops. The economy should be powered by renewable sources (defined as locally abundant solar, wind, water, and biomass waste).

SCALE 2: URBAN ECOSYSTEMS

5. Manage connectivity	The level of connectivity in a circular economy can be both positive and negative, helping to facilitate recovery and adaptation, as well as spread disturbances. The level of connectivity between materials, food, clothing, housing, water, and energy systems must be managed to ensure that the development of one area does not undermine or compromise another.
6. Incorporate system feedback	Developing a regenerative circular economy requires understanding and incorporating system feedback into decision-making. Identifying reinforcing and dampening feedback is critical, including variables that are slow to change yet produce large effects when thresholds are crossed. Inputs (resources) and outputs (waste) of a regenerative circular economy must be finely tuned to the regeneration and absorption rates of social-ecological systems - both source ecosystems and cycling ecosystems.
7. Foster diversity and redundancy	Biodiversity as well as cultural, economic, and institutional diversity are crucial to the ability of a regenerative circular economy to adapt to change. A diversity of scales of resource cycling increases the adaptive capacity and resilience of a circular economy. System redundancy also increases the potential for a circular economy to adapt to a changing world, where one part of the system can compensate for failure in another part.

SCALE 3: URBAN GOVERNANCE

8. *Encourage learning and experimentation*

A regenerative circular economy must be supported by continuous learning and experimentation. Open source and modular systems should be maximized in order to encourage experimentation, collective learning, and capacity building.

9. *Enable openness and participation*

Participation of a diversity of actors - human and otherwise - is important for a regenerative circular economy. Widespread participation in the production and cycling of resources should be encouraged to enhance system resilience. The development of common infrastructure that is transparent and decentralized is a key enabler for enhancing participation.

10. *Promote polycentric governance*

Governance systems should be nested, enabling collaboration across levels and scales. Governance should also be responsive to the nature of the resource system being utilized, and take into account interacting governance regimes from local to international levels.

CP - 01

Use life-friendly chemistry

***Principle:** A regenerative circular economy is one where materials and products are produced using chemical processes that are 'life-friendly,' that is, they promote human and ecosystem health.*

Life-friendly chemistry is based on the following principles:

1. **Break down products into benign constituents:** Not only do nature's chemicals break down after their useful life, they break down to reusable building blocks. Enzymes are the key facilitators of biochemical breakdown.
2. **Build selectively with a small subset of elements:** React selectively through shape, maximize use of weak bonds, leverage paired opposites for self-assembly, and optimize element proportions and positions.
3. **Do chemistry in water:** Nature uses water as a polar solvent, but also leverages water to make and break molecular bonds. Water also plays a role in making the complex 3D shape of biochemical structures.

The field of green chemistry is also instrucve for the development of life-friendly materials and chemical processes. Green chemistry advocates the use of chemical products and processes that reduce or eliminate the use of hazardous substances. The goals of green chemistry are achieved through several dominant approaches, including: biocatalysis, catalysis, use of alternave renewable raw materials (biomass), alternave reacon media (water, ionic liquids, supercrical fluids), alternave reacon condions (microwave acvaon), and new photocatalyc reacons.

CP - 01

Use life-friendly chemistry

The twelve green chemistry principles are outlined below:

1. **Prevent waste:** Design chemical syntheses to prevent waste. Leave no waste to treat or clean up.
2. **Maximize atom economy:** Design syntheses so that the final product contains the maximum proportion of the starting materials. Waste few or no atoms.
3. **Design less hazardous chemical syntheses:** Design syntheses to use and generate substances with little or no toxicity to either humans or the environment.
4. **Design safer chemicals and products:** Design chemical products that are fully effective yet have little or no toxicity.
5. **Use safer solvents and reaction conditions:** Avoid using solvents, separation agents, or other auxiliary chemicals. If you must use these chemicals, use safer ones.
6. **Increase energy efficiency:** Run chemical reactions at room temperature and pressure whenever possible.
7. **Use renewable feedstocks:** Use starting materials (also known as feedstocks) that are renewable rather than depletable. The source of renewable feedstocks is often agricultural products or the wastes of other processes; the source of depletable feedstocks is often fossil fuels (petroleum, natural gas, or coal) or mining operations.
8. **Avoid chemical derivatives:** Avoid using blocking or protecting groups or any temporary modifications if possible. Derivatives use additional reagents and generate waste.
9. **Use catalysts, not stoichiometric reagents:** Minimize waste by using catalytic reactions. Catalysts are effective in small amounts and can carry out a single reaction many times. They are preferable to stoichiometric reagents, which are used in excess and carry out a reaction only once.
10. **Design chemicals and products to degrade after use:** Design chemical products to break down to innocuous substances after use so that they do not accumulate in the environment.
11. **Analyze in real time to prevent pollution:** Include in-process, real-time monitoring and control during syntheses to minimize or eliminate the formation of byproducts.
12. **Minimize the potential for accidents:** Design chemicals and their physical forms (solid, liquid, or gas) to minimize the potential for chemical accidents including explosions, fires, and releases to the environment.

CP - 01
Case Studies

Beyond Benign
USA - www.beyondbenign.org

About
Beyond Benign develops and disseminates green chemistry and sustainable science educational resources that empower educators, students, and the community at large to practice sustainability through chemistry.

Why is it relevant?
- As a socially engaging resource, it is promoting the positive effects on human health and well-being by portraying how green chemistry can be implemented into products and industry.

Healthy Materials Lab
USA - www.healthymaterialslab.org

About
Healthy Materials Lab is a design research lab at Parsons School of Design, dedicated to a world in which people's health is placed at the centre of all design decisions. They are committed to raising awareness about toxics in building products and creating resources for the next generation of designers and architects to make healthier places for all people to live.

Why is it relevant?
- Fervent in imparting safe, renewable and sustainable scientific principles through design-led practices.
- Encourages green chemistry practices through teaching and learning initiatives.

CP - 02

Pursue efficient use of materials, energy and water

Principle: *To reduce the pressure put on natural ecosystems and work within planetary boundaries, there is a need to enhance the material and energy efficiency of products and processes.*

Nature-inspired chemistry and material development seeks to use low-energy processes, and minimize energy consumption by reducing the required temperatures, pressures, and me needed for chemical reactions. In order to economize on energy, material, and water needs, biomimetic design emphasizes multi-functionality, fitting form to function, and meeting multiple needs with one solution (Biomimicry 3.8, 2020).

System-wide strategies employed include service-based economy and sharing economy models. A service-economy model shifts from selling products to selling the service of a product. The ownership of the physical product remains with the producer, thus creating an incentive for the producer to design a product for ease of repair and remanufacture. A sharing economy promotes access to a common pool of goods and services that are provided or sold to customers and maintained by the owner. This promotes the maintenance and repair of products, and unlocks underutilized assets, thus decreasing waste. Other strategies include the promotion of local and seasonal products, and adjusting the sale of goods to consumer demand. Resulting in the use of fewer resources per product (Bocken et al., 2019), the aim of these strategies is dematerialization, or an overall reduction in the size of the resource system (Suárez et al., 2019).

CP - 02
Case Studies

Green Tomorrow House
Korea - www.arup.com/projects/green-tomorrow

About
The first project in East Asia that has achieved the Leadership in Energy and Environmental Design (LEED) Platinum rating. Located in Yongin, the development includes a 423m^2 zero-energy house and a 298m^2 public relations pavilion and is designed to be a sustainability showpiece in Korea. Arup provided sustainable buildings design and LEED consultation for the project, working in conjunction with Samoo Architects and Samsung.

Why is it relevant?
- Promotes the development of a sustainable design through innovative, environmentally conscious design.

Library of Things
UK - www.libraryofthings.co.uk

About
Collections of things other than books that are being loaned like books, for no charge. A library of things can loan out kitchen appliances, tools, gardening equipment and seeds, electronics, toys and games, art, science kits, craft supplies, musical instruments, recreational equipment, and more.

Why is it relevant?
- Localised accessibility to shared tools, materials, and equipment which can benefit and strengthen sustainable/circular community values.
- Promotes circularity through use of existing materials, slowing down the consumption of non-renewable raw materials by utilising existing ones.

CP - 03

Design for biological or technical loops

Principle: *All materials should be designed to either cycle within the biosphere as biological nutrients, or be cycled within a technical closed loop by human systems. Waste and pollution is designed out, and instead, 'waste equals food' for the system [3].*

In the biological cycle the reverse chain for biological nutrients returns those nutrients back to the biosphere via composting and anaerobic digestion. In addition, reverse cycles are not only confined within an industry, but also 'cascaded' across different industries (EMF, 2017).

The technical cycle encompasses the recovery and restoration of products, components, and materials, closing the loop through strategies like reuse, repair, remanufacturing, and recycling (McDonough & Braungart, 2013; Millar et al., 2019). Products, components, and materials should be designed to be maintained at their highest utility and resource value at all mes (EMF, 2015). This means increasing durability, repairability, repurposing, and reducing obsolescence (Reike et al., 2018), thus slowing down the flow of resources through the system (Stahel, 1981). Extended Producer Responsibility and industrial symbiosis initiatives can promote the maintenance of value and the up-cycling of waste into a useful resource (Suarez-Eiroa et al, 2019).

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CP - 03

Case Studies

Cupclub

UK - www.cupclub.com

About

Returnable packaging service designed to hold both hot and cold drinks. CupClub offers a tailored end-to-end service helping to reduce single-use plastic packaging. Not only does CupClub make it easy to do the right thing, but the product itself is a step-up from disposable cups.

Why is it relevant?

- Material is recovered and fed back into the economy.
- Benefits to the ecoregion are created from reducing waste stream pollution and impact on nature, hence contributing to designing out waste.

Worn Again

UK - www.wornagain.co.uk

About

Worn Again Technologies' pioneers' polymer recycling technology that can separate, decontaminate and extract polyester polymers alongside cellulose from cotton, from non-reusable textiles, PET bottles and packaging subsequently turning them back into new textile raw materials as part of a continual cycle.

Why is it relevant?

- Closing technical textile material loops.
- Utilising the abundant resource of existing non-reusable textiles in circulation today to meet annual demand.

CP - 04

Build with abundant, accessible, and renewable resources

Principle: *Materials and products should be produced and consumed at scales most effective for the cycling of their nutrients within biological or technical loops. The economy should be powered by renewable energy, defined as locally available solar income.*

According to complex systems theory, systems with a variety of scales are less brittle than the ones relying on a small number of large-scale items, because they leave more room for adaptation (Ulanowicz et al., 2009). The transition to a regenerative circular economy is an opportunity to develop material supply networks at local and regional scales based on widely accessible, abundant materials. Not only can this enhance the resilience of the overall industrial system, it can also enable resources to be more effectively cycled in ways that support local ecosystems. Nutrients can be sourced and released after end-of-life at appropriate levels of volume and concentration for local ecosystems.

While the production of technical materials is often done in a large-scale, centralized fashion, technical material waste is a locally abundant resource found all around the world. Cycling these materials within local and regional technical loops could lead to a more resilient, effective circular economy. Furthermore, biomaterials are distributed over large areas and can be harvested from a diversity of terrestrial and marine habitats (Kircher, 2018; Olson, 2001). The production of ingredients for biomaterials can also take place in artificial environments such as the cultivation of micro-algae to produce oils, proteins, and carbohydrates as building blocks for bioplastics (Das, 2018). Biowaste from the byproducts of agricultural, forestry, and aquaculture systems is also abundant in many regions. A wide diversity of small and medium-sized business entrepreneurs in the biomaterial sector could play an important role in enabling greater system adaptation, through the development and prototyping of many diverse product alternatives. If these entrepreneurs were supported to develop their materials by sourcing feedstock from diverse sources for local and regional markets, a future circular economy would be less reliant on large volume flows from centralised industrial supply chains, benefiting overall system resilience.

The same mindset of sourcing locally available materials can be applied to energy. While renewables present more diffuse sources of energy compared to oil and gas, many types are freely available and can meet the demands of local- and regional-scale economies. The challenge is to harness renewable sources of energy that are most suited to a respective locality.

CP - 04

Case Studies

Reflow

Ecobeans

Poland - www.ecobean.pl

About

EcoBean is a project powered by coffee. We turn waste left over from your daily cup of coffee, that would otherwise end up in the landfill, into clean energy products.
EcoBean collects spent coffee grounds from over 100 locations and they reuse it to make Coffee logs or 'briquettes'.

Why is it relevant?

- The coffee logs are cost-effective in production
- They also provide a sustainable alternative to conventional fossil fuels.

Piñatex

Philippines & UK - www.ananas-anam.com

About

Piñatex is a leather-like material made from pineapple leaf fibre. It is a natural and sustainably-sourced material which supports cruelty-free production and provides an alternative to current manufacturing processes that take place such as mass-produced leather (like chemical tanning) and synthetic material industries (which pollute the local environments with run-off waste).

Why is it relevant?

- Agriculture industry discards large proportions of plant 'waste', which have no current economic value.
- The use of pineapple leaves has increased the application of plant waste components significantly, changing from waste to abundantly resourceful.
- It allows the farmers and producers to loop back into the biological waste system
- It will potentially affect the air quality and local environment, avoiding combustion of discarded leaves.

CP - 05

Manage connectivity

***Principle:** The level of connectivity in a circular economy can be both positive and negative, helping to facilitate recovery and adaptation, as well as spread disturbances. The level of connectivity between materials, food, water, and energy systems must be managed to ensure that the development of one area does not undermine or compromise another.*

The nature and strength of interactions between actors in a system determines the level of connectivity. Connectivity can have positive and negative effects (Briggs, 2015). For example, highly connected social networks can spread information quickly and can support healthy communities. When a disruption takes place, such as a reduction in food supply or a natural disaster, highly connected communities can support each other and recover faster. Yet, connectivity can also mean that disturbances can spread quickly, such as with the spread of disease or financial exposure. For a regenerative circular economy, there is the need to manage connectivity to maximize the benefits and guard against the downsides.

An example is the need to manage the relations between material, food, water, and energy systems. The development of bioplastics that can be sourced from renewable sources of biomass present an opportunity for circular economy development. However, if they rely on food crops, such as corn, this could undermine food security. Furthermore, any disturbance to the agricultural sector, such as a changing climate, could have repercussions for both food and material supply chains. As the production of crops can draw heavily on water reservoirs, increasing corn production could compromise freshwater availability. The development of energy production from biomass may promote a regenerative circular economy as long as it doesn't rely on feedstock grown in a manner that depletes freshwater supplies or reduces soil fertility. Such scenarios underline the importance of understanding the dynamics of social-ecological systems in a local context where the production and consumption of materials, water, and energy are interrelated. It is imperative to examine the system interdependencies and vulnerabilities, understanding the effect that connectivity between these and other sectors could have on the overall regenerative capacity of a circular economy. In order to sufficiently monitor progress towards this principle, composite indicators need to be developed to measure the interlinked nature of a nexus approach towards sustainable development and a circular economy (FAO, 2014; Karnib, 2017; Nhamo, 2019). For example, composite KPIs for a Water-Energy-Food nexus can be created using the following indicators and weighing them through a multi-criteria-decision process:

- Proportion of available freshwater resources per capita (availability); Proportion of crops produced per unit of water used (productivity);

- Proportion of the population with access to electricity; Energy intensity measured in terms of primary energy and GDP

- Prevalence of moderate or severe food insecurity in the population; Proportion of sustainable agricultural production per unit area

Reflow

CP - 05

Case Studies

Fairtrade Foundation

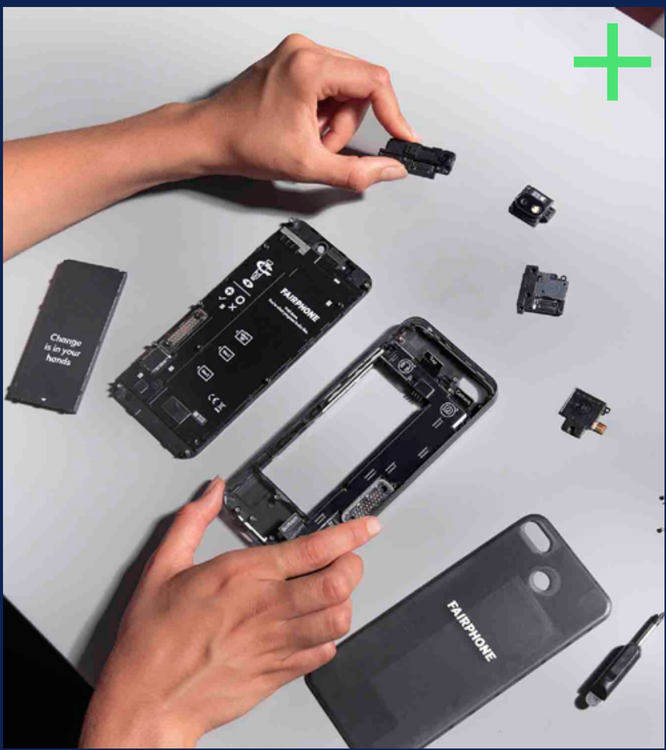
UK - www.fairtrade.org.uk

About

Fairtrade is about better prices, decent working conditions, local sustainability, and fair terms of trade for farmers and workers in the developing world. By requiring companies to pay sustainable costs, Fairtrade addresses the injustices of conventional trade, which traditionally discriminates against the poorest, weakest producers.

Why is it relevant?

- Ethical working environments throughout the supply chain leading to a positive, sustainable and stable workforce, ensuring there is sufficient food shelter and water for a life to thrive.
- Allows those who are vulnerable within precarious working conditions to be rigorously represented and provide protective economic safeguarding to implement a circular and sustainable ethos.



Fairphone

Netherlands - www.fairphone.com

About

Fairphone is a social enterprise company which aims to develop smartphones that are designed and produced with minimal environmental impact. They develop a mobile device that does not contain conflict minerals, has fair labour conditions for the workforce along the supply chain producing, and is a modular smartphone designed to be easily repaired and upgraded.

Why is it relevant?

- Limits the number of precious metals known to be incorporated in the manufacture of smartphones, which leads to the mistreatment of the labour force (these metals are known to be sourced in treacherous environments, where an insufficiently trained workforce are coerced/subjected to these conditions due to excessive demand).
- Promotes adequate wages relative to the work being implemented..

CP - 06

Incorporate system feedback

***Principle:** Developing a regenerative circular economy requires understanding and incorporating system feedback into decision-making. Identifying reinforcing and dampening feedback is critical, including variables that are slow to change yet produce large effects when thresholds are crossed. Inputs (resources) and outputs (waste) of a regenerative circular economy must be adjusted to regeneration and absorption rates of social-ecological systems.*

Developing a regenerative circular economy requires understanding and incorporating system feedback into decision-making. Reinforcing or positive feedback can accelerate change in a system, such as when the overuse of agricultural fertilizer contributes to a decline in soil fertility, thus requiring more fertilizer to make up for the deficit. Dampening or negative feedback can help maintain the current system state. For instance, good regulation can have a dampening effect on deforestation from illegal logging.

Understanding the sources of both reinforcing and dampening feedback and developing strategies for harnessing them can ensure that critical ecosystem services such as nutrient cycling and soil fertility are maintained for a circular economy. Many indirect species relationships can support ecosystem services. Soil fertility depends on complex interrelationships between chemical, biological, and physical conditions in the soil. Plant growth is affected by nutrient availability and the presence of soil organisms such as fungal mycorrhizal networks that contribute to soil structure (Abbo, 2017). A regenerative circular economy must consider these types of dependencies so as not to undermine the health and regenerative capacity of the ecosystem.

A part of integrating system feedback into decision-making is the identification of system variables that are slow to change, yet may have large-scale feedback effects once a threshold is crossed. Examples include CO2 emissions or the amount of fertilizer used in agriculture. Once carbon emissions cross a certain atmospheric threshold, they may trigger large-scale changes in the earth system such as rapid sea-level rise. If the amount of nitrogen or phosphorus fertilizer used on agricultural land crosses a certain level, runoff can lead to river and ocean eutrophication, or dead zones, as algae blooms cut off oxygen to plants that help keep the system in nutrient balance (Briggs, 2015).

Economic inputs (raw materials) and outputs (waste) are types of feedback that need to be managed in accordance with ecological regeneration and absorption rates. This is particularly critical for materials and products in the biological cycle. Positive examples include regenerative agricultural practices that return valuable nutrients to cropland in the form of human waste from surrounding urban environments (Pearson, 2007). Regenerative aquaculture techniques cultivate communities of multi-trophic species, where fish that are waste generating are grown with organisms like seaweed or shellfish that remove nutrients from the water, creating overall nutrient balance (Troell et al. 2003; Chopin et al. 2001). The effectiveness of these types of integrated systems highlights the importance of understanding and harnessing system feedback within a network of ecological relations.

CP - 06

Case Studies

Natura

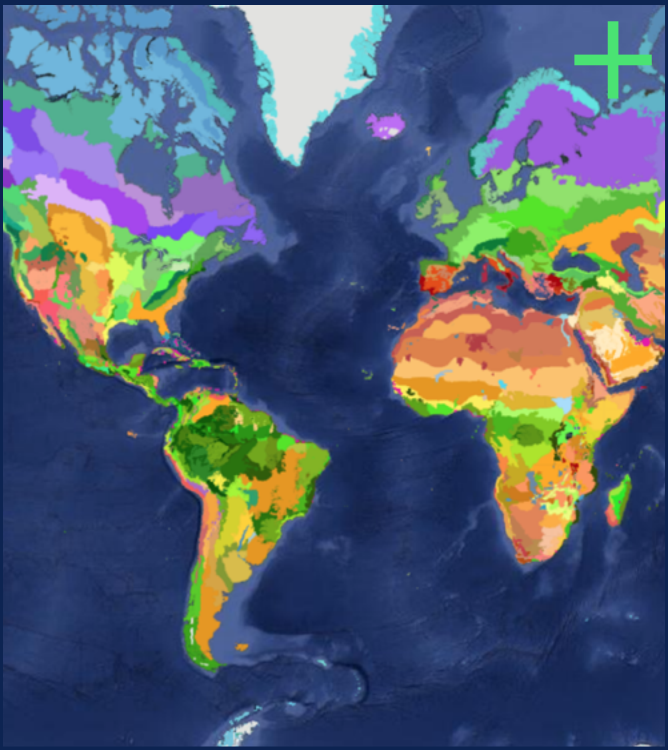
Brazil - www.natura.com

About

Natura's R & D scientists study each ingredient to understand how to extract the maximum benefits for skin and hair. They work directly with over 30 local communities in the Amazon region—including more than 300 families— to help them develop sustainable business models that benefit the forest.

Why is it relevant?

- Benefitting the natural local and regional ecosystem
- Material recovered and fed back into the economy, advocating sustainable, circular values.



EcoRegions Platform

USA - www.ecoregions2017.appspot.com

About

Platform shows a map of the 846 ecoregions that represent our living planet. Ecoregions are ecosystems of regional extent, which are color coded on the map to highlight their distribution and the biological diversity they represent. The map is based on recent advances in biogeography - the science concerning the distribution of plants and animals.

Why is it relevant?

- Allows a universal understanding of diverse ecosystems related to specific environments. Subsequently, this allows for increased application and awareness of the need of a particular ecosystem/ecological system.

CP - 07

Foster diversity and redundancy

***Principle:** Biodiversity, cultural, economic, and institutional diversity are crucial to the ability for a regenerative circular economy to adapt to change. A diversity of scales of resource cycling increases the adaptive capacity of a circular economy. System redundancy also increases the potential for a circular economy to adapt to a changing world, where one part of the system can compensate for failure in another part.*

In order to flourish in a changing world, a circular economy needs to be resilient and adaptive. Investing in biodiversity as well as cultural, economic, and institutional diversity is key to this adaptive capacity. Biodiversity enables an ecosystem to adapt to disruptions, such as climate change or land-use change, without losing core ecosystem service functions such as pollination, pest control, nutrient cycling, and waste assimilation (Briggs, 2015). Cultural diversity, including the use of indigenous knowledge and practices, can enable communities to respond to change and promote more appropriate, context-driven understanding. Economic and institutional diversity, including state and non-state actors such as NGOs, community groups, and businesses of varying sizes provide greater capacity to adapt to changes in environmental, social, and economic circumstances (Briggs, 2015).

A diversity of scales of economic production, consumption, and resource cycles is also important for a resilient system. System resilience is increased when a balance between efficiency (due to a small number of large-scale flows) and adaptiveness (due to a large and diverse network of small-scale flows), is achieved (Ulanowicz, 2009).

Redundancy is also an important feature of resilient systems. For a regenerative circular economy, 'functional redundancy' provides insurance by virtue of some parts of the system compensating when other parts of the system fail. 'Response redundancy' further increases a system's resilience whereby system components, such as institutional actors or communities, respond differently to change (Ulanowicz, 2009). This ensures the system can regenerate quicker after a disturbance or breakdown. Redundancy is particularly important to build in when incentivising innovation and the development of new systems, as some new ideas may fail while others succeed. For instance, being overly dependent on a particular actor, technology, or system of resource cycling may undermine the long-term success of circular economy development.

CP - 07

Case Studies

Natural Systems Agriculture

USA - www.landinstitute.org

About

The Land Institute is breeding new perennial grain and seed crops adapted to ecologically intensified polycultures that mimic natural systems, called Natural Systems Agriculture. Their goal is to develop an agricultural system that can produce ample food, reduce or eliminate impacts from the disruptions and dependencies of industrial agriculture, and inform cultural change through education.

Why is it relevant?

- Promotes community independencies through the exploitation of the local ecology and adaptive biodiversity. This encourages the utilization of local resources through advanced cultivation of the surrounding landscape, removing the need to rely on non- renewable raw materials.

Malai

India - www.made-from-malai.com

About

Biocomposite material made from entirely organic and sustainable bacterial cellulose, grown on agricultural waste sourced from the coconut industry in Southern India. They work with the local farmers and processing units, collecting their waste coconut water (which would otherwise be dumped, causing damage to the soil) and re-purposing it to feed the bacteria's cellulose production.

Why is it relevant?

- Biodesign for circular economy; minimising the use of non-renewable resources through biomimicry solutions.
- Creating biomaterials through discarded waste specific to local abundance.

CP - 08

Encourage learning and experimentation

***Principle:** A regenerative circular economy must be supported by continuous learning and experimentation. Open source platforms and modular systems can encourage experimentation and collective learning.*

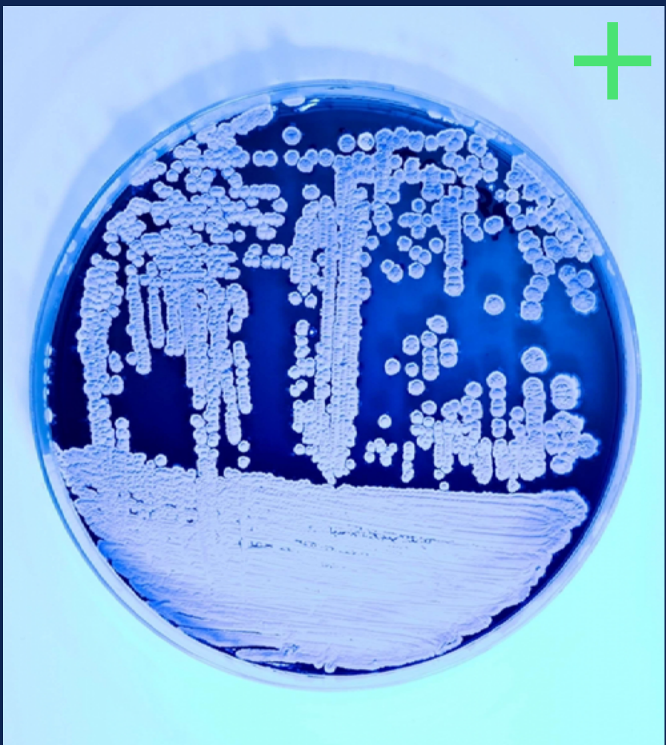
Knowledge of complex systems is always partial and evolving (Briggs, 2015), creating the need for continual learning and experimentation. If a regenerative circular economy is to be resilient, and thus adaptive to change, continuous updating of present knowledge must be prioritized. Adaptive management and adaptive governance are practices that focus on identifying, testing, and assessing alternative hypotheses for how a system works, and work to integrate learning and collective action across scales of decision-making (Briggs, 2015). These practices focus on cross-sectoral learning, where multiple stakeholder groups are consulted and brought together to interpret data, learn from each other's perspectives, and propose different approaches to systems change. These kinds of holistic learning processes are fundamental to developing a regenerative circular economy that adapts to new information and unforeseen circumstances.

As a tool to enable learning and rapid experimentation, 'commons-based peer production' is a system of production that relies on digital infrastructure, where collaboration between large groups of people can provide information goods without the need for market pricing or managerial hierarchies (Benkler, 2006). Examples include Wikipedia, the Linux operating system, and various other open source software projects. Commons-based peer production can play an important role in enabling 'boom-up' development by harnessing diverse local knowledge for a collective outcome (Langlois, 2008), allowing diverse people to self-organise available resources into dynamic collaborations and projects in a way that may outperform markets or bureaucracies (Benkler, 2016).

A key driver of these benefits is modular architecture, where parts operate independently, yet support the functioning of the whole system through common interfaces (Simon, 1962). In open source software, contributors can modify and experiment with parts of the code system without causing changes in other modules. This allows a highly distributed collective to work together and produce innovative outcomes. Nature also builds with modular architecture through boom-up synthesis, where a common set of chemical building blocks are used to assemble a diversity of natural materials that are tunable to local conditions (Kushner, 2011). Open source platforms and modular systems are tools that can encourage experimentation and collective learning towards a regenerative circular economy.

CP - 08

Case Studies



Faber Futures

UK - www.faberfutures.com

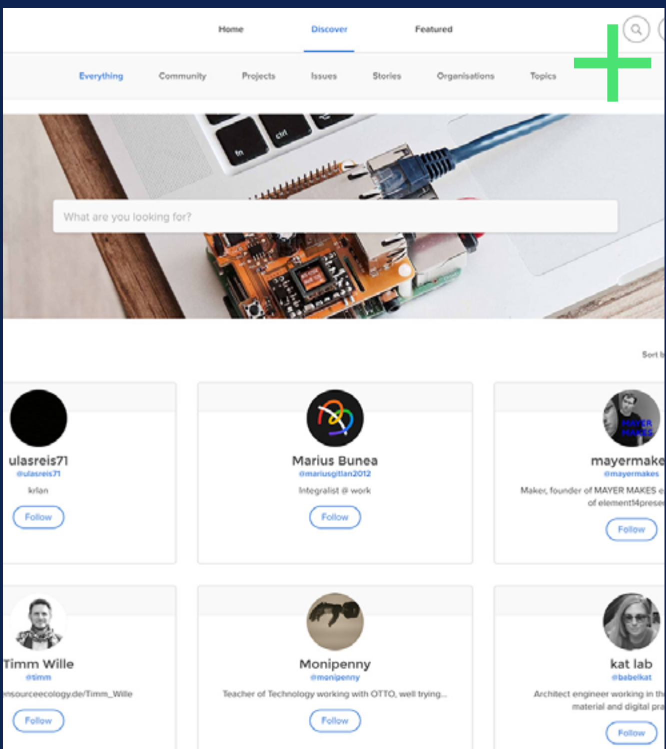
About

Faber Futures is a London-based award-winning futures agency operating at the intersection of nature, design, technology and society. Our multidisciplinary practice engages industry, institutions and multi-sector brands with ecologically-driven models for holistic innovation.

With sustainability at its core, our fledgling studio equips biotechnology start-ups, multi-sector brands and institutions with innovative frameworks, tools and networks to adapt to holistic systems for regenerative futures.

Why is it relevant?

- Approaching research as a continuous (rather than finite undertaking) can encourage the exchange of ideas and the development of regenerative practices, instrumental in making regenerative impacts.
- This can lead to partnerships with a variety of stakeholders, including how to enhance citizen engagement and learn as a collective.



Wikifactory

UK - www.wikifactory.com

About

Social platform for collaborative product development. Designed for open source communities, designers and product companies. Some of the key features are: Version Control, Tracking Issues and improve them collaboratively, Documentation Tools, 3D Visualisation, Permission Systems, and Social Features.

Why is it relevant?

- The integrated support systems are built for both public and private projects which encourage users to experiment and collaborate on topics.
- Several ways of engaging with users which can also be defined by how you would like to learn, therefore there is a diversity of users and the potential array of inputs or and topics that are being explored.

CP - 09

Enable openness and participation

***Principle:** Participation of a diversity of stakeholders is important for a regenerative circular economy. Widespread participation in the production and cycling of materials and products should be encouraged to enhance system resilience. The development of data commons, transparency, and decentralization are key enablers of participation.*

The question of who gets to participate in a regenerative circular economy is fundamentally about social justice, sustainable economic development, and the inclusion of marginalized voices. Bringing all stakeholders together to co-create visions and strategies for a regenerative circular economy is vital to building trust and legitimacy in decision making processes (Briggs, 2015). If governments and businesses pursue closed loop strategies without considering the need to broaden participation, monopoly control over resources could disadvantage many economies and societies. A circular economy where resources and value flow in tightly controlled loops controlled by a minority would be unjust and unsustainable. A regenerative circular economy is one where all stakeholders, no matter their location or socioeconomic status, can participate in shaping systems of production, consumption, and cycling.

Key drivers of participation lie in aligning the circular economy agenda with global trends in mass customisation (Da Silveira, 2001), digital fabrication (Gershenfeld, 2012), open design (Tooze, 2014), (re)distributed manufacturing (ibid), and open source material development (Materiom, 2019). These movements and technologies are beginning to transform how, and by whom, products and materials are manufactured. They signal a wider democratization of technological practices -namely, the rise of open access fabrication labs and the communities who use them to share materials, tools, technologies, and knowledge with like-minded peers (Tooze, 2014). When the production of materials and products moves from behind the closed doors of industry into the social realm, new opportunities and possibilities for enabling a more diverse set of narratives and actors, spaces, and practices within material development become possible.

Exemplifying these trends, entrepreneurs and local communities are harnessing the accessibility and adaptability of the materials in the biological cycle for positive social and environmental impact. Biomaterial innovations including Piñatex, Malai and TotoMoxtle demonstrate the capacity of biomaterial entrepreneurship to empower local communities in generating local trade using local resources, in celebrating local heritage and knowledge, and in enabling new actors to participate within the material production system for economic and social benefit. Biomaterial innovations such as Merdacotta and Chip[s]Board demonstrate how traditional material production systems stand to benefit from the participation and expertise of non-traditional actors such as agriculturalists, fine artists, and designers. When paired with emergent trends in personal fabrication and digital manufacturing, the low-barrier nature of biomaterials brings about new opportunities between material development, product design, and technological production which, in turn, enables new actors to emerge and participate (Tooze, 2014; Kuznetsov, 2010). Broad participation in the making of biomaterials is further enabled by adopting water-based chemistry methods and low-pressure, low-temperature fabrication techniques.

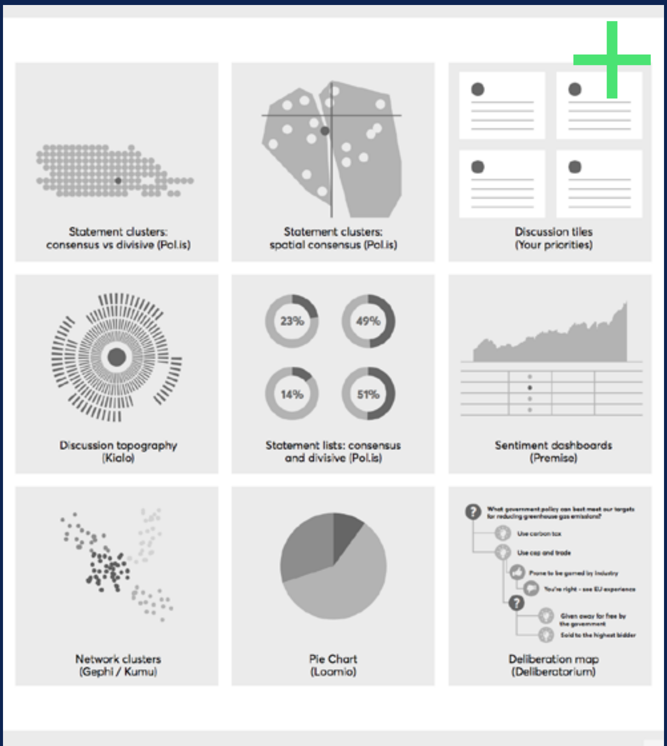
CP - 09

Enable openness and participation

Increasing participation in a circular economy means certification and data validity challenges are made more acute. Coordination between small producers may require significant investment in cooperative governance structures and collective physical infrastructure such as storage facilities. Distributed Ledger Technologies (DLTs), such as blockchain, may offer important ways forward for this set of challenges. By design, DLTs are built to accommodate a large and distributed set of actors, where trust and confidence in a common resource (be it a currency or database of supply network information) is developed through consensus mechanisms that govern decisions about the use, extraction, alteration, or addition to the resource. Blockchain is presently being used to bring greater transparency to existing supply chains as exemplified by the work of Provenance (Provenance, 2015). Given their decentralized nature and emphasis on transparency and trust building, DLTs may be particularly suited to be information infrastructure for new, more parcipative supply networks for a regenerative circular economy.

CP - 09

Case Studies



NESTA - Collective Intelligence Design Playbook

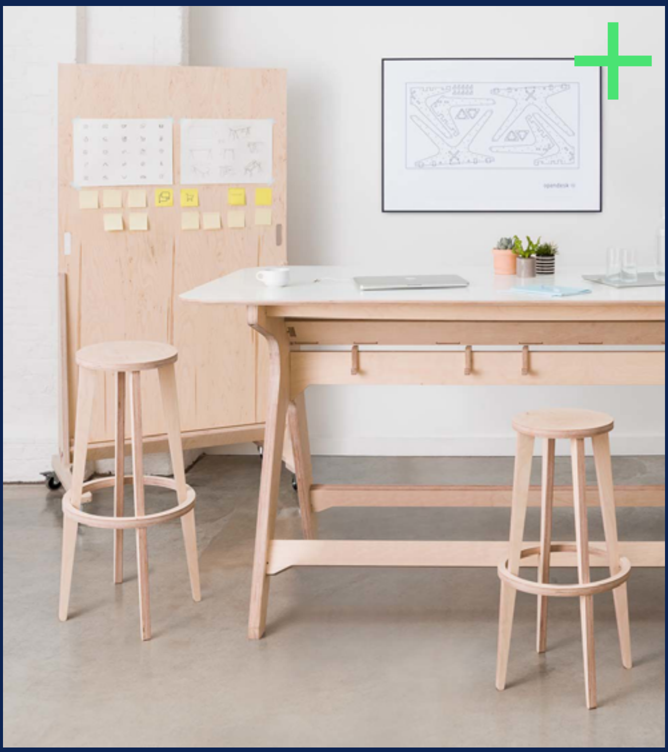
UK - www.nesta.org.uk

About

Nesta is an organisation that approaches innovation in practical ways, demonstrating how collaboration can be achieved using emerging technologies and is connected by a diverse group of people who are passionate about challenges facing society. Their playbook is a downloadable toolkit which includes tools, tactics, and methods to harness the power of people, data, and technology to solve global challenges.

Why is it relevant?

- It shares knowledge from many data sources.
- It encourages widespread participation through activities made accessible to all.
- The toolkit is available to amend to the needs of the user for them to achieve their specific goals.



Open Desk

UK & global - www.opendesk.cc

About

Open Desk provides furniture and furniture designs in the form of an online marketplace that serves as a platform for a global maker network. Their goal is to create inspiring workplaces which are adaptable to the user's needs. They have specifically chosen a distributed business model to support local designers, makers, and manufacturers; they can set their own fees as well as use local delivery services and take on localised decisions like material costs or local business taxes.

Why is it relevant?

- The global maker network can adapt designs to customer requirements and create an on-demand service that is less extractive and more resilient.
- It enables makers to manage their work independently, allowing them to connect to their local and regional customers as well as use local resources.

CP - 10

Promote polycentric governance

***Principle:** Governance systems should be nested, enabling collaboration across institutional levels and scales. Governance should also be responsive to the nature of the resource system being utilized, and take into account interacting governance regimes from local to international levels*

Polycentric governance refers to 'nested institutions,' where institutions are connected through norms and rules across hierarchies and scales. Collaboration across institutional levels and scales can enable rapid and coordinated response in the face of uncertainty and change (Briggs, 2015). Polycentric governance enhances the resilience of governance institutions by improving learning and experimentation, broadening participation, improving connectivity, creating modularity, increasing potential for response diversity, and building redundancy that can minimize and correct errors in governance (Briggs, 2015).

Governance systems also need to be responsive to the nature of the resource system being utilized. A circular economy incorporates many diverse types of resources, some of which are amenable to being treated as private goods (such as minerals and plastics), while others are beer governed as common-pool resources (fisheries, and forests). Common-pool resources often have many competing actors operating at multiple levels of scale, making multilevel governance arrangements necessary to avoid over-exploitation and collapse of the resource (Ostrom, 2005). It is important to take into consideration how goods should be governed when developing circular economy strategies. For example, strategies such as extended producer responsibility (Dubois, 2016; Kunz, 2018) and access or performance models that incentivise the return of material to the seller (Bocken, 2016) all assume that the goods in question are best governed under private markets. Privatizing common-pool resources can privilege one stakeholder group's interest while marginalising others (Ostrom, 1990). For example, the selling of land rights for extracting timber or other resources from the Amazon rainforest can undermine the rights of indigenous peoples. For the development of a circular economy to be ecologically regenerative and socially inclusive, natural resource commons must be appropriately governed, with inclusion of all relevant stakeholders.

CP - 10

Case Studies

Bioregion Vestland

Norway - www.bioregionvestland.com

About

Bioregion Vestland is initiating a new sustainable large scale project with the business industries located in Western Norway. They are utilising design-driven research and development, focusing on the geography of the natural ecosystem to create solutions for human society. The goals are to create innovation for products and services that should discontinue the use of fossil-based plastics as well as create a corporate social responsibility for the bioregion.

Why is it relevant?

- It is a coordinated effort and collaboration between different institutional actors at different scales: e.g. municipality, local communities, businesses, etc.
- Focusing on the use of biological loops in value chains which are also circular, sustainable, and profitable for the local economy.

Exemplar Project

UK - www.exemplarnet.org.uk

About

The ExeMPLaR project is an 18-month programme that focuses on the gradual accumulation of plastics in the region of South West UK. By addressing the causes of the problems as well as the efforts to solve them, the project is exploring the impact and costs to the environment. Meanwhile, it is enabling local stakeholders who are in turn supported by the Multidisciplinary Plastics Research Hub led by the University of Exeter across a few of their campus sites (which span a 100mile radius), to research and develop applications regionally for various purposes that would result in a higher value.

Why is it relevant?

- The project is enabling regional collaboration across organisations of different sizes and levels.
- It is also responding to the systems and strategies of the resource/waste stream, and building connections between its use internationally as well as locally.

Reflow

www.reflowproject.eu