Symbiosis in Development



MAKING NEW FUTURES POSSIBLE

TOM BOSSCHAERT

For Maaike Anne Stevens.

As long as there are people like you in this world,
it is worth fighting for.

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"Everything, everywhere will be okay."

- ABBAS, MY DRIVER IN THE DESERT OF ISFAHAN, IRAN

A. **FOREWORD**

by the author



I started writing this book 10 years ago, in the summer of 2009. The world was a different place back then. The challenges the world faces have only increased since then, and become more complex. This has inspired me to go on to finish this book, something I believe to be an essential missing tool in our arsenal to strive for an inspiring future that works, and to continue living on this planet. Here's a short story about why I wrote this book.

As a kid in the 80's I was hugely inspired by inventions of our age. I spent weekends on end reading popular science magazines about great new innovations and discoveries, amazed at secrets of the atom, and our billowing understanding of galactic mysteries.

As one of many kids star-struck by science and technology, I wanted to be part of this, seeing the opportunities to make life for so many people so much better. At the same time, the TV showed all those hungry kids, victims of disasters and the downtrodden. Science and innovation to me meant there was hope for all of us. Around 10, I messed with anything from electronics to biology. I 'invented' a perpetuum mobile, a rocket car with generators on each wheel, and was hugely disappointed when my uncle Andre had to explain that this contraption wouldn't solve the world's transport problems. I became fascinated by architecture, deep ocean life, and the beauty of things like Pyrite crystals and the golden ratio. A world of wonder.

Wide-eyed and bushy-tailed, and stubborn, at 17 I went to the Delft University of Technology in the Netherlands to study Industrial Design Engineering. It was the closest study I could find to becoming an 'inventor'. I wanted to contribute to the amazing solutions that positively changed the world, like a modern-day Leonardo da Vinci, and do things that helped those many less fortunate. The study had a tagline: "making products for people". That's what I wanted: to make the lives of as many people as possible better.

But during my studies I quickly saw that making these kinds of solutions was not the world I was in. My studies focussed on making ever better selling consumer products, not to actually help humanity. Hip

fun gadgets for people to buy, apps to sell more phone services, the next best selling piece of plastic. Looking up from my work, it seemed that issues such as world hunger, water shortages, climate change, and poverty had been shelved as impossible problems to solve by other people. Few people, in my environment at least, were talking about them or trying interface with these problems. When I raised questions about this in classes, I was told that those were topics of sociology, politics, and global economic interests, and not concerns of a design degree. I was shocked, and had to reconsider my choices. Was science, innovation, and design not a valid pathway to positive societal change?

This perspective turned design from an amazing innovation engine into mere gadgetry for me for short time. I didn't see how mobile phones, fancy carbon bicycles, and interactive websites helped to resolve issues that bring suffering and extinction to living things on earth. Increasingly disillusioned with this ostracizing world of consumption products, my work ground to a halt. In a spasm of desperation, I moved to Perth in Australia, formally to study architecture, but mostly to escape the crushing feeling of helplessness and lack of purpose of the gadget-design-land I found myself in.

In Australia I started reading piles of books, about things like ecological design, land ethics, the club of Rome, and various holistic philosophies. Few provided any real relief. Each seemed to have their own version of blinders on. What gave me fragments of hope were, to my surprise, abstract concepts such as chaos theory and complexity thinking. They at least tried to comprehend the complexity of the world around us without denying its essence. Chaos theory, with its famous parable about a butterfly flapping its wings causing a hurricane on the other side of the world, set me thinking. It made me wonder if there could really be small actions that can cause world-changing events. I dove deep into those, and wondered if they could be the key to my dilemma.

If small actions can produce world-changing effects, I thought, couldn't you purposefully find and execute these for global benefits? As with my perpetuum mobile design of my youth, I was helped out of that illusion soon enough. While small actions can eventually turn into world changing events, to control the effects of such actions is impossible, says chaos theory. This, after all, would require predicting the future, which chaos theory itself proves impossible. Yet, I found new hope, a new purpose: to find a way to act with the complexity of society that has a good chance of having a positive global effect.

I found that I wanted to work not designing *things*, but on design that supports positive change in societal systems. This was a new way of working, thinking, and acting. I became interested in systems theory, complexity theory, eco-engineering, cybernetics, and others dealing with fragments of these questions, which fed my desire for a practical approach. Looking around in the year 2000, I could find no framework to support this for practical application,and very few organizations focused on this. It became clear to me that there was a need for an integrated perspective on how to purposefully act on improving society for the long run, combining knowledge from different angles such as economics, sociology, and ecology. Something that allows you to act responsibly, while preventing you from drowning in infinite complexity.

The key to understanding this way of working, I slowly discovered in my experiments in Australia, to go away from the desire to develop new objects and singular solutions and focus instead on systemic impact on global society as a final measure of anything you do. The objects are mere tools along the way. This realization led to the desire to make a framework that supports innovation fueled by progressive systemic understanding. I started work on what was to become SiD in the summer of 2001, around the time of the 9/11 event. First, just for myself. Then, later, I saw the value it could bring for others who struggled with the same questions.

Since then, Symbiosis in Development (SiD) is formally developed from 2005 as a step-by-step process for generating sustainable symbiotic solutions. I continued my study and research at the Yale School of Architecture, where I had the chance to make use of many brilliant minds to help infuse this approach.

While studying at Yale, and in my sustainability consulting and design practice of Except Integrated Sustainability, SiD grew into a complete framework to work from start to finish on any challenge that requires responsible innovation. While in daily use, SiD grew to include aspects such as stakeholder participation, co-creation, and multi-factor optimization. SiD became not just a highly effective tool, but also an enjoyable process that delivers surprise, deeper insight, incredible a-ha moments, and learning from others in the co-creation process. In the end, SiD has helped myself and my colleagues at Except come up with strategies that do exactly as described on the box: make large positive societal impacts with small systemic interventions. With my amazing colleagues at Except, who I am greatly indebted to in the making of this book, we've applied SiD to over 600 projects worldwide. These range from some of the first designs in vertical agriculture, systemic solutions to complex supply chain challenges of companies like IKEA and Heineken, training hundreds of people in sustainability thinking, smart government policies and corporate strategies, and amazing buildings, city, and industry designs.

As far as SiD has come since its inception in 2001, I see SiD is far from done. As a framework meant to be practically useful, I look forward to see SiD improve and expanding its foundations and tools in the years to come. I look forward to keep on learning from taking SiD on a spin in large and small projects at Except, but mostly to see what people will do with it, reinterpret it and apply it to projects the likes of which I can hardly imagine.

Yes, this book is thick, and expansive, but I hope you'll find you can read it in parts, and that it also proves useful as a practical handbook. The book was made possible with the help of various people, most notably Renkse Kroeze in the role of early-phase editor and conversation partner, for whom I express my sincere gratitude. Emily Vierthaler, thank you for your editing support. Damon Taylor, thank you for the ever available mirror and master of conversation. And Hanna Maas for the wonderful hand-sketches throughout the book.

I hereby invite everyone who'd like to participate in expanding SiD to do so, and this is the reason why I have made SiD open source.

To a beautiful time, and that SiD may bring hope and opportunity to you as much as it has brought me, and may it truly lead to a more beautiful, resilient, harmonious, and flourishing world for all of us.

Tom Bosschaert, August 2019

B. **WHY NOW?**

The goal of sustainability is clear – we all want to continue to live healthy, happy lives, in a beautiful, and safe world. A world with space for leisure and community, beauty, art, and excitement. A world where we can see our children grow up knowing that the natural world is flourishing, and capable of regenerating any unforeseen destruction it may see in the future. A just and fair world, with peace and prosperity. Those that work on sustainability share the goal of societies in which cities run on abundant resources, connected through resilient economies, where material and energy loops are closed, and lush ecosystems provide us with abundance. But, this is clearly not the world we are living in now, nor the apparent direction we are heading in.

Despite wholehearted initiatives to turn the tide towards a more sustainable world, our problems are starting to become more severe, while our methods of resolving them are increasingly inadequate. We try to combat large systemic societal, economic, and environmental effects merely by applying band-aids. We're washing the dishes on the Titanic. We need new ways of thinking to deal with the challenges that face us, activated by practical action plans for significant systemic change, and to follow up on these plans.

The old path of unmitigated growth, monolithic and object-oriented thinking, leads to our common enemy of hunger, mass migration, and war, driven by resource shortages, ecocide, and systemic societal fracturing. This isn't a far flung distopian future, this is happening now.



"We're washing dishes on the Titanic."

YET...

Despite our plight, within the complexities of our society, exist the seeds of solutions. Finding and using these seeds, nurturing and rearing them to overtake our old ways, is our joint challenge. We can take advantage of our exponential times; new technologies, systemic insight, and a more holistic thinking new generation. The best part is that this isn't just a way to steer clear from doom and gloom. It's a way to steer our ship into a fascinating, beautiful, flourishing, and just future. One that works better for all living things, including us. Not just less bad, but mostly more fantastic.

But how do we decide what to do first, or how to go about realizing it? How do we prevent mistakes made in the past? How do we start to work on things like sustainable, equitable, and resilient systems? And what are they in the first place?

Welcome to Symbiosis in Development (SiD). SiD is built from 20 years of hands-on practice to provide a structured approach to answer these questions, as a tool to improve the old world and build the new. Two decades in the making, SiD is a first step in the revolution of evolution. If you have the patience and perseverance to make SiD your own, a new world awaits.

WE ARE LEGION

We are the world's dominant species. We have forever imprinted ourselves on the face of this planet. In impact and in number. There are twice as many people now as there were in 1970. High scenario projections predict there will be twice as many people in 40 years as there are now. We are legion, and we are growing. The great power this gives us allows us to do both formidable and terrible things. With great power comes great responsibility, and great power requires great resources. What will we use it for?

What happens to a growing population that has limited resources? How can we spread prosperity when vital resources are increasingly depleted? How can we use our great power to prevent the seemingly inevitable?

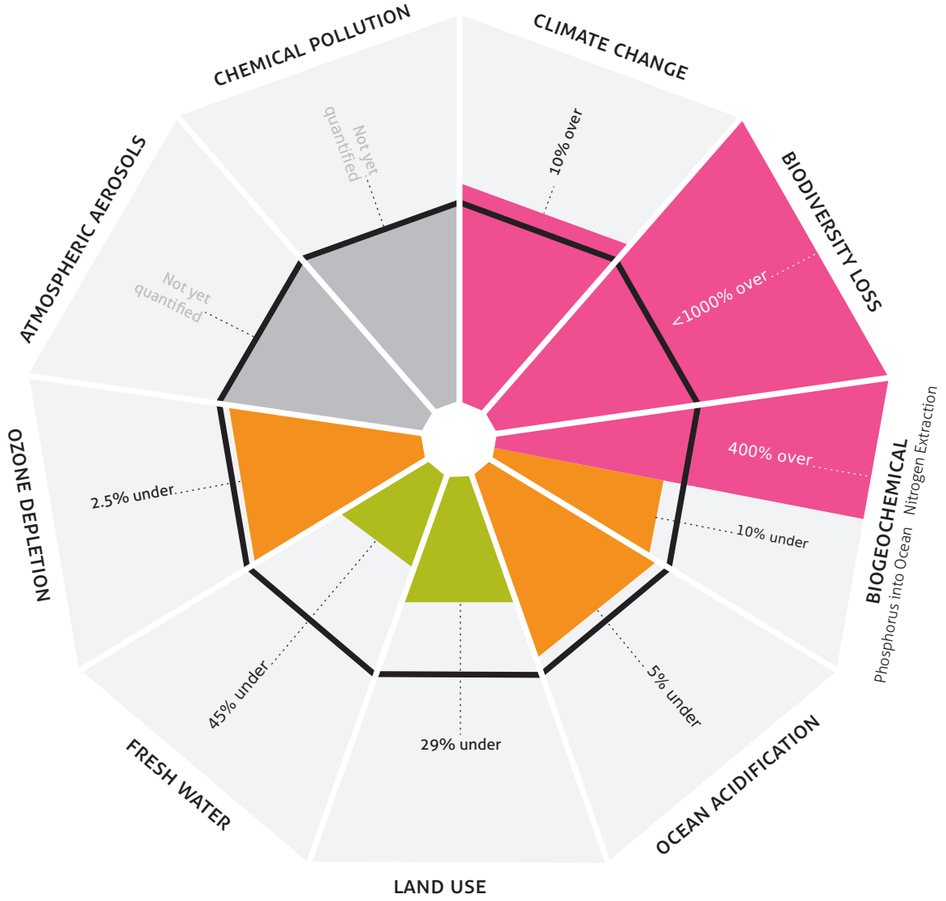
OUR SYSTEM IS FAILING US

We're not talking about the future. We're talking about now. Population growth is the great driver of this system change. That, combined with increasing resource use per capita, creates an exponential impact, increasing scarcity and resource control imbalance. In the last decade, violent riots against national governments have erupted in all major economic zones in the world, including France, the United States, Greece, China, India, the Middle East, Germany, South America, and Asia. The banking crisis saw more institutions and businesses close their doors in 2008 than during the Great Depression in 1930. Food prices continue to rise, while access to good food, water and employment is decreasing the world over. Meanwhile our ecosystems are declining with unprecedented rates. Biodiversity is dropping alarmingly. Daily life is increasingly expensive, while families earn less. Children are exhibiting stress symptoms at a young age and suicide rates rise. These fractures are not for lack of these resources, it's for their unequal distribution. And somehow we become accustomed to news like this. This may be the biggest problem of all. Because, in the end we think, what are we to do?

We can't care enough about this: the system that is our global habitat is failing us. We have stressed its limits. We grew ourselves into a corner. Something has got to give. If that moment comes without control, which way will the system break? Who will come out on top? Who will suffer the dire consequences? The increasinly few that control most of the world's resources, or the rest of us?



Photo: KPA/Zuma/Rex Features

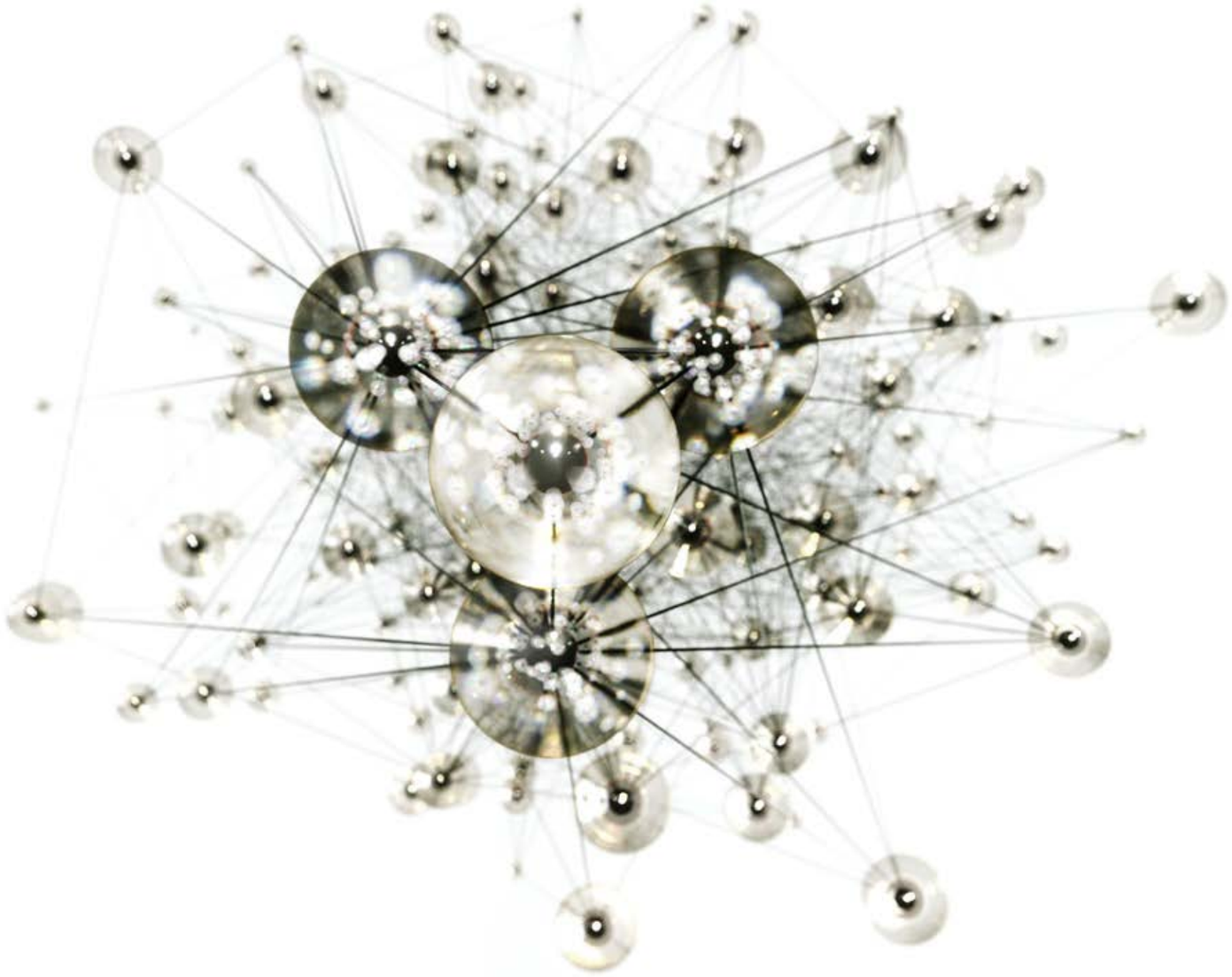


The 9 planetary boundaries, related to their maximum to sustain life (thick black line), updated 2016.

WE CROSS PLANETARY BOUNDARIES

The Planetary Boundaries are a measurement framework developed by the research group of Johan Rockström from the Stockholm Resilience Centre and Will Steffen from the Australian National University. The diagram on the left shows the current state of its assessment (2015). The diagram shows the state of nine indicator groups that each represent a critical resource for the continued survival of mankind on earth. When a planetary boundary is crossed, there is a risk of "irreversible and abrupt environmental change".

The boundaries are still rough, and its assessments preliminary, but the framework's powerful concept demonstrates the need for awareness and further research. In three of the nine categories, the planetary boundary are crossed already, with another two three close to capacity.

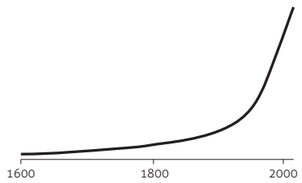


NETWORK IS POWER

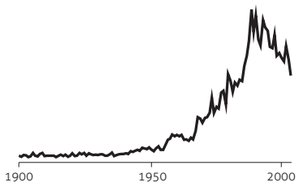
Our communication, energy, food, and trade networks are the systems that control our lives. Without roads no trade, without GSM network no wireless communication, and without cables no power. And underneath it all is the network of our ecosystem, making it possible to be alive. Our times have changed. Networks on all layers of society have superseded individual entities in power. We have seen the rise of a new type of company: the network company, new business models, and operating paradigms. Social networks have rapidly outperformed other markets in their ability to influence people globally. We've witnessed that centralized control of these networks can lead to great injustice, evaporation of basic rights, and new, often invisible power structures.

We have learned to understand that those that control the connections between things, control the things themselves. Like puppets commanded by invisible strings. We have also seen that new ways of looking at the network can provide rapid, exponential change, just look at social media and blockchain. Building lightweight, decentralized, resilient networks are a powerful lever for change, and one of the few ways we can reduce our consumption per capita, while improving quality of life.

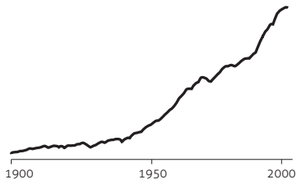
The object-oriented era, where building things was the route to power, is over. The future belongs to those who understand that creating and controlling networks of connections between things are the pathway to power: it is not physical objects that control the system, it's the network. Let's use that to our benefit.



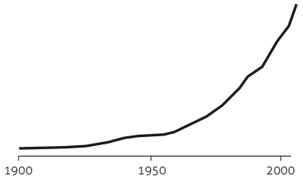
WORLD POPULATION



NATURAL DISASTERS



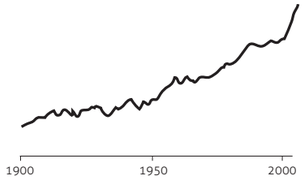
GLOBAL FOSSIL-FUEL
CO_2 EMISSIONS



GLOBAL SPECIES EXTINCTION



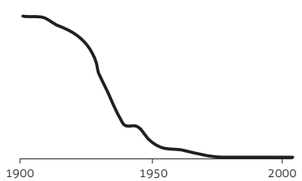
GLOBAL MEAN TEMPERATURES
(ANOMALY IN 5 YEAR AVERAGE)



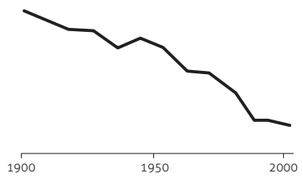
GLOBAL COAL CONSUMPTION



GLOBAL DEATHS IN CONFLICT



POPULATION OF SOUTHERN
HEMISPHERE BLUE WHALES



GLOBAL ILLITERATE POPULATION

FROM GROWTH TO RESILIENCE

The future is uncertain. The continuous growth of population and consumption has reached critical turning points in economic, environmental, and social realms. Our existing economy is built on the paradigm that growth is necessary to ensure survival. Our challenge now is to create an economy that shifts focus from growth as an ultimate goal, to sustainability, and in particular, resilience.

An uncertain future brings with it an inherent unpredictability. We cannot plot scenarios of what is to come, and rely on these as a safe way to plan into the future. The only way we can hope to transgress such a period of uncertainty is by preparing to be able to overcome the unknown. This is what resilience planning does. It helps us to strengthen society in a way it can manage, adapt, and overcome unexpected challenges. Challenges such as increasingly erratic economic shifts, resource shortages, weather patterns, shifts in biodiversity, and social unrest. A resilient society is built by adapting its networks to deal differently with the resources we have. By reorganizing how the elements of our societies are related to one another, allowing them to become more flexible, adaptive, transparent and diverse, society becomes more resilient. For example, moving from linear systems of resources and production and consumption to more circular ones. From centralized power systems to decentralized agent based systems. From monocultures to polycultures in agriculture and urban planning.

While the network dominates the power of our world of today, the companies, governments, and agents that understand the power of resilience will be the leaders of the future. How then, do we build towards resilience and sustainability?



ROADMAPS TO RESILIENCE

We understand that rebuilding the foundations of society, changing the operations of multi-nationals, and altering the patterns of metropoli are challenges we have never faced before. That these are unusually complex challenges, which are also numerous. We have a choice. To simply not try for lack of courage, as we proclaim it impossible, or to find reasonable ways to proceed. We are not without help. We have an increasing workforce, intelligence, knowledge and data, technology and insight on our side. And we have a growing awareness of the necessity for a new pathway.

For us to move forward with the speed we need, on a constructive pathway, we have to find the right balance between evolution and revolution. In this pathway, we replace growth-focused organizations with resilience-based systems step by step. Some systems are eradicated. Some are optimized. And for several vital ones, we start new innovative ones in parallel to keeping older systems. Until the old is not necessary anymore, and the new world overtakes. Each part of our system is different, and requires a different approach. And for each, we need a pathway. Because all will need to change.

Progressive pathways for change are a realistic and feasible approach to practically start moving on the short term, and head towards the 100% goal in the long term. This can be done, if we create significant benefit for all parties involved. All parties take care of their own interest, but as a whole, we move in the right direction. Like instruments in an orchestra, we all have our part to play. We bundle these different pathways into roadmaps, cooperative models of orchestrated change, always leading up to the 100% of our goal: a truly sustainable society.



Symbiosis in Development

LET'S GET STARTED

What are the steps to get this going? A first step in the development of these roadmaps is to develop a systemic understanding of how our world works, and where we can best intervene. We look at layers where stakeholders and systemic forces operate, from ecological processes, market forces, social patterns, law, and engineering. We then use system mapping to see connections and the character of the network. From this we use creative problem solving to discover intervention points that bring benefits across the board. These interventions provide the notes in our symphony. To weaver the symphony of our roadmap, we plot these in time, maximizing supportive effects, and build the long-term strategies. We map each party's contribution into action plans, their benefit, cost and impact, and woven together into unison. These action plans of interventions together provide us with a unified roadmap for change, towards a resilient, just, and self-sufficient society.

Need some more detail? Great. This book tries to do just that. It provides a structured step by step approach to develop these roadmaps that can be applied to any industry, institution, or complex societal challenge. SiD helps teams cooperate, understand systems, develop resilient solutions, and to build the roadmaps we need towards a flourishing future. 20 years in the making, SiD is a tool to improve the old world, and build the new. The first step in the revolution of evolution. Let's make some Symbiosis in Development.



C. THE ESSENCE OF SID

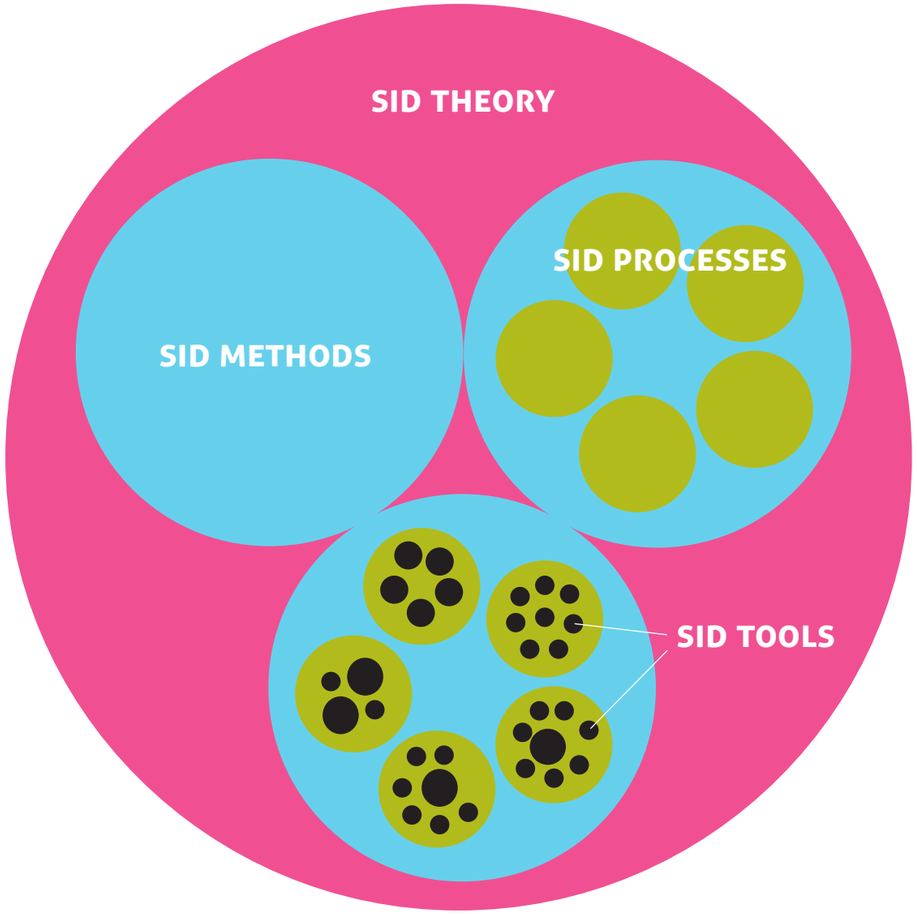
SiD is a framework to develop symbiotic, sustainable solutions. SiD is a complete process from idea to implementation, aimed at teams of cooperating experts, and individuals alike. It combines a holistic systems approach, interdisciplinary collaboration, design thinking, and light-weight iterative development cycles. This results in top-down systemic strategies, activated by bottom-up interventions. The interventions are pushed towards implementation using short term actionplans that follow long term roadmaps towards systemic change. The results are resilient, harmonious, and autonomous organizations, cities, nations, and industry. In its application, SiD gives a deep insight into the interconnected systems our society such as supply chains, bio-based and ecosystem services, circular economies, and system dynamics.

Okay, so that was a bit of a waterfall of terms. At the end of this book, what wasn't clear about that paragraph will be concrete. To start off gently, in this chapter, we provide a global overview of SiD, before we dive into the details of the theory in chapter 1.

WHY USE THE SID FRAMEWORK?

If anything the past has told us, is that no matter where in the world we want to act, big or small, we have to consider long term consequences of our actions. We recognize that we need to take into account all aspects of society in our challenge to end up with a better world. Just focusing on sub-aspects such as energy or food issues are insufficient, as they are all related and eventually affect each other. SiD enables you to take the full system into account at all times, and uses this as a strength to find the most effective solutions that cost the least amount of effort and resources.

SiD does not tell you what to do, nor what is right and wrong. Instead, it allows you to figure out what the right questions to ask are in any given situation. Then, SiD gives you a process to enable figuring out an answer, step by step. It allows you to track possible downsides of your actions, and gives you the tools to make powerful concepts and evaluate them along the way. You can use it alone or with a team, from a small student project or family business, to decade long development and transition projects in cities, businesses, industry, and governance.



SID'S FOUR COMPONENTS

SiD consists of four main components: Theory, Method, Process, and Tools. These components are nested inside one another, as can be seen in the diagram on the left. The structure of this book follows this layering.

SiD Theory is about the fundamental concepts that lie at SiD's core, and explains the main 'language' of the framework, such as the sustainability definition, the anatomy of systems, networks, objects, system dynamics, system transitions, and roadmaps.

SiD Method describes how the SiD theory is applied in a step-by-step process of goal setting, system analysis and understanding, solutioning and roadmapping, and evaluation. The method is an iterative approach; during a single project it is cycled through several times.

SiD Process focuses on day-to-day practice and explains how the method can be applied in a practical project management approach, build a working process from A to Z, build a team, involve stakeholders, etc.

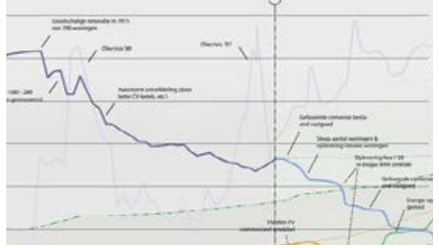
The Tools section lists a variety of useful aides that can be used in a SiD process and may be helpful at various stages of a project.

HOW TO READ THIS BOOK, AND FOR THOSE WANTING TO GET THEIR HANDS DIRTY QUICKLY

This book has been written as a reference handbook. It is not necessary to read it from front to back. You can jump from area to area, and back and forth, depending on your interest.

The first part is highly theoretical, which can take some effort to get through. The last parts are practical, step by step instructions. Depending on your preferred way of learning, you may want to learn more about practice before you start looking at in-depth theory. To facilitate this, each chapter has an introduction, an overview of the content, and further sections dive deeply into the subject matter.

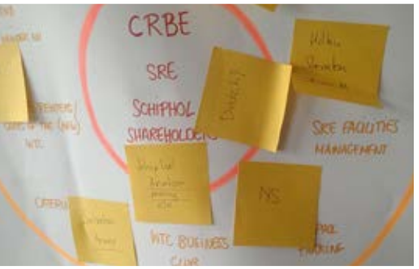
If you want to get a quick practical overview of SiD before diving deeper into details, read this introduction chapter, and then only read the first introductions and overviews of Theory, Method, and Process. Skip the Tools section, until you find a reference to follow up. Then, go back to the sections you want to know more about, and go as deep as you like.















SID TAKES TIME

Mastering SiD, or any systemic sustainability approach for that matter, takes time and effort. The topic of sustainability, and dealing with its many facets, is inherently complex, and rich in knowledge. SiD helps to streamline and accelerate this, but cannot make the challenges simpler in their essence. In our experience, it takes a few years of full-time engagement to master SiD and all its related facets for sustainable development from start to finish. Thankfully, it's not necessary to understand SiD entirely for it to be useful. Many tools and approaches work well on their own, so you can learn step by step, and start implementing it yourself immediately. In those cases, the practical chapters of Method and Process may help you get going quickly, as well as the many exercises throughout the book.

We hope that once you've done a few SiD projects, and you've allowed yourself to become familiar with the theory, it becomes useful even in a day-to-day context. Say when, in the supermarket, choosing between peanut butter brands. We also hope that brings you bright ideas, and solutions you did not know you could grasp without complicated software, or months of work. Once you've reached that stage of systems insight, practicing SiD can be a straightforward affair, almost an like an invisible intuitive process in the background.

MODULAR FRAMEWORK

SiD is a modular framework that allows existing tools from outside the framework to be slotted in when necessary. SiD is a framework, not a belief, dogma, or certification system. It's flexible, adjustable, and open for you to add your own techniques and change it where you want. Feel free to apply tools that you already know at any point in the process. For example, you may know some business analysis tools like doing a SWOT analysis, or Life Cycle Assessment (LCA).

GO IT ALONE OR TOGETHER?

Many examples and exercises in this book are geared towards small teams of people (3-5) working together. However, SiD was developed as a solo-tool at first, and works just as well for that. SiD has also been tested in the field with up to 70 stakeholders working together. Sometimes it's better to do certain sections of a challenge alone, and others as a group. We give pointers about this along the way, mostly in the Process section.

SID: THE A-HA MACHINE GIVEN TIME

In our experience, SiD is great for getting those unique 'a-ha' moments where you suddenly see 'it'. That one epiphany that makes all the difference, that perfect solution that afterwards seems so obvious. SiD's method 'uploads' available information about the system to your mind, where it's processed to recognize patterns in these systems. To suddenly see patterns in complex systems and derive a way forward, we have few tools to rely on but our own brain. These patterns are often the key to great solutions, but your brain needs to marinate in the challenge to find them. In this mental process, which is to a large degree subconscious, it is vital to allow yourself room for creativity and relaxation. Just as Archimedes needed to be forced by his wife to take a bath, resulting in his 'Eureka' moment of discovery, so too will your brain need mental rest to process in the background. So, to drive the point home, you can't cram a SiD process into a few hours and expect it to work miracles. Taking time away from the problem during the 'system understanding' phases greatly expedites 'a-ha' moments. Make sure to allow this, no matter what format you choose to work in. You'll thank me for it later.

OPEN SOURCE AND SHARING

SiD stands on the shoulders of giants, learning from ideas and frameworks developed by others. To support this process, I made SiD open source. Many of the diagrams and aids discussed in this book are free to download on the SiD website www.ThinkSiD.org. If you want to alter or share this book, or any SiD materials, you can do so, by complying to the Creative Commons license at the end of the book. If you make any tools, or improve the ones available, please share them back with the community.

By making SiD open source, we hope SiD itself is sustainable and has a bright future in building a sustainable society, and we look forward to you joining us in this mission.

creative commons

BY NC SA

SID & THE UN SUSTAINABLE DEVELOPMENT GOALS

The United Nations published its list of Sustainable Development Goals (SDGs) in 2015, as part of its 2030 agenda. We introduce these here, as they come back throughout the book in various forms. When the SDGs were released, we were thrilled to see that they emphasize a holistic approach to sustainability with 17 global challenges to achieve a sustainable society. See the diagram on the right for the full SDG list.
The list shows, as SiD argues, that sustainability is a challenge that goes beyond mere energy and material concerns. The SDGs are powerful for communicating and reporting this, and tools to support them are under development around the world. SiD is used to analyze SDG impacts, organize and process to develop solutions for them, and as a reporting framework for the SDGs. Or, in reverse, the SDG's can be used as a goal framework to guide a SiD development process.

The SDG's are also a helpful reporting framework, to communicate the impacts of your projects. The SDGs do not (yet) have clear corresponding goals, does not show interrelations between the SDG areas, or provide any form of a working framework to achieve improvement. Also, the SDGs do not by themselves stimulate a systemic approach. While systemic in their origins as a whole, each SDG goal is in itself object oriented. This means that for now, the SGSs are most useful as a set of object oriented areas of concern, as a sub-goal set, or final reporting framework of impacts only. This is useful for policy and goal setting, and reflecting on targets, but not as a framework for systemic improvement.



A WORKING FRAMEWORK FOR THE SDGS

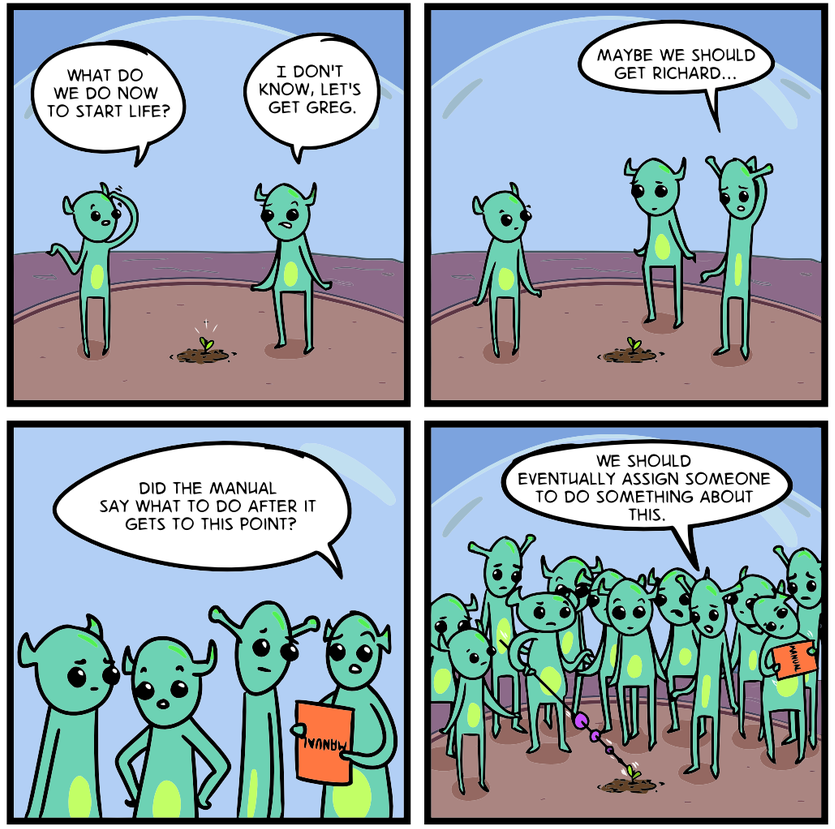
In order to actually work towards improvement on the SDGs, we need a working framework. This is where SiD comes in. SiD can explore the SDGs given a certain challenge, map their impacts, and detect interrelations on a systems level. Beyond that, SiD can show the system dynamics behind them, and their network of interrelations. From this, powerful systemic solutions can be found that positively affect multiple SDG areas at once. In the process, SiD guides you to find and plan activities to make a lasting long term impact on the SDGs, and beyond, towards resilient, harmonious and autonomous societies.

See page 74 for a diagram showing how the SDGs can be mapped onto the SiD framework.

SDG IMPACT SCANS

For determining the impact of organizations on the SDGs, and help reporting and impact improvement, Except started development on custom built SiD SDG scans. These include custom indicator sets for specific industries, and data collection tools. This is an ongoing effort, as well as SDG impact scans for cities and sectors such as agriculture. There's still a long road to walk to achieve this. The next years will see effort of parties around the globe to start working on new tools that help to achieve positive results on the SDGs. Keep an eye out, they may be valuable for SiD processes and other integrated sustainable developments.

With that short introduction to the SDGs, let's end the overview of SiD with an example of a happy alien colony, demonstrating a use of SiD's theory.



A HAPPY COLONY OF ALIENS IN SPACE

The objective of sustainability is, put shortly, for mankind to continue to survive on this planet. Preferably, flourishing and happy, but that requires survival in the first place, and lack of critical hardship in the second. What does it take for us to survive like this? In order to figure this out, and get a feeling for its base principles, it helps to use the following thought experiment. Imagine an alien colony floating around in space. What does it take for it to survive? Imagining this clarifies some of the base theoretical principles of SiD, which is helpful to have in mind before diving deeper into the theory chapter. So let's have a look.

PREVENTING COLLAPSE

In order to understand how our alien colony floating around in space can continue to survive, it helps to think about its reverse, preventing it from collapse. This, since societal collapse has been well defined and studied. Collapse doesn't have to be complete annihilation, it is more often the degradation of a civilization to a more primitive state. In either case, collapse goes hand in hand with death and destruction of all kinds of values we hold dearly, such as cultural sophistication, economic value, and human rights. We don't want that, and therefore we want to prevent it.

Here we have our alien colony. Floating in space. They are lovely aliens, they merely hope to survive and flourish. Let's look at what they'll need to achieve this, and not collapse.

THE COLONY NEEDS AUTONOMY

To begin with, the colony will need their basics in order. All life needs some input of resources. They may need to consume sustenance to stay alive, which they need to make. They may also need heat to keep warm in space. Basically, they'll need some material resources, perhaps including things like medicine to stay, in the most basic form, alive. In order to stay that way, they need to have an indefinite supply of these resources that will keep the colony alive, and an infrastructure of extraction, production, and distribution. This may include recycling everything to reduce reliance on outside sources, and so on. In SiD, these requirements are covered under the word 'autonomy'. Autonomy is about the colony's self-sufficiency, and making the decisions to remain that way. Okay, Autonomy covers the basic needs. What else do they need to survive?

THE COLONY NEEDS HARMONY

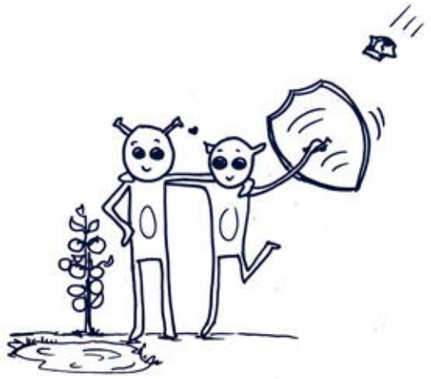
In order to survive further, the colony should maintain some level of peace. It's all fine and well to have enough food and medicine and shelter, but if there's so much tension that they keep killing each other, well, that will threaten their existence. Things that may cause them to be upset with another can include how resources are shared, power structures, participation, and so on. All things related to this are called 'Harmony' in SiD, which point to the need for the management of internal tensions of the colony.

THE COLONY NEEDS RESILIENCE

With autonomy and harmony in place, they're doing pretty well floating around. But then there's outside influences. They're floating in space, so at any time, a meteor or whatever unidentified thing can cross their path. They can be floating by a moon, and its shadow takes away the light of a star needed to survive. Or whatever you can think of can happen floating in space.

In order to deal with this and survive, they need some properties. For example, they need to be able to detect things coming their way, like our eyes help do. Also, they need to be aware about what the meaning is of what they are seeing (awareness). And, if they understand that some giant space rock is hurdling their way, they need the capacity to get out of its way (flexibility). In the event of being struck anyway, it would help if there isn't just one alien, but many, so that at least some will survive (redundancy). There's a bunch of these aspects that help the colony to survive unexpected and sudden changes in their environment. These we call 'Resilience' in SiD. All the aspects such as awareness and flexibility come back in SiD's sets of network parameters that drive Resilience, and help to figure that out.

So, in order for a colony to not collapse, they need to be autonomous, in harmony, and resilient. If they have these properties, they can survive. If they manage to get them up to a certain level of comfort, they also set the preconditions for them to flourish and be happy, if they want.



THE COLONY NEEDS HEALTHY SYSTEM DYNAMICS

These three aspects, autonomy, harmony and resilience, form the foundation of a sustainable society. If all three of them are in the 'green' then the colony has a good chance to survive. But, it's never that simple. These three aspects influence one another. For example, increasing the colony's resource intake, and thus their autonomy, may make them heavier. This then reduces their agility of movement, which reduces their resilience. There's hardly ever an ideal move, there's always a trade-of, within certain contextual circumstances. Some of these interactions can get rather complex, much more than a simple trade-off. Some may develop slowly over time, or are so subtle on an individual's basis that we can't see their massive effects on a grand scale, like climate change. We call the patterns in these interactions 'system dynamics', or 'system behaviors'. These are critical to keep in mind when trying to make the alien colony survive. For example, the relation between autonomy and resilience changes when the colony grows: it cannot grow indefinitely using the same structure. As it gets bigger, resilience is reduced if autonomy isn't changed in structure by decentralizing infrastructures, and so on.

It would be great if the alien colony has a detection system to find these shifts in resilience. Unfortunately, we humans don't really have an example they could follow. As a human civilization, we're pretty good at understanding that we need to secure water, food, power, and some other resources to survive; the autonomy part. We mostly understand the importance of the harmony part but we're not particularly good at arranging that (yet, I hope). The resilience part is where we still struggle the most, which eludes us often. And that also causes us to miss important system dynamics between all of them. We do not really have the 'eyes' to see them, or even the awareness of their existence. We make many decisions that make us less resilient in the long run for short term autonomy or harmony gain. As our society grows, we see increasingly self-reinforcing system behaviors that threaten our survival through it. This will make us sitting ducks in space, like an alien colony in space unable to move, eating up finite resources until it perishes.

For example, we are only recently aware of one of the most important system dynamics that we face, one that all of our societies are governed by, both the alien colony and us. The one system dynamic to rule them all: the law of diminishing marginal returns. We have no detection system, metrics, or governance in place to deal with this on a societal level yet. Large companies that are heavily subject to this are often not even aware it exists. For anyone wishing to survive in the long run, the alien colony as well as us, we best start looking at these things. Below I explain a little about the importance of the law of diminishing marginal returns, as an example of how critical the understanding is of these systemic behaviors. Further in the Theory chapter we discuss others as well.



DIMINISHING MARGINAL RETURNS

Joseph Tainter (1949-) is an anthropological scholar and historian, and one of the world's most interesting experts on societal dynamics. Tainter was fascinated by one central question: why did old civilizations cease to exist, even sophisticated ones? He wasn't happy with the usual answers, for example that the Mayans collapsed because of a famine, and the Roman Empire because they were overrun by Barbarian tribes. He figured the Mayans had dealt with famine before, and the Romans dealt with Barbarians before, so he wondered what was it that made them collapse this time around? What made their societies so fragile that they couldn't overcome that adversity? So, he studied a lot of old civilizations, including Mayans, Chacoan, and the Romans, using network and complexity theory, and he found a pattern. He wrote a magnificent book about it called the Collapse of Complex Societies (1988). In this book, he shows that societies become 'brittle' over time due to the law of decreasing marginal returns, an over-arching system dynamic. We get further into system dynamics further in the theory chapter, but to summarize here's a short simplified overview.

As a society grows and develops, it increasingly needs more of everything. A developed society has a larger footprint per capita than a more simple society, and this is an irreversible process (until collapse). More of everything means not just more energy and food, but also less tangible things such as capacity to handle trade transactions, cultural diversity, and management overhead. This means resources, including time, need to come in increasingly large supply to satisfy the needs of a society. And there are always limits to resources. Once the resources become scarce, it puts pressure on everything, making the system 'brittle'. If not a new, more concentrated form of the scarce



resource is found, the system becomes critical. At that point, pretty much anything can set off the process of collapse. Collapse can then be slow and gradual, like with the Roman Empire, or with a sudden shock. As mentioned, collapse doesn't mean a total eradication per se, but certainly a decrease in complexity, and with it, a reduced capacity for support for many people, meaning death and suffering.

So, applied to our colony of aliens, it means that when it grows, it will need to fundamentally change its operations, infrastructures, and even base resource usage patterns to prevent becoming brittle and collapse. Even out in space, where there is infinite room to grow, there are limits to growth, and a necessity to tune systems to their changing dynamics over time. So, besides being autonomous in having food, energy and materials, and besides not killing each other, the colony needs to be aware of and adapt to changing system dynamics to remain resilient, and survive whatever the future throws at them.

LEARNING FROM ALIENS AND COLLAPSE

Looking at our world, we can see the cracks in the system of our increasingly brittle society appearing. One can even deduct large societal movements such as the Arab Spring or the rise of nationalism in the western world as early systemic warning signs. We also have some hopeful unique properties that may help us in the long run. Our society is unique in comparison to older civilizations in that we are globally connected. For the first time in history, we have a world economy and resource system that can help to balance resource needs. This can keep a certain part of society from collapsing on its own. The downside of this is that this puts harmony under pressure. There's already a fair share of issue with migration, and countries stealing each other's resources such as oil, land, food, and water.

We also have unprecedented technological advances, that may allow us to tap into more concentrated or abundantly available resources, such as renewable energy and nuclear fusion. This may help us beat the curve until we finally figured out that we need to globally curb our own growth, or figure out ways to deal with the growth cracks until we do.

But, besides battling the symptoms, even better still is for us to learn, understand, and apply the solutions that systemic insight brings us. We can develop some eyes and awareness of them, and develop ways to ride the wave of change out of the danger zone. Like the alien colony setting up control rooms to check for system dynamics in their colony. It's not hard to imagine some beautiful screens showing the development of their colony, some essential parameters to track, and a panel of wise aliens determining how to act on its dynamics.

There is no reason to think that our society does not comply to the law of diminishing marginal returns, and there is plenty of proof to indicate that we have become increasingly 'brittle'. But there are still many ways we can go forward. In that, it helps to allow ourselves to start looking at our society as an alien colony floating in space. What systems would we put in place to detect these system dynamics? Where in the system that has become brittle can we intervene to increase resilience? What measures can increase autonomy and resilience at once? How can we better embed harmony in the world? What part can we play in this? Questions I hope using SiD will help you answer.

CASE STUDY: IKEA'S SELF LEARNING SUPPLY CHAIN

"I never fully realized IKEA's true power until we did this project," says Matthieu Leroy, Sustainability Specialist at IKEA Media Production. To improve the green procurement of paper and print for its 200-million-copy catalogue, Media Production of the furniture giant from Sweden teamed up with sustainability innovator Except Integrated Sustainability. Together they worked with suppliers, Trade Extensions, and Deloitte on creating a sustainability-driven Self-Learning Supply Chain that's transforming the paper and print industries around the world.

The largest annual print run on the planet, the IKEA catalogue, achieved 100% Forest Stewardship Council (FSC™) mix credit certification for more sustainable paper sourcing worldwide in 2014. But that was just the start. Leroy: "We were looking for a game changer to make the entire life cycle of the catalogue much leaner and greener."

So, in spring 2014, a half dozen specialists from Except locked themselves up with IKEA staff for a three-day innovation session at Except's headquarters to find that



game changer. Fast-forward eight months, and IKEA's purchasing managers have a brand-new purchasing interface at their fingertips that helps push the catalogue's sustainability footprint down.

As a result of the significant contributions from all collaborating partners CO_2 emissions per catalogue copy dropped 28% between FY14 and FY16. Energy consumption per copy went down 5% in that same period. The use of renewable energy increased 30% and water consumption diminished 35% in the last year alone, by selecting suppliers with lower environmental footprints.

SYSTEM THINKING FINDS BREAK-THROUGH POINT

Tom Bosschaert, founder and director of Except, explains: "We always look for the smartest lever to effect maximum change within a system, be it a company, a large city, or a global supply chain in this case." To find these levers, Except used its Symbiosis in Development (SiD) framework, combining systems thinking, network theory, and life-cycle understanding in a co-creation process. By visualizing the complex networks surrounding the catalogue the team discovered how the system can be changed most effectively at the root.

Executing this approach on the global supply chain of the IKEA catalogue was a particularly interesting challenge. What hidden levers would be exposed to effectuate maximum positive change? Tom Bosschaert continues: "We've done this process hundreds of times. We know it works, but each time is equally thrilling, because you simply don't know what will come to light. Where do the hidden gems lie hidden this time?" As it turns out, in this case, a powerful solution was found hiding in exactly this network.

DISCOVERY: UP-CYCLING INFORMATION

IKEA had already collected a significant amount of sustainability data from 130 paper mills and printing factories across the globe that may participate in IKEA's catalogue production. While this data was there, during the systems analysis, it was revealed that the supplier selection was not utilizing the smart choices this data could provide. While present, the data had become simply too much for any human mind to process.

In the first SiD co-creation session the team of IKEA and Except worked for three days non-stop on creating the strategy for the development process to come. Using systems-mapping they created insight into the data that describes the life cycle of the catalogue from forest logging and paper manufacturing to print. They also mapped which people in the decision making chain of the catalogue had the biggest influence on its sustainability performance. From this systemic analysis the team could pinpoint where the biggest sustainability gains could be achieved with the least amount of effort and time. In this case, improving the use of already-available information was the key. By visualizing data in a different way, more insight was derived, leading to better decision making on what supplier to pick at critical points in the life cycle of the catalogue. And that boosted its performance.

They also saw that data sharing with, and within, the supply chain enabled suppliers to compete and cooperate to create the best performance for themselves and the supply chain as a whole. They then set out to build the tools that did this.

HUMAN SCALE DATA

After validating the data and calculations in the database, a team of IKEA, Except, and Deloitte clustered the existing data into 18 Key Performance Indicators (KPIs) summarizing numerous sustainability, quality and operational metrics of IKEA's 130 potential supplier locations worldwide. Next, Except designed a visual interface that intuitively displays all of this data in a single glance. It uses an infographics driven overview that ties into the existing Trade Extensions platform used by IKEA for its data collection and sourcing optimization process.

Before, purchasers had to delve through pages of data in an excel sheet to evaluate a supplier's performance. The visualization tool completely changed this with a screen of color-coded visual graphs that gives the purchasers an instant overview of a supplier's entire performance, quality, and sustainability KPIs. Mouse-overs reveal more granular data as needed. The design gives the user control over how they view and mentally process the data, which leads to better decisions in a shorter timeframe.



The self-learning supplier-selection dashboard for IKEA. Each line shows over 250 KPI's summarized in one instantly understandable mosaic of colors (Anonimized).

SUPPLIER RELATIONSHIP

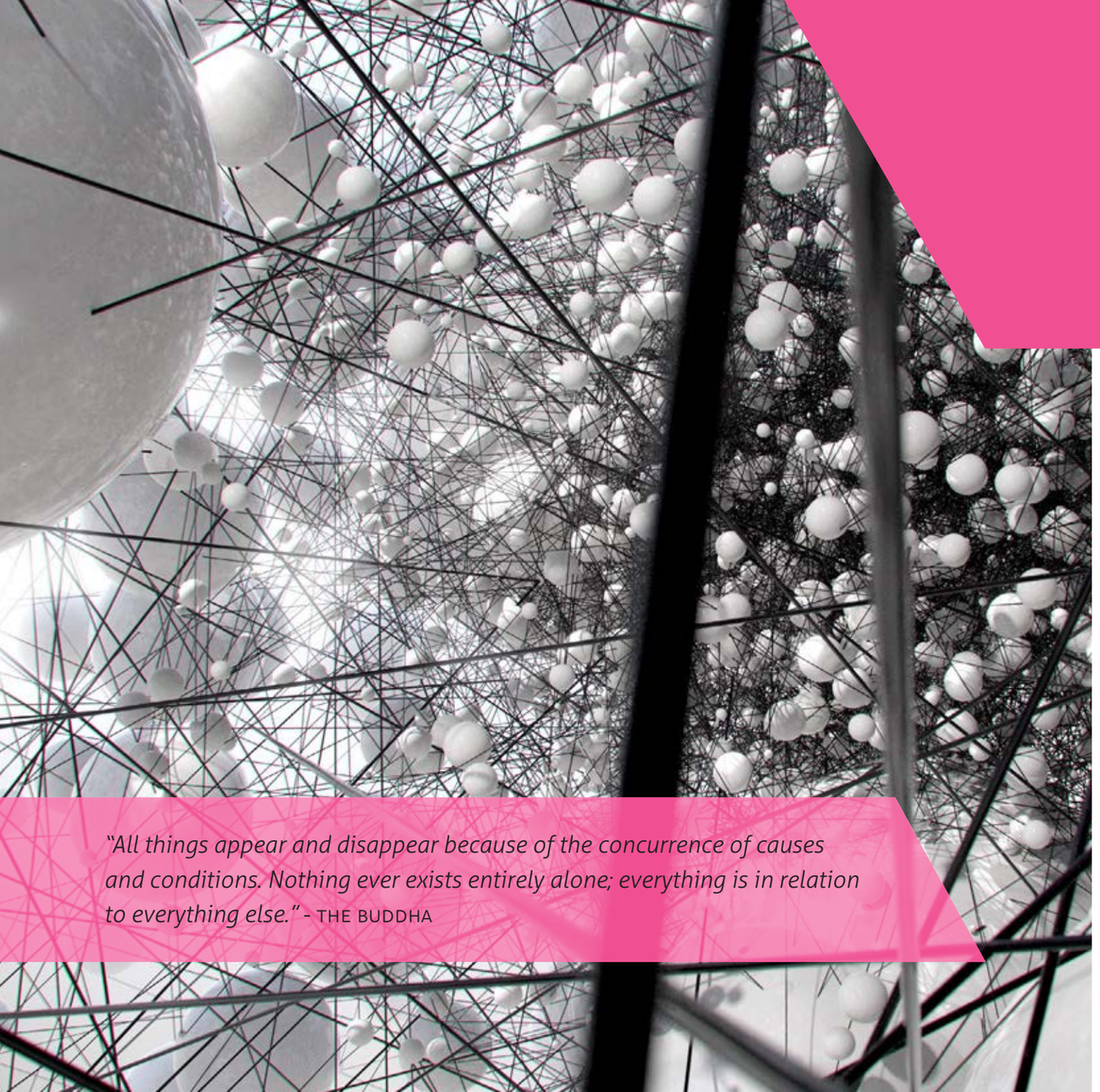
Now that the internal decision making process was improved with the visualization tool, the next step in the strategy was to focus on the performance of the suppliers themselves, effectively the global print and paper industry. Before, suppliers delivered data about their operating performance to IKEA, and IKEA would use it to make its purchasing decisions. Through the process, the team realized that the catalogue performance could be boosted from the side of the suppliers by feeding back critical information on IKEA's decision making. In effect, this generates a 'supplier race', where suppliers start competing with each other through greater intelligence on their position relative to others, IKEA's green goals, and helping them see what they can do to improve. It helps them prioritize their corrective actions, improve performance and as a result to be considered by IKEA for business increase. The feedback also improves the value of the data process for the suppliers themselves, incentivizing participation.
The intent of this is to boost the performance of the entire industry, not just those suppliers picked for the catalogue production. It's an example of IKEA taking responsible action within the entire supply chain. As one of the IKEA purchasers discovered: "Suppliers started using it to make the case for investment with their management or Board", showing how the increased insight of decision making is already starting to influence companies up the supply chain.

INTERNAL IMPACT

IKEA applies a similar logic to its relations with internal stakeholders outside of the supply chain. It wants to build transparency and dialogue on the sustainability aspects of its catalogue production process. Enter the Data Dashboard, a compact version of the Purchaser Dashboard, minus the granular data and functionalities. The Data Dashboard serves internal stakeholders such as store co-workers and catalogue responsibles. The Data Dashboard shows the history, current status, and targets for 13 aspects such as input materials, energy, CO_2 emissions, and waste, aligned with the Global Reporting Initiative (GRI G4).

SIGNIFICANT RESULTS IN A SHORT TIMEFRAME

"These dashboards are strengthening the interactive, collaborative dynamic with all of our stakeholders, from suppliers to the general public," notes Leroy. "I knew that, as a big player, IKEA had the leverage to drive a transition toward greater sustainability in our own paper and print supply chain. We have the potential to create positive impacts at the industry level that extend beyond our catalogue production. That's far beyond what we originally expected or imagined." For a project with a start to end time of less than a year, it makes an exemplary case for the systemic approach to performance improvements in sustainability, efficiency and financial performance. The team is now looking at ways to implement the same thinking elsewhere in the system for further performance increases.



"All things appear and disappear because of the concurrence of causes and conditions. Nothing ever exists entirely alone; everything is in relation to everything else." - THE BUDDHA

1. SID THEORY

This chapter outlines the foundational concepts for applying a system-level understanding of sustainability. This is fundamental not only fur understanding SiD, but to figure out what sustainability is in general, and how you can work with it. In this section we create a shared language across all team members, essential in cooperating in multi-disciplinary teams. For this, we'll define what exactly we mean by words like 'sustainable', 'system' and 'complexity'. These concepts underpin Method, Process, and Tools, together enabling you to develop pathways towards sustainable systems. We'll also dig in a little about system dynamics and other related theoretical aspects that may help you advance over time.

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1.1 WHAT IS SUSTAINABILITY?

1.1 WHAT IS "SUSTAINABILITY"?

In this section we discuss the importance of a good definition of sustainability, and unravel SiD's own version of it. Besides being fundamental for understanding sustainability, this section can also give renewed insight into what our world could be, and how we can relate to it. By envisioning a better future in this way, it captures the beating heart of SiD.

THE PROBLEM WITH A VAGUE DEFINITION

Ask ten people what they think sustainability is, and you get ten different answers. Likely responses are things about material recycling, prevention of waste, renewable energy, and issues surrounding the climate. Others feel sustainability is more about how we'll manage to survive as a species on this planet, curbing population growth, or saving biodiversity. As one of the most important words of the last few decades, sustainability as a concept is the driver of many programs and initiatives in society. If understood correctly, it represents the pinnacle of challenges in our century. Yet, as important as it is, there is little solid ground to find when investigating what sustainability exactly is. And this is a problem.

Since the start of this century, the realities of our impoverished environment, social inequality, fragile economy, and unstable climate, have brought 'sustainability' to the forefront of debate in almost all sectors. Inevitably, the word has eroded since then. At this point, it is used in virtually every marketing strategy, political speech, and new product labeling. We see that many 'sustainable' developments are not sustainable at all, often due to a lack of understanding of what it actually means rather than any nefarious purpose. Because the word is so often abused, it loses energy, meaning, and power.

To add to this erosion of meaning, time has shown a fair amount of well-intended sustainability measures that turned out to make things worse. As they say; the road to hell is paved with good intentions. There are regulations on power saving, in the name of sustainability, that produce increased environmental toxicity. Some recycling practices burden developing countries and hurt social equality, and many 'sustainability' certifications, labels, and policies seem to simply invent their own reality, and sometimes do more harm than good. At the same time, virtually no-one seems to have the

tools and methods available to separate the wheat from the chaff, so to speak. This leaves these issues lingering, and enables less than pure motivations to take advantage of the situation. Next time you see a disposable bag claiming it's a sustainable product, realize that the word 'sustainability' in this case, and you yourself, are being made a fool of.

Vagueness in understanding the very foundation of sustainability is not the only issue we face, but it's certainly a large part of it. After all, if few people know what something exactly is, how could you hope to achieve it? Imagine two people trying to build a house together, but with a different understanding of what the house should be. It would be a disaster. If we don't agree on what the word 'sustainability' means, it's impossible to agree on what we're trying to do. Having a good definition of sustainability is therefore fundamental to any attempt at doing something 'sustainable'. So, why is the term 'sustainability' so elusive and vague? In part, this is due to history, and in part, due to the complexity of the subject.

THE BRUNDTLAND COMMISSION DEFINITION

The most used definition of sustainability, or actually, of "sustainable development", is derived from the 1987 United Nations report called Our Common Future, written by the Brundtland Commission. This definition is adhered to in most policy and development trajectories globally. It states that:

> *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*
>
> Brundtland Commission of the United Nations (1987)

This definition has inspired many, and has been instrumental in achieving the realization that sustainability relates to time and to people. It's been the source of insight for many, that it is our children that will bear the consequences of our choices. Unfortunately, that's also what makes the definition hard to use, and, in the end, creates confusion and indecisive situations. We surmise that the Brundtland definition was probably never written to be used so extensively as it is, but as a de-facto standard, it needs to be evaluated for what it has become. Let's look at why the Brundtland committee's definition is problematic.

Firstly, this definition is not describing what sustainable development is, but what it should result in. Meeting the needs of current and future generations is an outcome of sustainable development, not the process or the thing itself. This makes it not be an actual definition. This makes all the difference in trying to get to the heart of the sustainability issue. You can't use it to evaluate what you're doing. It's like trying to explain the rules of soccer by stating the scores of a match. In order to evaluate sustainability, the Brundtland commission definition misses quite a bit.

Second, it's great to preserve options for future generations, but future generations do not have a voice. We can't call up the future to ask whether or not we did something right or wrong, so it's difficult to evaluate based on this definition.

These, and several other issues, make the Brundtland definition, while important, inspiring, and useful in some cases, not useful as a foundational definition. When pitted against some of the more confusing issues



of our time, or when used to solve difficult questions, the Brundtland commission's definition rarely creates clarity.

Other definitions of sustainability exist, such as the following:

> *"A strong, just and wealthy society consistent with a clean environment, healthy ecosystems, and a beautiful planet."*
> Thomas and Graedel (2003)

> *"A sustainable global society founded on respect for nature, universal human rights, economic justice, and a culture of peace. "*
> Earth Charter (2009)

These exhibit similar issues, mostly defining what sustainability should lead to or looks like, and not pinpointing what it actually is. We found that for SiD we needed to fill this gap. What is sustainability, then?

SID'S SUSTAINABILITY DEFINITION

SiD's sustainability definition is printed on the right in appropriately huge letters. The first two sentences define what sustainability is, actionable, and testable. The second part exemplifies what the definition means when applied to our civilization. In order to understand the power of this definition, we'll unravel the first two sentences, discussing its main concept of system-orientation, what a state is, and what we mean with complex and dynamic. If you understand why the definition is like this, you'll grasp the most important lesson in this book. Let's explore that, step by step. Hang in there, it's worth it.

SUSTAINABILITY IN RELATION TO SYSTEMS

The first part of the definition nails sustainability down as a 'state of a system'. That may seem needlessly abstract. Why use such difficult language, what's the use of defining it this way as a 'state', and what is a 'system'? There's certainly value in simplicity, so let's see why we chose to define it in this way, and the power of insight that comes with it.

Consider the following thought experiment. Imagine you have just bought a toothbrush that says it's sustainable on the package. What exactly does this mean? Does it mean the toothbrush is made from environmentally-friendly material? Does it mean it's made without slave labor? Does it mean that it promotes a sustainable lifestyle? Or all of the above? Contemplate the toothbrush's bushy existence and its influence on society. You may find that the toothbrush's impact on society is different depending on all kinds of contextual factors. For example, the impact of it on the environment differs when it's used daily with a lot of water or with very little water. Or if its production process involved toxins that were dumped in a river or not. This impact

THE SYMBIOSIS IN DEVELOPMENT SUSTAINABILITY DEFINITION (V4):

Sustainability is a state of a complex, dynamic system. In this state, a system can continue to flourish resiliently, in harmony, without requiring inputs from outside its system boundaries.

Applied to our civilization, this state is consistent with societies powered by renewable energy and closed loop material systems, living in thriving ecosystems, on a biodiverse planet, with healthy and happy individuals living in just, tolerant, and diverse cultures, supported by open and transparent economies.

also changes depending on where it's made, and how it was transported to you. It will change in the future when it's incinerated after its useful lifespan rather than recycled to make a new product. And of course, it helps to support a hygienic set of teeth, which will prevent suffering later, but that's not just related to the toothbrush.

Therefore, if you really think about it, the 'sustainability' of the toothbrush depends on factors outside the toothbrush itself. Sometimes it depends even on factors that have not even happened yet, such as what you will do with it when it's worn out. Because the product does not carry in itself the control to define how it's made, used, or discarded, you can't really say that much on the 'sustainability' of the toothbrush from the object itself. Sustainability is, at the very least, part of many factors that lie outside the toothbrush, in its production cycle, its social impact, how it will be discarded, etc.

This leads to the realization that an object can't really be called sustainable without knowing the answers to these questions. And really, when you think about it, we don't really care either. We are not interested in an eternally existing toothbrush. (At least not in this book.) It's not so much about the toothbrush itself, as it is about all about the relations of the toothbrush with things that we do care about, the environment, the people, your life, society, etc.

This example explains why, in SiD's perspective, sustainability is not a physical property of material objects. Sustainability in SiD is expressed on the system level. This implies, when talking about it in general terms, the 'system' of human society on this planet. What we mean with that is, that it doesn't make much sense to talk about a sustainable toothbrush or not, but more about to what degree a toothbrush affects the sustainability of society. In this perspective, saying that an object is in itself 'sustainable' is simply nonsensical. It's a bit like saying a person is 'love'. This makes no sense, because 'love' is a relational quality. It is something that describes a relation between things, and is not a property of them. Just so with sustainability.

This is the case for all objects when talking about sustainability. A wooden table is not necessarily more sustainable than a metal table, an electric car not always more than a petrol driven car, and natural medicine not necessarily more than artificial medicine in every case. Their impact on society depends on the context in which they are used, their life cycle, purpose, and their role in the system as a whole. At the time of writing, for example, electric cars are not yet technologically advanced enough to be used as ambulances, because of their long charging times. This means choosing an electric vehicle as an ambulance would mean they would sit charging for several hours a day in which they cannot be used. This may drive up the cost of healthcare, or maybe cost human lives, which may not be worth the environmental impact reduction of using a petrol ambulance. But who knows, maybe next year they are?

While we can certainly speak of eco-efficient products or environmentally friendly objects, we can only speak of sustainability in relation to systems. The object itself is a manifestation of something else, such as a need, a desire, societal trend, or just as a historical artefact. We care about the continuation of our society, and this is what sustainability is about. It's the part the Brundtland commission definition got right. This makes sustainability a property of a higher order than objects: a property of the system in which the objects reside, where all things interact.



WHAT IS A 'SYSTEM'?

If sustainability is a state of a system, what is a 'system' then exactly?

A system is a dynamic set of actors, relations, objects and things, and all its interconnections, such as a city, company, community, or society as a whole. All of the 'hardware' and 'software' of a system combined, if you will. Such a system 'lives' in reality, like a living organism, which means it exists in time and space, constantly moving, changing, interacting, and shifting.

What is and isn't a system is defined by us, people. It's not a scientific truth such as gravity, it is a theoretical device we use to think about the world in a specific way. We 'create' a system by defining its boundaries, which determine where the system stops, and other systems or the 'rest of the universe' begins. We do this to focus and manage the complexity of a certain challenge. Always looking at everything in the universe as one big connected system may be more truthful, but it's also debilitating. So, we determine the boundary of our system, which is usually a step higher than the challenge we're looking at. For example, when we're looking at creating a building, or social service, we investigate the city that this will be in as the system, or perhaps the region, or the country.

By doing so, we essentially lift the focus area out of the complex network of things and look at it as if it was a separate entity (yet connected to everything else, but in a more abstract sense). Cities, an event, a region, or our planet, all can be seen as a system. The system does not always need to be defined carefully, especially in the beginning. And, to truly investigate a system, we need to look at it in its entirety. In order to look at all 'sides' of the system properly, we investigate it across all dimensions, scales, and in the full spectrum. Doing this is called the 'integrated' approach, and we'll get to the details about how to do this further on.

WHAT IS A 'STATE' OF A SYSTEM?

A 'state' of a system can be seen as a position that the system is in, regardless of its containing objects. It is not the same as a property, which would be inherent from its physical makeup. A state is only concerned with the configuration of its physical presence. For example, a light switch is in the 'on' state if its switch is turned to the on position, and in the 'off' state when it's in the off position. Whether it's in the on or off state, the light switch consists of the same materials, nothing is added or removed, it just changed state. As opposed to the light switch being red or blue, which are physical properties that are inherent into the material of the object, a state is simply how the relationship between its components are set.

So too with sustainability. One system can be in a 'state' of sustainability, while the other is not, even though they consist of exactly the same stuff. This is a critical understanding about sustainability. Understanding that sustainability is a 'state' of our society means that we can reach a sustainable society with everything we have already. We do not need any extra 'stuff'. Rather, we need to reconfigure the relationship between us, our stuff, and each other. We could have been in a sustainable state in the past (and perhaps we were), we can be so today, and achieve this in the future. But we are not today, and getting there isn't so easy, since we departed this state, probably a few hundred years ago.

SYSTEMS IN TIME

Systems do not only have a spatial boundary, but also one in time and in context. Something is 'sustainable' for a certain, relevant, time frame. We are clear to say 'relevant time frame' because, to take a simple example, it is irrelevant for us to be concerned about the sustainability of the Earth and its life forms beyond the expiration of our sun, which is scheduled to happen in 100 million or so years. Often a 'relevant time frame' can be taken as several generations. Since these succeed each other while the definition is still active, as time goes by the essence should be maintained over many generations. In reality, looking much further than 50 years ahead is often not feasible. Yet, 50 years is insignificant compared to human history. This is also where resilience comes in again. Resilience is a long term property encompassing patterns of change, while growth is just a part of the ebb and flood of the system in motion.

In the end, nothing is eternal, and nothing should be. Sustainability is not about endlessness or development for eternal preservation. There's always a natural end to a system's life span. And so it should be. Sustainable, explicitly, does not mean immortal, or eternal. Things come and go, and a sustainable system 'pulses' like all natural systems do, aiming to adapt itself to be better-fitted each time around. A sustainable system also inherently accepts there is an end to things, and gracefully resolves itself when that moment is there. Like dead trees in a forest become new habitats for other organisms, leaving room for the cycle of life to continue. This rise and fall of things is also present on the system level. It is about being able to continue to flourish, remain doing so as long as possible while being relevant, without endangering the system that it's a part of.

GROUP EXERCISE

Practice understanding what sustainability means by thinking about how you would look at the below items in a systemic context. Remembering that only systems can be sustainable (or not), how would you rephrase the following items?

- A 'sustainable' soda can
- A 'sustainable' city
- A 'sustainable' house
- A 'sustainable' organization
- A 'sustainable' policy measure

GROUP EXERCISE FORMAT (20 MINUTES)

Assign a term to each individual in the group. Let each person think for about 5 minutes on the subject. Then, have a 10-15 minute reflection on the results afterwards, one by one. Optionally, have a group discussion following.

What you hope to see in the resulting discussion is that in each case, it is useful to 'reverse' the term, by making it reflect on society. EG, a 'sustainable' soda can is a soda can that maximally contributes to a sustainable society. A 'sustainable city' is a city that contributes positively to the sustainability of the country, or of the global human society as a whole. And so on.

COMPLEX SYSTEMS

The word 'complex' appears in the definition to underline that we are talking about systems from the understanding of non-linear, infinitely complex entities, almost like biological entities, and not from a predictable, finite, mechanistic understanding of systems. Let's look at that further, and why it is important.

We differentiate between 'complex' systems and 'non-complex' systems. These terms are analogous with terms used in various fields such as respectively 'nonlinear' and 'linear', and "complex" vs. "complicated". Non-complex systems are systems of which the objects and relations can be fully indexed and understood, they are finite in their composition, and in some cases, can be fully modeled using physics, mathematics, or other science tools. They're called non-complex, rather than 'simple', because non-complex systems can still be very complicated and far from simple. For example, the electrical system of a house, is a non-complex system. You can model it using mechanical system analysis and predict its behavior. But it can still be pretty complicated to figure it all out. Working with these non-complex systems has been the prevalent mode of systems analysis, design, and innovation for the last century. We know how to accurately model them, and what kind of behavior they can exhibit, which can mostly be explained from a mechanical perspective. Complex systems, however, are an entirely different ballgame.

A complex system is a system which consists of a number of objects and relations so numerous that we can't keep track of all of them. Complex systems are also called chaotic systems or non-linear systems (to further confuse it all). Complex systems exhibit behavior that cannot be predicted using normal mechanical (non-complex) systems behavior or computer simulation. Hence, the 'non-linear' name. An easy example is the weather. Nobody can accurately predict the weather more than a week into the future using mathematical models - there are too many factors involved, and the events that generate the governing future patterns may not yet have happened. As we try to predict further ahead, the complexities multiply so fast, any attempt at doing so grinds to a halt.

Some complex systems may appear like a non-complex system, or have been treated as such in the past. This is a dangerous move and continues to cause issues in society. Ever had a bad weather forecast ruin a party? This also happens to our economy, for example, by introducing policy measures that are well-intended but do not take into account the complexity of the system. One can blame the poor policy performance on 'unexpected' events, but really, only the expected is unexpected in complex systems. An economic policy that does not account for complex dynamics is simply not resilient, which means it was plain bad policy. Thinking you can predict a complex system is a thinking error. Just as our brains are more than a sum of molecules, so are complex systems more than the sum of their parts. They tend to behave less like machines and more like creatures displaying 'emergent' behavior. Acting on one aspect of a system in isolation will always have side effects on the rest of the system. Expecting complex systems to respond like machines is a one way road to disaster.

In this book, we focus on complex systems over non-complex ones, because we feel they are the determinants of the future of our world. In sustainability literature, non-complex systems modeling is often used to explain certain economic or social patterns.

While useful as an exercise, and to use for insight, we should exercise caution when encountering this sort of argumentation. It's tempting to want to simplify complex systems to try to understand their behavior in mechanical terms, in order to move forward, but it's also dangerous. It is in the quality of 'complexity' that systems do their special thing. Because of this importance, we find the word 'complex' essential in SiD's sustainability definition.

Even though complex systems can't be predicted, they can be studied, learned from, their behaviors analyzed and intervened on in order to make them, for example, more resilient. We'll get into more detail about this later on. To help get a feel for what a complex system is and isn't, we've assembled 12 general rules that complex systems typically comply to on the next page. We go further into system dynamics and complex systems further on in this chapter.

DYNAMIC SYSTEMS

The SiD definition defines sustainability not as a physical constant, but as a state of a *dynamic* system. This means that sustainability is an edge condition of something that always moves, changes, grows, shrinks and acts in accordance to changes in its environment and internal composition. This means that a system can move and change while still remaining in the 'state' of sustainability, as long as it doesn't cross the border of its state. Defining it as such allows us to evaluate and work towards sustainability without locking ourselves into static and rigid structures, which would inhibit resilience.

Because there's always something that changes, be it due to smaller or larger changes in climate, the natural cycles of birth and decay, the laws of entropy or something else, a system needs to be able to adapt itself in order to be able to continue doing what it does if it is to survive (resilience). Therefore, a sustainable system is always dynamic. Without dynamism there's no capacity for adaptability, flexibility and therefore no resilience. A system without resilience is hard-pressed to be sustainable. After all, if it can't survive changes in its environment, how can a system be called sustainable?

We can therefore expand our understanding of sustainability to be not just a state of a system, but explicitly that of a dynamic system. It puts sustainability in the realm of systems analysis and science, including network and complexity theory. This enables a myriad of new perspectives on how to achieve and work with sustainability, allowing many new innovative pathways to be explored.

RESILIENCE AND AUTONOMY

The second sentence of the SiD sustainability definition is:

> *"In this state, a system can continue to flourish resiliently, in harmony, and without requiring critical inputs from outside its system boundaries."*

The first sentence identifies what we understand the word sustainability to truly be: a state of a complex dynamic system. This second sentence identifies what this state actually is. This sentence can be broken down into three terms, defining that a sustainable system is one which is resilient, autonomous, and in harmony. As you can see, we captured the part "without requiring inputs from outside its system boundaries." in the word 'autonomy'.

Resilience, Autonomy, and Harmony are the main three system indicators for sustainability in the SiD system. Resilience determines the degree to which a system can survive unexpected occurrences, a critical part of continuing to exist. Autonomy determined to what degree a system can take care of its own needs, and its ability to continue doing so. We'll discuss Resilience and Autonomy in detail further on, but Harmony may seem a little odd here as a term. Let's look at that for a minute.

HARMONY, SOCIAL JUSTICE AND ETHICS

In the first part of the definition, we use the word 'harmony'. In the second part of the definition, where we exemplify what a sustainable society may surmount to, we refer to just societies. These include the necessary elements of social justice and discussions about fairness. Inharmonious systems (unjust, inequitable, large divisions of resource control, etc.) give rise to internal strife and even war, and thus, endanger the sustainability of a system. A system can be resilient and autonomous, but without harmony between its agents it will still collapse due to the eruption of internal tension. One can even say that a system that is resilient and autonomous, but not harmonious, is the opposite of what we hope to achieve, conjuring up images of hardy evil empires impossible to overthrow.

Harmony finds much of its intelligence from agencies dealing with human rights, and ethics. Ethics discusses matters of equity, social justice, the perception of value, and how we determine 'good' and 'bad'. You can read about some main ethical perspectives in the tools chapter, and we'll discuss Harmony together with Resilience and Autonomy in detail in section 1.2.4.

WE AIM TO FLOURISH

The word 'flourish' is also present in the definition. This gives us a way to positively regard difficult to quantify values such as quality of life, cultural and artistic value, etc. Resilient, self sustained, harmonious life is already great, but there's value in excitement as well, which is where flourishing comes in.

12 RULES OF COMPLEX SYSTEMS

1. Complex systems are **numerous** (uncountable) in their components in which all components influence each other. They exhibit non-linear behavior emergent from their interactions beyond each component's mechanical (linear) behavior.

2. Complex systems can be **understood but not predicted**. Any action upon them may have unpredictable (side-)effects. Don't make decisions based on prediction; instead, prepare for resilience, adaptability, flexibility and so forth.

3. Complex systems **grow like organisms**, and, like them, perish like them. No complex system is meant to exist for eternity. Understand and accept the natural cycle of things, and aim for self-reproductivity and longevity rather than eternality.

4. Complex systems **require an increasing number of resources per added unit of complexity**. This means there are always limits to their growth. Systems respond differently at different scales, but may exhibit similar patterns at different scales.

5. Complex systems **change rapidly in revolution-like jumps, as well as in slow evolutionary progression**, and both together. These events can be triggered by anything. Patterns in details are just as important as large-scale variables.

6. Complex systems **do not necessarily behave the same way given the same conditions**, nor is historical behavior always an indication of future behavior.

7. Complex systems are **always dynamic, never sit still, and are never entirely in balance,** even if they seem to be.

8. Complex systems are not aware or alive per se, but **may exhibit survival or seemingly cognitive behavior**. It makes sense to mentally construct a complex system as a biological entity with a character to increase your understanding of its dynamics.

9. Complex systems **require incubation periods for changes to be registered**, processed, and acted upon. Be patient. Measure in the full spectrum for any changes lest you miss a rebound effect or changed state somewhere.

10. Complex systems, at the moment, **can best be understood by human brains**, as they're also organic complex systems. Immersing oneself in a complex system and fully interacting with it is the best way to learn its behavior. In other words, try to get out from behind your desk and connect.

11. Complex systems **interact beyond their chosen system boundary,** which needs to be taken into account at all times. Maximize the beneficial properties of these externalizations and minimize the system's dependency on them for increased sustainability.

12. Complex systems **always offer hidden dynamic processes** that can have beneficial as well as destructive effects. Find these patterns to boost capacity for change and prevent harmful externalities.



HOW DOES IT ALL ADD UP?

With the SiD sustainability definition, we determine that a sustainable system is one which is self-sufficient, resilient enough to continue operating under a wide range of expected and unexpected events, and is harmonious and just while it flourishes. To translate that to our modern society, this means a society where all the energy and material loops are closed, we no longer make use of finite resources, and wealth and power are distributed in an ethical way. It means that our ecosystems and fellow species are thriving, allowing us to benefit from their resources without breaking them down as we do so. It means an equitable society in which we all have a chance to lead a life with quality and create a meaningful existence for ourselves, our children and loved ones. And, our resources are more or less equitably distributed. This is what the last part of the definition describes. And who doesn't want that? Well, there are some. Discuss among yourselves...

Now that we have a basis to align and agree on as far as what we hope to achieve on a system level, let's try to see how this breaks down into the practical, real world, and how we can go about achieving this. In the next sections, we start by creating a language to analyze systems and their components, how we can measure them, and how to create new solutions that achieve that goal.

EXAMPLES: OBJECT OVER SYSTEM

OBJECT-ORIENTED SUSTAINABILITY GOES WRONG
Why is system thinking and an integrated approach so important for sustainable development?

Let's imagine our society as a complex creature with various bits and pieces that keep it running. These bits and pieces are our everyday technologies – cars, planes, light bulbs, computers, as well as us, nature, and all other 'things'. The technological bits move people from place to place, facilitate communication, allow us to read after dark, travel around the world, and perform many other amazing and useful functions. Ideally, we like to keep all of those, but without their negative impact. Many current 'sustainable' projects and environmental policies are focused on these 'negative' objects. In other words, they are centered around finding bits within the organism of our society that could be running a bit more efficiently, and making an effort to replace them with "better" versions.

We've seen many examples of this type of 'sustainable' solution, often developed with the best of intentions, that resulted in worse scenarios than if they had not been conceived at all. Examples are solutions that save energy that at the same time pollute our environment with toxins, or eco-friendly devices that are produced under dismal human conditions. We see many examples of 'green' solutions that are pushing the damage from one area to another, from one time frame to the next, and from one generation to another. As we see now, these are due to what we call an 'object-oriented' approach (see examples on this and the next page).



The system as a whole, its purpose, direction, and impact, will not change if we just switch out bits and pieces. It isn't just the bits that need upgrading. It is the configuration of the overall system that is at fault. We need to redesign the organism itself. We need to begin functioning differently within our societies, changing the patterns of our behavior, and reducing our impact by orders of magnitude, not just by tiny increments.

The true nature of the problems that we face IS, per se, systemic, and requires an entirely different approach. To cite Einstein: "We cannot solve problems with the same kind of thinking we used when we created them.". If we don't use a new systemic approach, we're trying to cure the symptoms, but not the disease, and things will continue to go very wrong.



THE LIGHT CONUNDRUM
Artificial light has been essential for our development. It has extended our working day, providing increased productivity, safety, and quality of life. But these little fake suns come at a big energy cost. As society expands, so has their burden on our energy resources. Thus, the European Commission banned the tungsten filament light bulb in 2009, the trusty mini sun that has lighted our homes for over a century, because it emits most energy in the form of heat and is therefore not efficient for lighting purposes. The only alternative at the time was the Compact Fluorescent Light (CFL), commonly known as a power saving bulb. Sounds good. But few of us knew that CFL's use mercury vapor to do its thing, a highly neurotoxic substance. Even the most perfect recycling program won't prevent some of the lamps breaking, impacting our health and the environment. So for the sake of energy savings, we have introduced a toxic substance in our lives and nature, a substance we spend large amounts of effort on trying to get rid of. This is a typical example of 'trading pain'; we save some energy, but at the expense of damage to our health and ecosystems. CFL's can be a beneficial addition, depending on how its energy is produced and how the lamps are used, but just substituting one for the other is not necessarily a sustainable act. Thankfully we have good LEDs now.



BIOPLASTIC NOT SO FANTASTIC
Bioplastic is another invention that promised to improve our society's sustainability performance overnight. As with most object-oriented solutions, there's no free lunch and bioplastics, most commonly in the form of PLA, can do great damage when not applied well. Firstly, when swapping normal plastics for bioplastics, the bioplastics can end up in existing recycling streams. Being a different type of material (but hard to differentiate by the consumer), bioplastics degrade the quality of the plastic batch, making the normal plastic batch near useless, and crashing recycling performance.

Secondly, bioplastics do not dissolve when thrown in nature; they require industrial composting under pressure and elevated temperatures. This means the big plastic waste issue that haunts our environment isn't anywhere near closer to being solved when using them. Bioplastics need their own, separated, and controlled recycling stream to perform well, and this is hardly present. Lastly, some feedstock for bioplastics comes from lands that could otherwise grow food. Food is a more critical resource than waste-plastic, so we're trading productive land for waste, which isn't a sustainable solution. Bioplastics can be useful, but only when applied in a systemicly appropriate way.

EXAMPLE: A SYSTEMS LEVEL IQ TEST

This is a non-essential background story. Feel free to skip it, or read it if you like an anectdotal story on the systemic use of IQ tests.

Do you have thoughts about the value of IQ tests? Have you discussed the usefulness and applicability of such tests? There's a big chance you have. In my circles, including myself, most people seem to hold the belief that IQ tests are incapable of assessing the whole of a human being's capacities, and thus are of limited value. Until I heard this story. This story demonstrates a great example of something that is contentious on an object level (testing individuals on their IQ score), but is massively valuable on a systems level when used right.

I heard this story first on a US podcast by Radiolab, called "The Miseducation of Larry P.". A more expansive and detailed account of this story can be heard by listening to that show (freely available online).

THE NATURE OF AN IQ TEST

There are a variety of IQ tests available, and the tests have evolved through time, originating in the work of psychologist William Stern in 1912. Their use includes: as a means to determine the suitability of potential employees for jobs, the performance of education systems, the mental health and wellbeing of individuals, and as a means to regulate entrance to social clubs (eg. Mensa). I remember doing one in high-school as part of a voluntary scan to determine what professions I would be suitable for. I also remember a mental feedback loop while doing it, about being nervous on how my performance would influence the choices about my future, and how my nervousness would affect this. I spent half of the test in near panic about my nervousness itself.

As these tests have found various places in society over time, so too have criticisms on their usage. Some argue that the tests can only ever determine a (small) part of an individual human's capacities, risking misrepresentation of a person's value. Others argue that the nature of performing such a test in itself is highly susceptible to context and psychological anomalies, and will invalidate any usable result. All in all, there's much opposition to the tests being used for anything other than voluntary testing without consequence. So too, I thought IQ tests had little societal value. Until I heard this story. And the story requires a bit of background to follow, about leaded gasoline.

THE ORIGIN OF LEADED GASOLINE

Tetraethyllead is an additive used to raise the octane rating of combustible fuels, allowing for substantially higher compression, and thus higher performance. This property was first used by DuPont, and applied by General Motors in 1921 for gasoline engines. Knowledge about the toxicity of lead gasses had been known for 3000 years already, from the Greeks. Lead being a strong neuro-toxin was widespread knowledge from the 19th century. Because of the strong existing negative associations with lead, DuPont called it 'Ethyl'. Which, by the way, shows the importance of calling things by their rightful name.

Already in 1924 public controversy rose after workers died in the refineries. Experts publicly warned of the dangers of leaded gasoline for several years, to no avail. There were even alternatives to lead as an additive to solve the problem of 'knocking' in engines, but through many years of public manipulation and health reports, its use was continued. Leaded gasoline was universally adopted around the world from that time.

THE DISCOVERY OF THE DAMAGE

Around the 1950s, a scientist named Clair Cameron Paterson was performing research into the age of the earth. He used very old rocks he found from around the world to do so. In the process of analyzing them, he found that lead contamination invalidated his results. After solving this by working in a clean-room (and determining the age of the earth fairly accurately), he became interested in lead contamination. Why was all this lead there? He started to study different soil and ice samples from around the world and found high presence of lead everywhere on earth, specifically tied to recent time periods. He correlated it to the start of the use of leaded gasoline. Because he knew the health dangers of lead, he continued this research and contributed greatly to the opposition to the use of lead in gasoline over time.

Following this, reports were published in the 1960s on the health effects of leaded gasoline. The reports proved direct health effects, due to the presence of lead, in virtually everyone alive. This had been challenging, because of the insidious and long-term nature of lead toxicity on human health and mind. The reports were devastating, showing significant mental health reductions, especially in children. After some backlash from industry, the Environmenmtal Protection Agency (EPA) in the USA eventually made regulation in 1973 to "phase down" the use of leaded gasoline from 1976 onwards. You'd think things were over and settled with by then. But then you'd be wrong.

ON THE BRINK OF RETURN

The early presidential administration of Ronald Reagan in 1981-83 intended to release industry on all kinds of environmental regulation. They used economic cost-benefit analysis as a means to oppose environmental regulations. All kinds of 'costly' regulation was overturned in this time. DuPont formally requested to remove all lead regulations, and the EPA, under new Reagan-controlled leadership, was eager to comply. They claimed that it cost the US industry over $96 million per year to replace lead in gasoline with other stuff. For this reason, the EPA announced to remove all regulation for leaded gasoline across industries. When the news broke, a public uproar ensued. So, the EPA commissioned a cost-benefit analysis from its own EPA scientist Joel Schwartz. Schwartz however did not agree with the proposed plans, and went rogue...

THE COST-BENEFIT OF THE POPULATION'S IQ

Schwartz assembled research done earlier by scientists such as Herbert Needleman in the 60's and 70's. Needleman had shown proof of general population health effects of leaded gasoline. He did this by using widespread IQ testing. While the IQ tests didn't say anything useful about the individuals, they were used by Needleman as a systemic test, measuring the general population's mental health. Needleman showed that the influence of lead caused the whole population to go down by several IQ points. He showed this to be true especially in children, who are 4-5 times more sensitive in their development to the presence of lead. While a reduction of a few IQ points may not seem much, as a statistical measure, it means a in increase in the amount of people with a very low IQ (~80) of about 20-30% and a decrease in people with a very high IQ (~130).

Schwartz took this research, and made the commissioned cost-benefit analysis of the EPA to include costs due to the financial impact of this lower population IQ. He included higher social care costs, the lost earning capacity of the reduced mental health of the population, medical care, and increased mortality rates.

Schwartz's cost-benefit calculation at the time showed a $3.5 billion a year per 1 ug/dl lead in the bloodstream benefit of the regulation. The total net benefit of the leaded gasoline restriction as a whole came out in total to US$ 6.7 billion from 1985-92. This beat the intended result of the cost-benefit comparison on the Reagan administration at their own game.

CONSEQUENCES OF THE ANALYSIS

The expected industry backlash, and the attempts to undermine, discredit, and disprove the research, only served to strengthen the case. It was proven beyond doubt that leaded gasoline restrictions were doing more good than harm, by a large margin. In 1985, not only did the EPA retain the regulations, they sped up their phasing in. The results are that between 1976 and 1980, lead use in gasoline dropped 50%, and blood level lead presence dropped by 37%. Between 1975 and 1984 lead use dropped by 73%, and airborne lead by 71%.

In 1993, additional and updated research by Schwartz reset the total benefit to US$ 17.2 billion per year in reduced medical costs for children and hypertension in adults, and lost earnings. By 2011, the United Nations announced it had been successful in phasing out the use of leaded gasoline worldwide, although there were still a few countries where it was for sale until 2017.

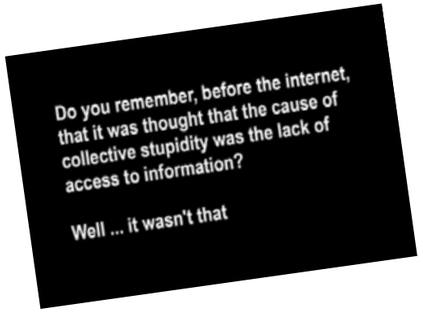
While sounding like a victory, the damage by use of lead in gasoline has left a big scar on the development to life on earth. There has been a statistically significant correlation proven of leaded gasoline use and violent crime rates, in the US as well as in South Africa. Researchers including Jessica Wolpaw Reyes, Rick Nevin, and Howard Mielke say that the banning of leaded gasoline amounts to up to 34% decline in crime from 1992 to 2002 in the USA. Besides this, the lead put into the atmosphere is still there, and will impact all life on earth for centuries to come.

WHAT CAN WE LEARN?

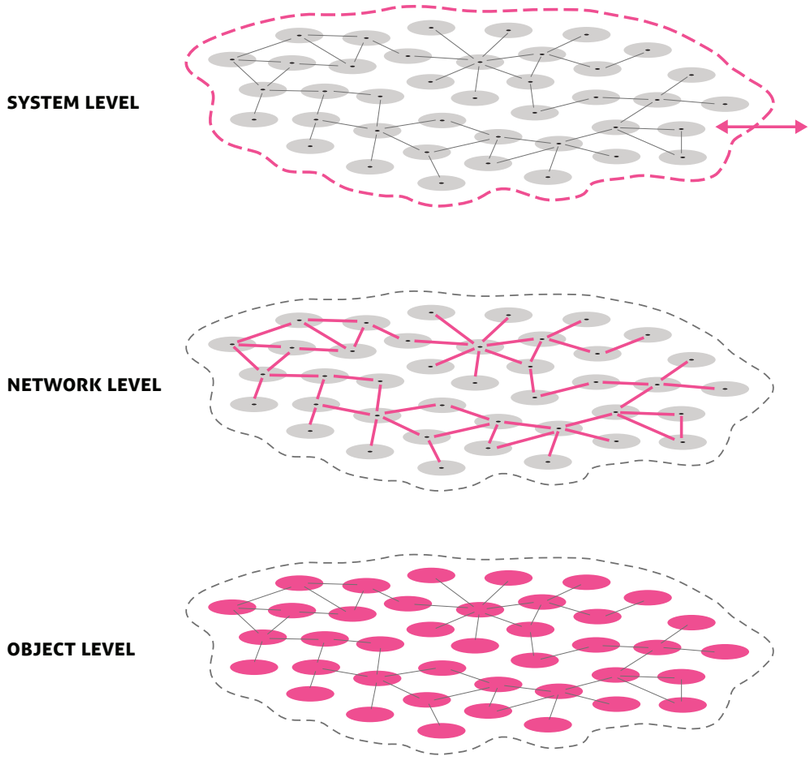
This story started with a question about IQ tests, and questioning their use and validity. As the story hopefully demonstrates, something that may seem of limited value on the level of the individuals, may become one of the most valuable tools when regarded on a systemic level. On the system level we're not necessarily looking for completeness of perfection. In many cases, we're looking for a general 'thermometer' that gives us an average of the system's performance. The value of the IQ test does not lie in its capacity to evaluate individuals compared to one another. Its value lies in its use as a general thermometer of the population as a whole over time, or in different scenarios.

THE CASE FOR INTEGRATED VALUE ASSESSMENT

The story also shows the value and importance of using more integrated impact assessments, rather than economic parameters alone. In this case, the inclusion of medical costs and reduced earning potential was already enough to show a huge discrepancy in cost-benefit. To continue to make our world a more healthy, fair, resilient place, it benefits us to push for more integrated measurements to be used in all policy decision making, as well as in corporate governance. With lead, We knew before the birth of Christ that lead was extremely poisonous, so that should have been an easy one to avoid. What decisions do we make today that we'll regret later, just because we only measured the cost-benefit on an economic level?



1.2 THE ANATOMY OF A SYSTEM



1.2 THE ANATOMY OF A SYSTEM

A system in SiD is a set of objects and relations between individual components (agents) that operate together, exchanging things such as information, energy, materials, value, and other resources. Systems are a mental and analytical model to understand the world in a more comprehensive way. They are not real, but they form a framework for understanding. A system may take many forms. A city can be seen as a system. The pond in your neighbor's back yard, our entire civilization, a company, or a government may all be seen as systems. Systems are defined and separated by their system boundary. Systems are thus a collection of agents, and their relations (the network), that operate in time, space and in context, defined by their boundary.

A system, in SiD's definition, consists of three levels:

1. System
2. Network
3. Object

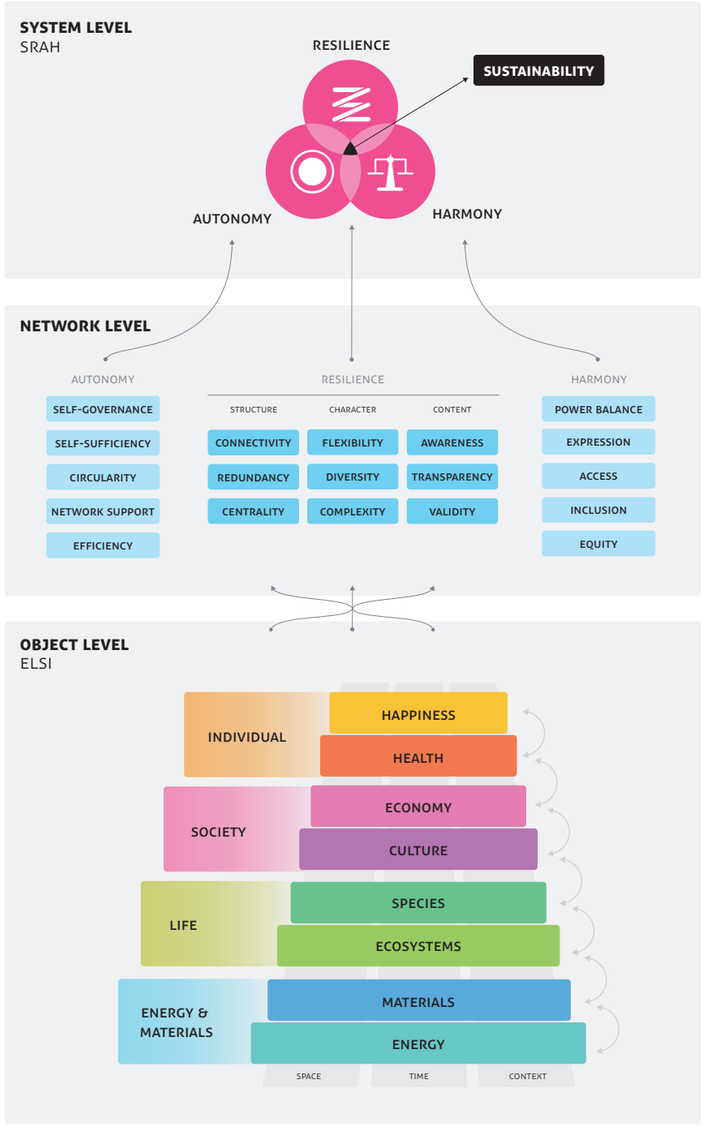
The Object level is the collection of physical elements in the system, the Network consists of all the relations in between these objects, and the System is the collection of all the objects and the network, seen holistically. It's possible to introduce more levels between these three, but for general use, these levels are sufficient.

In this section we will first look at each level separately, then introduce the tools to use them, their corresponding indicators, parameters, and properties.

SID SNO HIERARCHY

The diagram on the right is the SiD System-Network-Object (SNO) Hierarchy. It provides a complete overview of SiD's category system, indicators and parameters across the three layers of SiD.

In this chapter, this structure is explained, and each element is explored in detail.



1.2.1 INTEGRATED ANALYSIS

As we've seen, for sustainable development to succeed, we need to take into account all the critical areas of interest a system may consist of, and have an effect on. This is what we call 'integrated analysis', or 'thinking in the full spectrum'. If unguided, this process leads to overwhelming overload of information and work. To address this, SiD offers a complete framework for exploring, indexing, evaluating and finding solutions for all aspects related to complex systems. This is called the SiD SNO hierarchy, seen on the left. A central overview of this is critical to be able to work on the development of systemic solutions and implementation pathways.

WHY SUCH A COMPLEX SYSTEM?

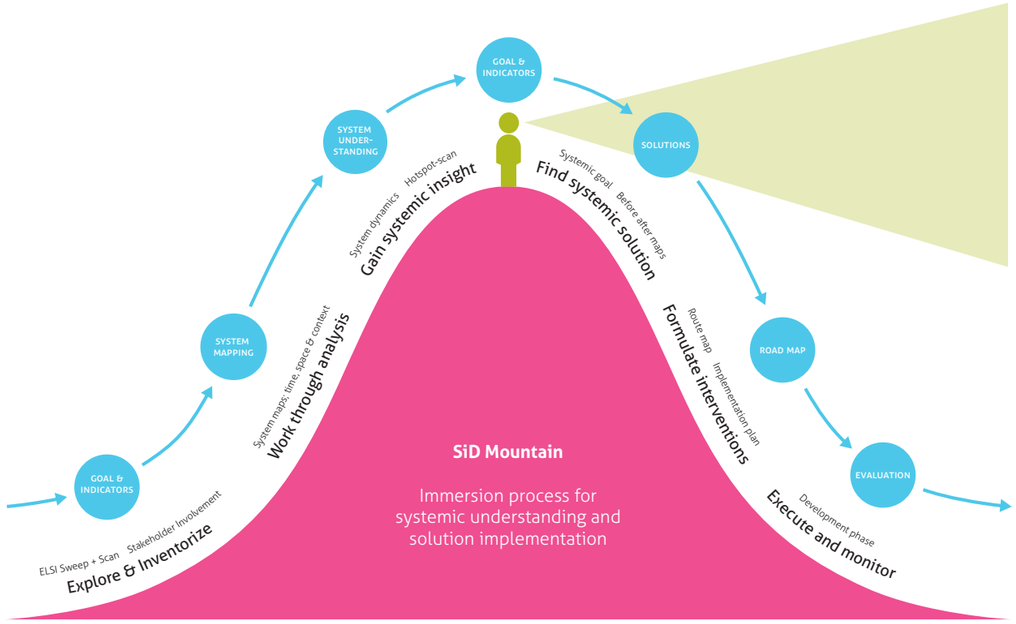
Our world is infinitely complex. We've explored what happens when we stare blind on one aspect, and not keep track of other important areas of interest. To do a proper job, we have to take everything into account. However, we can't do that, as it would mean an infinite amount of work and data. For example, when we construct a new building, we want to take into account not just its energy usage, but also its effect on biodiversity, economic parameters, and how it influences the society of its surroundings, to name a few. If we want to be responsible and take everything that is important to us into account, we can easily name hundreds of aspects. This becomes unmanageable if done without a structure. This is why many sustainability approaches simplify reality into a handful of categories that are practically relevant for a specific project. While that is workable, there is no standard for this, and developing one for each project, time and again, is time consuming, hampers standardization, unified reporting, or the development of over-arching strategies and tools. But it is what we're currently doing.

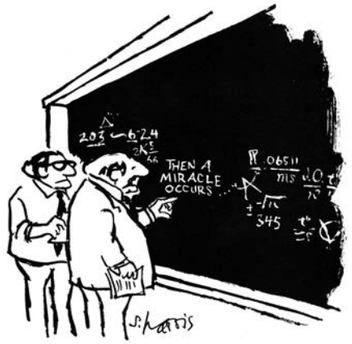
To solve this conundrum, for SiD we developed the SNO hierarchy system. It may look complex at first, but once you're familiar with it, it's a manageable, understandable, and inspiring tool. It has guided hundreds of integrated sustainable development projects, and helped them gain deeper insight. The elements of this system is what we'll explore mostly in this chapter.

STRUCTURE OF THE SNO DIAGRAM

The three layers of SiD deal with categorizing indicators in a different way. The object level of the structure (at the bottom) uses a the ELSI categorization system to explore all physical aspects of the world around us, bottom-up. This enables you to easily make custom indicator sets for your area of application, while still working in the full spectrum. Putting this framework as a lens onto a challenge is also useful in the process of getting to know the system, involving the stakeholders, and finding indicator sets that suit the language and focus of your field of application.

The Network level, in the middle, has a full set of tools to explore relations in a system, and unravel system dynamics. While more generally applicable, on the network level also allows interpretation on a case by case basis. This level offers a basic set of network parameters for you to work with, and if needed, build on. These are powerful lenses to look at the dynamics of the network, and connect object and system level.



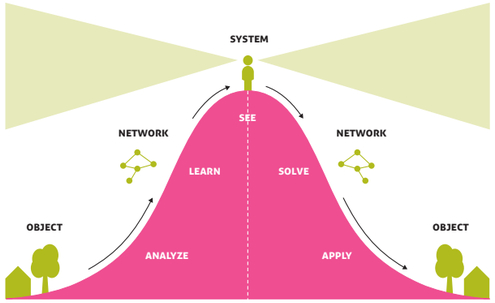


"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

The System level at the top is where we can determine sustainability, and its powerful three main indicators of resilience, autonomy and harmony, are uniform and generically applicable. Building insight by analyzing through this system from the bottom-up yields unparalleled insight into the complexities, opportunities, pitfalls, and solution pathways of challenges.

CLIMBING THE MOUNTAIN

Working with this system on concrete cases is the subject of chapter 2, the SiD Method. In there, we go step by step through the exploration of these layers of a system, learn from it, and learn to apply solutions and evaluate them. The diagram on the left, the SiD Mountain, shows a representation of the mental process of stepping through SiD from start to finish. A simplified version is shown below. Because SiD is iterative, you go through this process several times in various cycles, from fast to more thorough.



INDICATORS, PROPERTIES, AND PARAMETERS?

Indicators are specific measures that 'indicate' a certain performance aspect of a system that we want to explore. We define these for each project specifically. With the right indicators, we can tangibly express our project goals in measurable performance parameters. For example, measuring the time it takes you to run up a specific flight of stairs can be an indicator of the fitness of your body. You can set a measurable goal for that. Some indicators are better than others. For example, measuring how tall you are (an object property) doesn't tell you much about your health, and is therefore not a great health indicator.

Indicators are different from properties, in that indicators are usually not a directly measurable aspect, but a combination of these, combined in a particular formula. For example, if we want to measure the health of a person, we can come up with a formula that takes into account various properties of a person. This may include blood pressure, body temperature, sense of wellbeing, etcetera. 'Energy' is an example, which may be measured by a set of properties including the amount of kWh used, the source of energy, the amount of CO_2 generated per kWh, and so on. These properties then inform the formula, which results in a measurement on the general indicator of Energy.

The word 'parameter' is used in the network level. Parameters are not properties that can always be easily measured, but they can usually be derived from a variety of properties. Also, they are not indicators because they do not typically signify a goal. They are neutral measurement points about aspects of the network that help to evaluate its nature, either quantitative or qualitative. They can then in turn be used to inform the system indicators. Network parameters are re-inter-



In this diagram the UN SDG's are mapped to the relevant section in a (simplified) SiD SNO diagram.

preted on a case by case basis. For example, the network parameter of 'transparency' may mean something different when dealing with a policy situation than when dealing with an engineering challenge.

INDICATOR SETS

SiD's indicator hierarchy helps to build indicator sets for particular needs, allowing you to customize performance measurement per project. When working on similar projects, they can be reused and refined. Eventually you can cross compare all these projects back to the base SNO hierarchy, and benchmark projects across the board.

When performing systems analysis, using a generic set can only serve as a guideline for the creation of custom indicator sets. When designing system interventions you need to be able to make and understand indicators yourself. This is because each system is different, and you need to know what, and how to measure its performance in its context. Stakeholder involvement is particularly relevant here, since various parties will have a different language, standard of reporting, and area of interest that you may need to take into account.

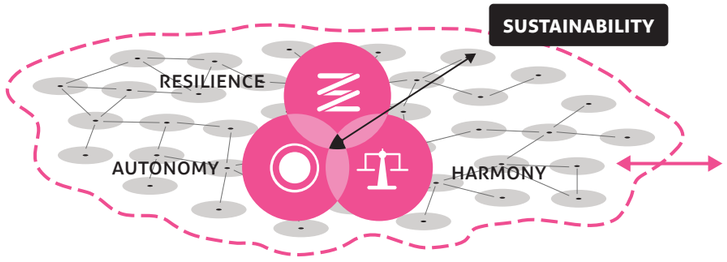
Building an indicator set begins by identifying the areas of interest for each ELSI8 category. Then, you developing indicators for those areas of interest. This can be done in a few hours for the start of a project, and subsequently developed deeper in iterative cycles. At some point, typically, stakeholders become involved. This approach is discussed in the Method and Process chapters of this book. After doing this for the ELSI8 layers, the same can be done for the network and system level categories.

Performance indicators often use external frames of reference. For example, indicators used in Life Cycle Assessment provide standardized templates for certain measurable aspects of a product's impact. Or, the United Nations Sustainable Development Goals (SDG's) can be used to categorize indicators. When developing indicators, you may draw on knowledge from virtually all the sciences.

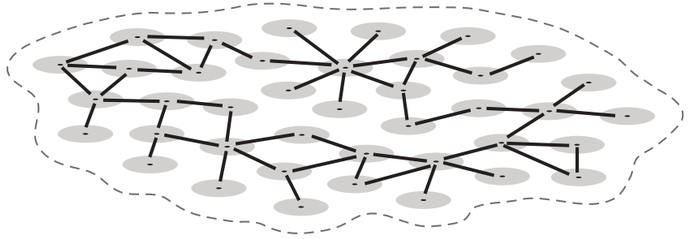
When using the UN SDG framework, for example when aiming for impacts in particular SDGs with a project, use SiD to explore what relations each goal has in the system that is under investigation. The UN SDG goals are broad, so they usually have multiple areas of impact in the various levels of SiD. On the left you can see a diagram showing the main relations of each SDG goal onto the SiD SNO stack. This is only a simplified example. For each project, this mapping will be different.

A complete treatise on indicators and indicator design is beyond the scope of this book. In most cases, identifying in the first cycles areas of interest concerning strategy, design, and development decisions is sufficient. Proper indicator design may follow later, with the help of various experts. In the following section we'll detail the standard indicator design tools included in SiD for all three levels: object, network, and system. Let's start off from the top, with the System level its RAH indicators.

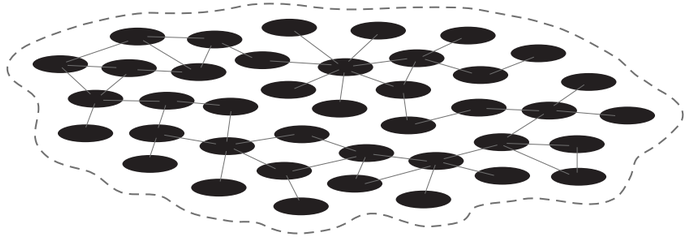
SYSTEM LEVEL



NETWORK LEVEL



OBJECT LEVEL



THE SYSTEM LEVEL

SiD' system level is where the underlying levels (the object and network level), come together. The system level determines the edges of the system and evaluates the performance of the system as a whole. The object level builds from bottom-up, the network level from top-down, and the system level is informed from both of these perspectives. It is on the system level that sustainability can be evaluated, together with its base components: resilience, autonomy, and harmony.

The system is the most abstract of the three layers. As a consequence, it can be the most insightful layer, as well as the most confusing. However, on the system level lies the most impact, our final long-term goal, and, if we can manage to find them, the actions that have the most leverage for systemic change.

Objects are easy to understand, systems are more difficult. A product designer, for example, intently studies his product and its interaction with the user. However, to leverage systemic change, the product itself is no longer the main focus, but the system it operates in is. For this, we need to study the place of the product in the system, and its short and long term effects on it. This means including all the aspects of the product's life cycle, including the companies and people responsible for the various stages of its life cycle, its role in society, and impact on aspects such as awareness and transparency of society.

SYSTEM BOUNDARY

Systems consist of the collection of objects and networks contained within them. The properties of a system therefore consist of the object and network properties (the RAH indicators), as well as a definition of where the 'edge' of the system lies, called the 'system boundary'. The addition of a system boundary makes measuring the SNO indicators more manageable.

The boundary defines what is and what is not part of the system. Without a boundary, everything is a part of everything else, and it's impossible to work with the system. After all, at which point would we stop looking? The major definitions of a system are therefore its boundary conditions in space, time, and context. A system boundary can be defined as, for example, a certain geographical area, measured over a 50 year period, to the third context degree. The relations that interact with the system from beyond its boundaries are called 'externalizations'. These always need to be accounted for, in some way. We talk about how you can define good system boundaries further on in the Method section. For now, remember that for most cases, having exact boundaries is not so important.

SMALL PREVIEW OF HOW IT COMES TOGETHER

Together the three system entities - objects, networks, and system - make the fundamental building blocks of SiD's system-based thinking. We set goals on the system level, and operate on the object level to make the goals happen. System and Object level are connected through the network parameters, where we can find hidden opportunities to use system dynamics to our advantage. Starting to think in these layers of abstraction helps to unlock the power of a systemic approach.

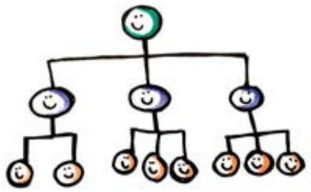
EXAMPLES OF SYSTEMS

On the right you can see a number of typical 'systems' that have proven effective and useful when considering sustainability challenges.

When looking a a subject, the system to take under investigation is usually a scale jump above the one that was defined as the subject in the first place. For example, when a particular building is the subject of a challenge, the system is usually defined as the neighborhood or the city that the building is in. If the subject of a challenge is a certain company's product, the system is usually defined as the society in which that product is used, as well as the company itself as a system. This helps in the refocus for goal setting, and to maximize positive impact.



A NEIGHBORHOOD, CITY OR REGION
Any group of people living together in a geographically defined space is a typical example of a useful 'system' subject.



AN ORGANIZATION OR COMPANY
A group of people working together to achieve a certain goal or purpose, that have an organizational boundary. An organization as a system doesn't have a geographical boundary, but more of a contextual, organizational one.



A PRODUCT-SERVICE SYSTEM
A product-service system is the 'ecosystem' in which a certain product or service that provides certain value to a user lives. For example, a ride-sharing service, a capsule coffee machine, or a the system of returnable drink bottles.



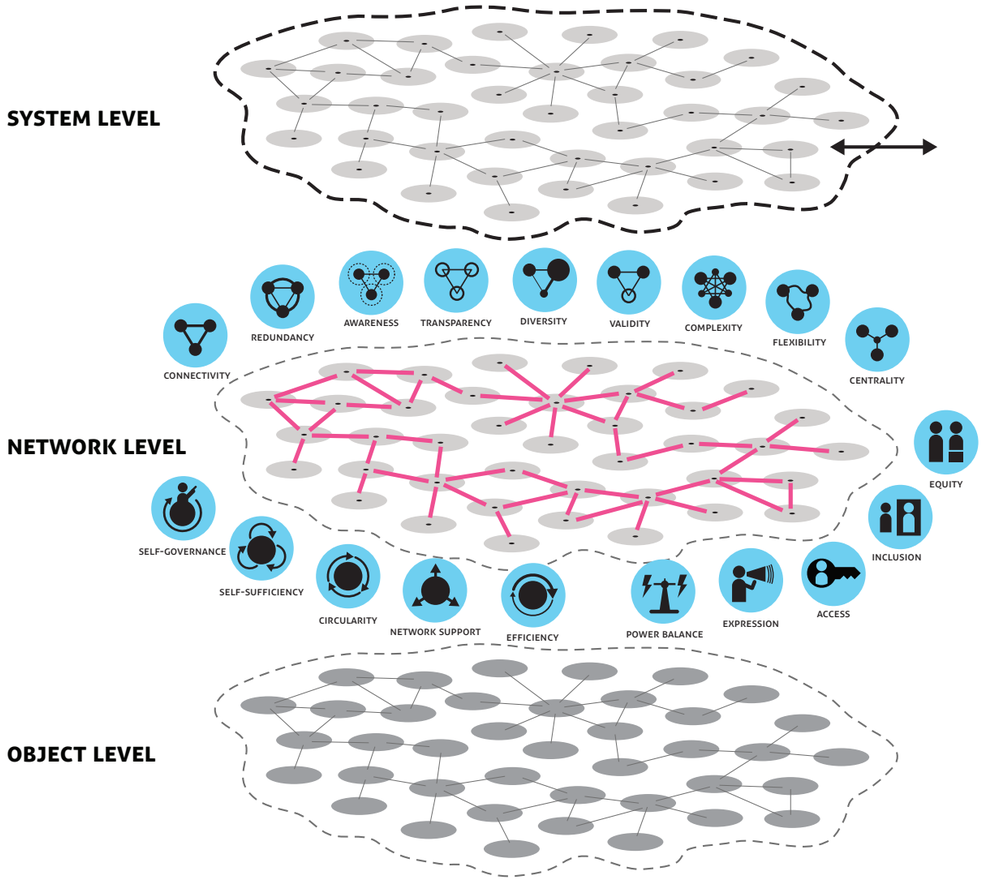
A COUNTRY'S FOOD SYSTEM
Food is an object, which lives in a product-service system, within a life cycle system, in certain geographical contexts, driven by many organizations along the way. Investigating a food system in all these dimensions is fascinating and useful to learn, find areas of optimization, and new ways to deal with our food.



AN OBJECT LIFE CYCLE
All objects have a life cycle, be it a product, building, or service. Looking at the entire life cycle, from the primary source of energy used, from inception via production, use, and to end-of-life is a helpful way of looking at a system of an object. This is usually combined with another way of looking at the system.



A DECISION-MAKING SYSTEM
As an example of a more abstract system, when looking at governance, it can be useful to look at the process of decision-making as a system. For example, within a given society, what is the system of decision-making that affect certain societal impacts?



THE NETWORK LEVEL

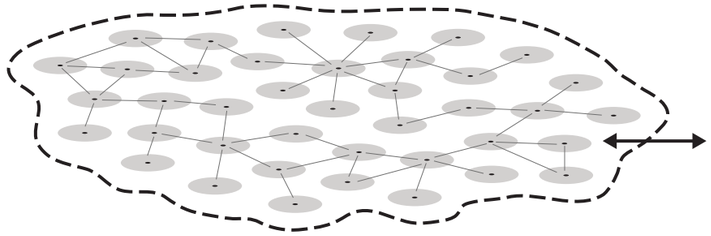
The network is the level on which all objects exchange things with one another. It's the flow of people and information, resource flows, laws, regulation, trade, economy, and so on. It is the collection of all relationships between all objects in the system. The system as a whole consists of the combination of the objects and the network. It serves as a mid-level between the system-level and the object-level. Connections in a network may also be referred to as 'relationships' or 'flows'. In some cases, for instance for work performed in social dynamics, it's useful to think of the connections as 'values'.

The network level is by necessity more abstract than the object level, and some parts of networks are easier to understand than others. We're used to thinking in terms of networks concerning communications, transportation, and economics. However, the network extends beyond these and captures all 'flows' within a system. Some of them are more difficult to grasp than others, such as cultural connections. Unlike the object level, the network connections are all intangible, and often have a transient or dynamic nature to them, more so than the object level.

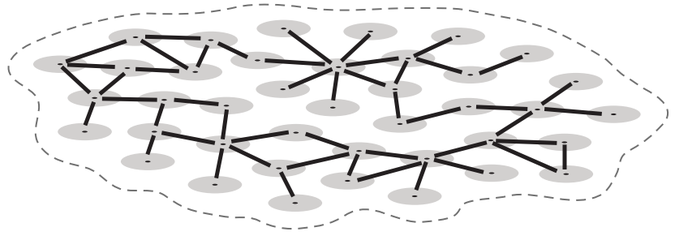
NETWORK PROPERTIES

Simply put, the network properties are about the collection of inter-object relationships, in time and space. Examples are the amount of friends you have (your interpersonal connectivity), the time it takes for a bank transfer to complete, and the amount of transport connections going in and out of your city. In SiD the default way to index and evaluate the network level is using the SiD network parameters, which include parameters such as transparency, connectivity, diversity and flexibility (see section 1.3.4).

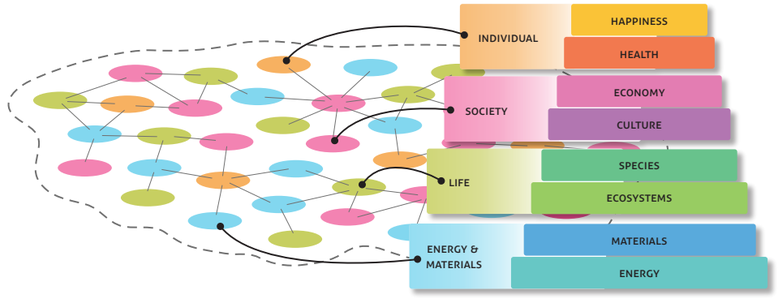
SYSTEM LEVEL



NETWORK LEVEL



OBJECT LEVEL



THE OBJECT LEVEL

Objects are the elements that physically make up the system. If we take a city as an example system, the objects are everything you can point to and give a name. Buildings are objects; park furniture, pipes, cars, money, books, people, animals, and trees are all objects. If you imagine taking a photograph of something, and pointing to everything in the photo you can see, those are objects.

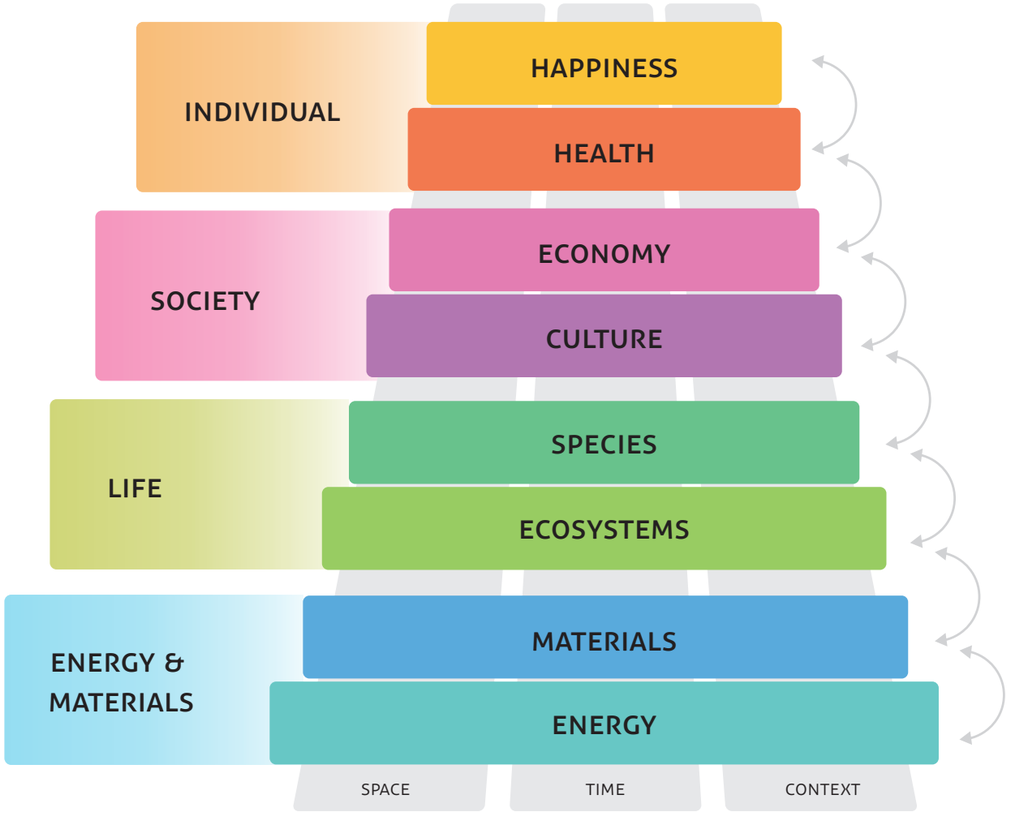
This is the level where you'll encounter the topics mostly encountered in sustainable development, such as energy use, materials, ecosystems, land use, climate change, economic impact, etc.

OBJECT PROPERTIES

The properties of objects are defined by their physical reality. These properties are things such as size, mass, color, material composition, geometry, etc. Combined, all these properties describe the object in its full extent. Those are facts that won't change unless an external force acts on the object. Everything you cannot see, but is there, is likely to be a relationship, and is not an object but part of the Network level.

In SiD, we use the ELSI system to index objects in a system, and to develop indicators for them. We'll explain this in the next section in detail.

OBJECT LEVEL
ELSI4/8 STACK



1.2.2 OBJECT LEVEL IN DETAIL

Object indicators are the most common form of sustainability indicators. They index and measure the performance of an object in its systemic context. Examples of object indicators are energy efficiency, environmental impact, cultural value, carbon footprint, material recycling, cost, or ease of use.

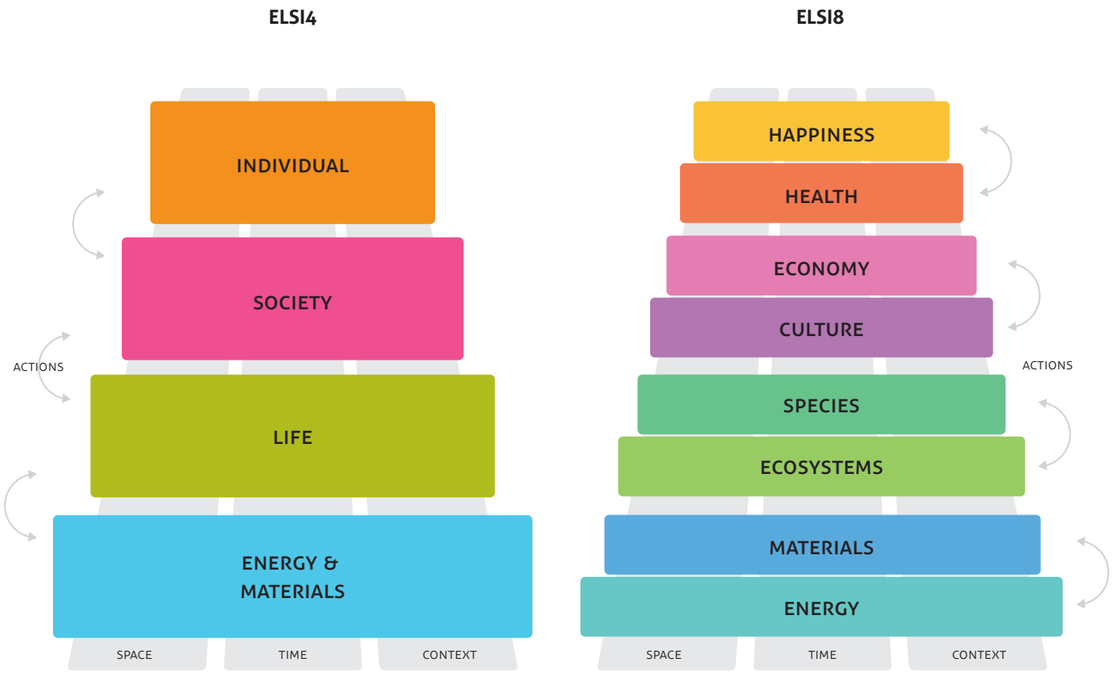
Object indicators describe a relationship between an object, other objects, and the system as a whole, and their value is dependent on the context. Each project will have a focus on a different set of objects and impacts. For example, when looking at a hospital, the amount of beds it offers and the recovery rate of patients may be a primary focus, while working on a marketing project it may matter how many people are reached, and its impact on behavior.

Because each project has its own needs, we discovered it's impossible to make a standard set of object indicators for every purpose, as you'd end up with an impossible amount of indicators to work through each time. Nevertheless, you want to take into account the full spectrum of societal impact. To resolve this, we use a standard framework of categories, to use as guidelines to map indicators for each project. If the categories of this framework are in the full spectrum, we can develop specific indicators that fit each project, while also working covering each area of the spectrum.

In the early days of sustainability science, the 'People, Planet, Profit (PPP)', or triple bottom line, framework was used to categorize the various aspects that are important. We ran into problems when trying to use PPP as a categorization system, because it doesn't cover all the areas we feel are necessary, nor does it provide a logical relationship between the 3 P's. Because of this, we set out to develop a more complete and sensible framework.

The result is the SiD ELSI categorization system, shown on the left. With this, you can quickly develop areas of interest and indicator sets for each challenge, while also being sure to work in the full spectrum. Let's look a bit deeper into ELSI.





SiD ELSI4 and ELSI8 stack

THE ELSI OBJECT CATEGORIZATION TOOL

ELSI is a categorization system for all existing physical things in our world. It's a foundational tool that gives insight into not just the spectrum of objects in a system, but also their dependency and causal relationships. It helps investigating and making a full spectrum indicator set, as well as set goals, guide analysis and research phases, and helps to develop solutions that work on all levels. It is a replacement for the 'people, planet, profit' (triple bottom line) categorization.

ELSI describes all the functional categories of system-elements that are found in the world. All physical entities in the universe fit within the ELSI system. Together, they show causal relationships among each other and can be used to prioritize interventions.

We make a distinction between ELSI4 and ELSI8, listed below and on the left. We use ELSI4 for communication and as a handy mental tool, and ELSI8 for scanning area of interests, indicator development, and spectrum brainstorming. ELSI's name derives from the first letters of the primary categories of ELSI4.

ELSI4	ELSI8
Energy & Materials	Energy
	Materials
Life	Ecosystems
	Species
Society	Culture
	Economy
Individual	Health
	Happiness

ELSI can be represented in various ways. On the left, you can see the SiD ELSI4 and ELSIA8 Stack diagrams, and further on in the book you can see the SiD ELSI Rose, which is a representation if looking at ELSI from the top-down, while the Stack looks at it from the side.

ELSI's name derives from the first letter of the main categories of ELSI4:

- Energy & materials (matter)
- Life (species & ecosystems)
- Society (economy & culture)
- Individual (health & happiness)

ELSI helps form an overview of all the object-related aspects of a system and their causal relationships, and is one of the core components of SiD. ELSI is used for creation of indicator sets, indicator selection, general awareness on full-spectrum sustainability, impact mapping, and many other stages of systems analysis. It effectively replaces People, Planet, Profit with a more inclusive and consistent model.

ELSI CATEGORY NESTING

ELSI's categories are nested within each other. Each category is nested in the one below it in the stack and all ELSI8 categories are nested in its parent ELSI4 category. There's a causal relationship between these nested elements. For example, all materials are made from energy, therefore, materials are a (small) part of the energy category. All ecosystems are made of materials, and are therefore a subset of the materials category. The economy is a subset of culture, just as each individual is always part of a society, and so on.

ELSI8 Category	Example subclasses	Example AOI's	Academic fields	Example tools
Energy	Radiation, Chemical, electricity, Heat, Fossil, Motion, Wind, Solar, Geothermal, Magnetic	Energy use Renewable fraction Energy types	(Astro) Physics, Engineering	Energy audits, LCA, FLIR cameras, Computational Fluid Dynamics
Materials	Water, Land, construction materials, Metals, Rare earth, Toxic materials, CO_2	Material sources Freshwater use Toxins Recyclability	Physics, Material science, Chemistry	LCA, Ecoinvent database, Material Flow Analysis
Ecosystems	Rivers, Mountains, Agricultural land, Species habitats, Oceans	Soil impact Land use Climate change Natural Capital	Ecology, Geology, Environmental Sciences	Millenium Assessment Framework (UNEP), Landscape Ecology Patternbook
Species	Mammals, Birds, Insects, Bacteria, Amphibians, Rodents, Reptiles, Funghi, Trees, Plants, Weeds	Biodiversity Birds Insects Mammals Indigenous/invasive	Biology, Ecology, Ethology	Biomimicry, Permaculture, IUCN Red list
Culture	Education, Politics, Art, History, Urbanism, Governance, Language, Freedom of speech, Gender equality	Demographics Literacy, education Emancipation Free press Art support	Humanities (anthropology, law, arts, languages...), Social sciences (education, politics, history...)	Spiral dynamics, Hofstede's Cultural Dimensions, SmartAgent method
Economy	Transportation, Finance, Business, Industry, Agriculture	Wealth distribution Turnover/profit Wages, employment Marketing, logistics	Business, Economics, Marketing	Economic flow analysis, Gapminder, Business Model Canvas
Health	Environment quality, Health care, Sports, Food quality and access, Safety	Air/water/food quality Hazards Healthcare levels Physical exercise	Medicine, Public Health	Health profiling, WHO statistics database
Happiness	Education, Leisure, Stress, Equality, Community, Self-actualization	Access to nature Freedom, Satisfaction Free time Stress levels	Philosophy, Psychology	Satisfaction with life scale, Happiness Index, Maslow's hierarchy of needs

That's why ELSI is represented in ways that show that each section belongs inside the one below it. This relationship can also be seen in the ELSI Rose diagram.

By being nested, ELSI shows important relationships and hierarchies. When something 'happens' to one of the lower levels of ELSI, such as energy or ecosystems, it will affect everything above it (or 'in' it, since higher elements are nested inside lower elements). This means that ELSI says that ecology, for example, has a higher causal significance than economy, but both are important to support all individuals.

This hierarchy of causal relationships is a powerful mental tool. It helps people understand foundational relationships, it helps to guide complex discussions on priority, and gives a visual tool to help practical exploration with teams. As a brainstorming tool, ELSI can help to bring to light a group's biased focus. For example, when doing an exercise to name important factors of a challenge in each ELSI category, and stick them on an ELSI poster with post-it notes, you can quickly see which areas have more attention and awareness in the group. This can be enlightening, and can help refocus and explore areas previously left unseen.

The structure of ELSI is based on a causal relationship between all the elements. On one end of the spectrum, at the top, we have the happiness of every individual. This is, in many cases, the end goal of all our actions: to allow individuals to be happy. However, in order to achieve this, many other factors need to be satisfied to assure this happiness can take place (as Maslow's Hierarchy of Needs also shows, see page 420).

On the other end of the spectrum, we have Energy, the most abstract and fundamental building block of our universe. The subsequent structure in between is a logical causal structure that brackets all physical things in our reality. For example, all materials are built up from energy, and ecosystems are built up from materials. Species are reliant on the ecosystems and (human) culture is a subset of these species. Economy is a subset of culture, and each individual is part of this economy. Each individual is reliant on personal health to be able to flourish, and Happiness is the final resultant within the individual.

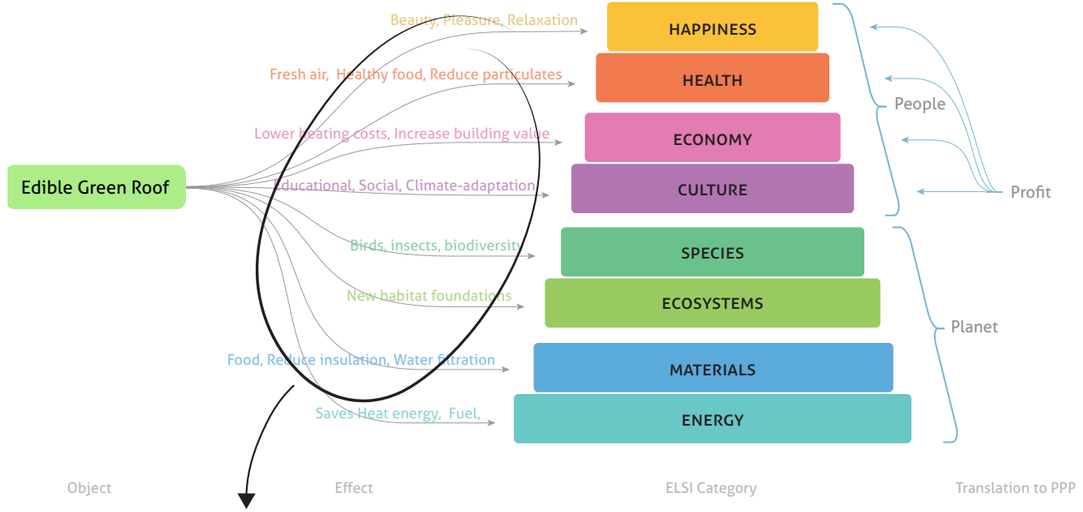
Each of these sections can be expanded to have many subcategories, all of which are nested in the category above.

We'll discuss the individual ELSI8 sections in more detail in the next subparagraphs.

USING ELSI IN RELATION TO SID

We've seen that ELSI works so well, that people can be absorbed by its charming simplicity and insight, and forget that the network and system levels exist. ELSI is meant as a categorization tool for the object layer, to ease categorizing objects and mapping their relationships between all of them, and not simply to list all the components. Just doing an object categorization is never enough without also involving the relationships between all these items, the network and their effects on the system as a whole.

EXAMPLE: ELSI IMPACT SCAN



ELSI IMPACT MAP

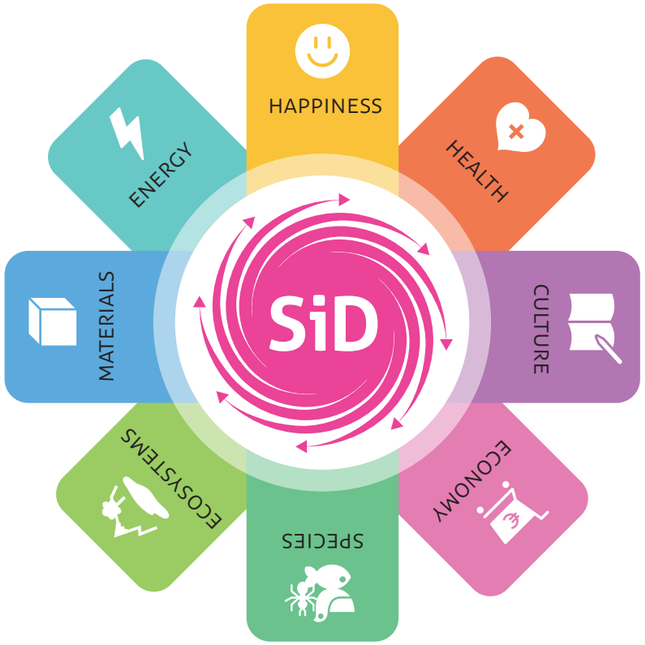
An ELSI impact scan is a tool to quickly scan areas of interest of a subject against the ELSI stack. This helps investigating what areas a subject affects, where negative and positive impacts may be found, and is a powerful brainstorming tool for groups, when setting goals or developing solutions.

The above example is a graphical representation of this. Typically, these are made by groups on large sheets of paper to develop a preliminary scan, then put into a spreadsheet to expand and refine further by experts into a project's goals, indicator set, or solution framework.

An ELSI impact scan is a useful tool as part of a SiD spectrum scan or sweep, which is covered in section 4.1 in the tools chapter.

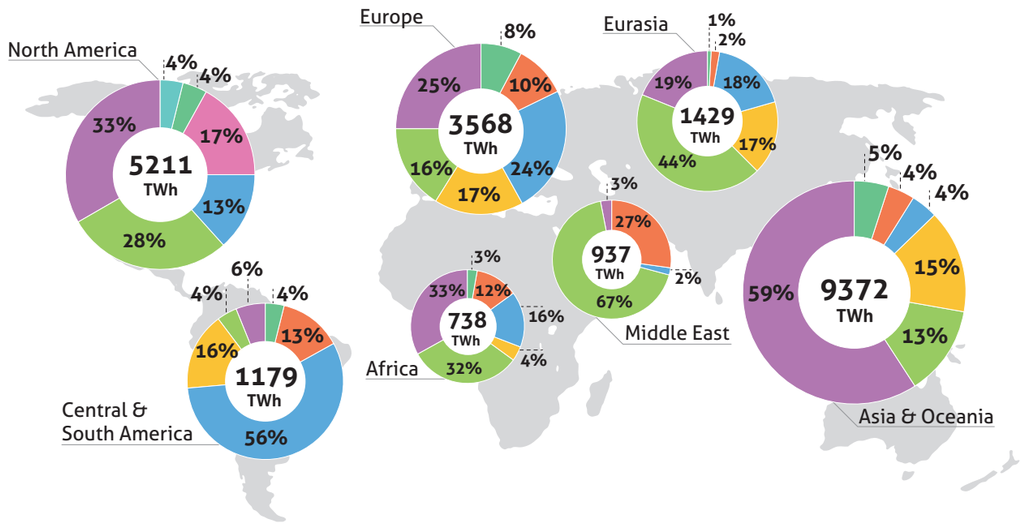
1.2.3 ELSI CATEGORIES IN DEPTH

In this section, we'll review each ELSI8 category, looking at various aspects that may be of interest for each. We provide some resources that may be useful during SiD sessions as well. If you read this book from beginning to end, and don't want to go too deep before getting a good overview of SiD, you can skip this section for now, and read on about the network and system in detail in the next paragraph.



SiD ELSI8 flower

ELECTRICITY GENERATION BY ENERGY SOURCE



DATA SOURCE: THE WORLD BANK - WORLD DEVELOPMENT INDICATORS, AUGUST 2019

ENERGY

ENERGY

- Includes: Radiation, chemical, electricity, heat, motion, wind, solar, geothermal, magnetic, etc.
- Reflects on: energy storage, smart grids, renewables, fossil fuels, insulation, etc.

Energy is the basic building block of our universe. It exists on a galaxy level down to the tiniest particles, and forms all the matter and phenomena we see around us. It is vital for our survival, but also imminently available in many forms. Energy consists in different states, each with its own characteristics and potential. Energy cannot be created or destroyed, but it can be transformed from one type to another, and flows from a 'high' energy state to a 'low' energy state if isolated and left alone (second law of thermodynamics). The different characteristics of higher and lower energy states makes some forms more useful than others. For example, when converting electricity (a high state) to heat (a lower state), it cannot be easily turned back into electricity, only with great transformation loss.

ENERGY TRANSFORMATIONS

Energy can be transformed from one form to another, for example, radiation from the sun can be transformed to electricity using PV panels, or into thermal energy by simply striking an object. Similarly, a piece of wood, which has stored potential chemical energy, releases this into heat when it's burned. When going from one state to another, we have to deal with efficiency losses, so the trick is to use the energy type that matches what is needed as much as possible. For example, to heat up a house, it's more efficient to use the heat from the sun with solar collectors to heat up a house directly, as opposed to first converting sunlight to electricity with PV panels, and then using electric heaters to heat up the house.

Energy is never truly lost, but it can be converted into a state where it's no longer useful. For instance, if heat dissipates from a house, the energy is dissipated into the atmosphere where it makes such a small difference that it can't be regained (laws of entropy).

FOSSIL TO RENEWABLE

For most of our society today we rely on fossil fuels to deliver the majority of energy we use, including oil, gas, and coal (see diagram on the left). We know that burning this fuel counts for the majority of CO_2 concentrations that impact climate change. The big quest therefore is to find renewable sources that cause little to no environmental damage, and that we can rely on to supply the energy we need for society.

SOURCES OF RENEWABLE ENERGY

There is an abundant amount of renewable energy around us, primarily from solar radiation which we can convert directly, and which sets in motion our climate system (giving us wind). Other sources are hydrological (including ocean wave energy, and hydropower from dams), geothermal (utilizing the heat of the earth's core), and biomass (storing solar radiation in carbon structures). All of these technologies have a cost associated with them, financially, environmentally, and culturally. Creating a healthy balance between the different renewable energy solutions we have

is a challenge we face now. A characteristic of some important renewable sources is that they fluctuate, such as wind and solar energy. These can compensate each other to a degree, but for an effective and reliable renewable energy grid, we need to be able to ensure that there's always enough energy available. Currently, we constantly generate a standard amount of energy using non-fluctuating sources (such as fossil sources) to compensate. This is called a 'base-load', and a high base-load is detrimental to attempts at reducing our energy use. To help alleviate this, we can store energy temporarily to smooth out the fluctuations. Electricity is expensive to store, but research into promising new battery types, for example using salt water, are under way. In the meantime, biomass can be easily stored, which makes using this renewable energy type an important contribution to a sustainable energy grid. We can also try to balance supply and demand, running energy intensive processes that are not time critical only when there's surplus energy available. Another solution is a 'smart grid', which connects all of the suppliers and users to balance out the fluctuations, explained below.

ENERGY STORAGE

Energy can be stored, but depending on which form it is in, this can be done more or less effectively. Storing chemical energy is usually easy, as it's often embedded inside fuels such as oil or wood. Storing electricity is more difficult and requires great efforts from science and technology to achieve, and cannot be done without losses over time. In many cases, this requires an energy form conversion. For example, rechargeable batteries found in cars and products convert electricity into chemical energy to store it, and convert it back upon release, which leads to significant losses. Electricity can also be stored in other ways. For example, excess electricity can be used to pump water up a mountain. When you need energy, you can let the water run down again, driving a generator, and get part of the electricity back. Energy storage is at the forefront of technological innovation, and each year new discoveries are made. Often though, there are ways to resolve energy challenges using simple low-tech solutions. Using systems analysis and mapping to keep track of the areas surrounding the challenge will help find these where possible.

SMART GRIDS

Smart grids are an example of an energy solution on the network level. Smart grids are the generic term for technologies where the electricity network can manage the balance of power between a variety of users, producers, and storage devices. It helps resolve issues with the fluctuating nature of renewable energy sources, which at the same time paves the way for individual households not to just consume but also produce energy. By connecting many solar, wind, and other renewable sources such as geothermal and hydropower together with a bi-directional network for energy consumers, fluctuations can be evened out. For example, while it may not be windy in one area, it may be in another, causing a smoothing of the energy supply. At the same time, energy demand fluctuates, and connecting this over large networks also flattens out these fluctuations. Connecting local energy storage systems such as electric cars, combined with self reliant homes that can generate electricity, for example with PV's on the roof, a reliable renewable energy infrastructure is achieved, and a lower base-load energy infrastructure can be used.

ENERGY BRAINSTORM AIDS

LIST OF ENERGY FORMS

This list is a nice reminder that we're surrounded by energy, and it's not even a complete list.

Kinetic	The motion of a body
Potential	Any 'stored' energy
Mechanical	Sum of kinetic and potential energies
Mechanical work	Displacement
Mechanical wave	Mechanical energy propagated by a material's oscillations, e.g. that of ocean surface waves or sound
Chemical	Contained in molecules
Electric	From electric fields
Magnetic	From magnetic fields
Radiant	Electromagnetic radiation including light
Nuclear	Binding nucleons to form the atomic nucleus
Ionization	Binding an electron to its atom or molecule
Elastic	Returning energy from the distortion of a material
Gravitational	From gravitational fields
Intrinsic	Rest energy equivalent to an object's rest mass
Thermal	A microscopic equivalent of mechanical energy
Heat	Thermal energy emitted

RENEWABLE ENERGY SOURCES

A small summary of the most common forms of renewable energy.

Solar PV	Capturing energy from the sun's electromagnetic radiation
Solar Thermal	Capturing the heat from the sun's radiation
Wind	Capturing energy from air currents
Hydro	Capturing energy from water currents
Wave & tidal	Capturing energy from periodic water movements
Biomass & fuel	Capturing energy from organisms
Geothermal	Capturing energy from the earth's core
Photosynthesis	Capturing the sun's energy by chemical means
Hydro chemical (osmotic)	Capturing energy from chemical differences in water bodies
Nuclear Fusion	Capturing energy from fusing atomic nuclei. Not (yet) made practically possible. Not to be confused with Nucleair Fission (non-renewable).



MATERIALS

- Includes: water, fertilizer, metals, wood, ceramics, plastics, textiles, fuels, VOC's, greenhouse gasses, etc.
- Reflects on: bio-based & circular economy, supply chains, toxicity, availability, appropriate use

The atoms from the periodic table of the elements, combined in diverse molecular structures, form the physical world around us. There are some materials we rely on heavily to sustain our existence on this planet, including fresh water, food, oxygen, the potassium and phosphate in our fertilizers, construction materials, and so on. Some materials we rely on are sourced from fossil sources, including oil, which we not only use to create energy but as a basis for most artificial materials such as plastics. Fossil and mineral resources are finite, and some of them are running out. Some of the most critically scarce materials on earth may surprise you. This includes fresh water, but also phosphate, a critical component in fertilizer and essential to life, is dwindling. Furthermore, we are running out of specific types of sand, which we use to make microchips, and rare earth materials we use to make electronic components.

Many of modern society's critical material flows have existed for less than 100 years. Our society grew from natural roots, where cycles of waste, food, building materials and water kept each other in balance. The industrial revolution allowed us to increase materials flows on a scale never seen before. Many materials lost the value they once had, because of this scale increase in extraction and production. Because of this, it became cheaper to just discard these materials after a single use than to try to reuse them. That pattern has changed little today, although the awareness of the problem has increased. A challenge before us is to start closing resource cycles of use and waste, production and use, and create a renewed appreciation of the value of material resources. It's not just the materials themselves that are the problem. The energy use, land use, water use, and CO_2 emissions associated with these resource flows also carry a heavy impact.

We've also mined materials that have laid still for eons without our ecosystems coming into contact with them, and artificially altered materials into forms that are not known in nature. Life has not built up a tolerance against them. Exposing life to these substances is causing huge future consequences. Radioactive substances are a good example, but there's many other biological and chemical substances as well. Plastics, for example, are an enormous source of environmental and health damage. When thrown away, plastics lead a life of destruction around the planet (witness the plastic soup, for example, or microparticulates). When burned, plastics create dioxins in our air, some of the most toxic gasses known to mankind. Unfortunately, we have treated these flows like any other waste material for the most part. Only in the last few decades we sometimes consider their harmful impact, and attempted some efforts to reverse the damage these inflict. Yet, at this point, many of these materials are now wandering loose in our ecosystems, and can be found in everything we eat, drink, and breathe.

Our challenges therefore include:

- Switching from a society that relies on finite sources, to one that relies on bio-based materials benefitting ecosystems during production (bio-based economy).
- Changing our linear production pathways of mining, use, and discard to circular, closed loop life cycles that retain the quality of materials, and delivers the services we're used to (the circular economy).
- Stop utilizing the harmful and toxic materials we've spread around our ecosystems as much as we can, and start collecting them.
- Dematerializing our economy to provide essential services using ecosystem services, and service based product-service systems rather than heavy material systems.

TOOLS AND EXAMPLES

In sustainability practice, a way of looking at the impact of materials on the world around us is through a tool called Life Cycle Assessment (LCA). LCA is a generally accepted, standardized practice that looks at the impact of materials from their inception to the end of their life. It is a complex and intensive process that can only be executed by experts, but the results can be used to compare material impacts. As an example, there's a simlified LCA table of materials to the right.

An example of an extreme material impact, and society's way to deal with it, can be found in the documentary movie 'Into Eternity', which shows the planning and construction of the Onkalo nuclear waste bunker in Finland, to remain there for thousands of years. It shows the impact of our decision to use a solution (nuclear fission energy) to cover our short term needs, with incredibly long term impacts on society.

LCA SCORE OF COMMON BUILDING MATERIALS 1

For you to get a feeling for LCA scores, below table has comparable LCA scores for primary nonrenewable energy (PEI PE), primary renewable energy (PEI RE), GWP CO_2 equivalent emissions, and Durability.

MATERIAL PER M2	PEI PE	PEI RE	GWP CO_2EQ	DURAB.
Limestone & Mortar	71	3.5	5.4	80-100
Fibre-cement sheets	88	38	3.4	40-60
Ceramic panels	285	50	21	> 80
Titanium-zinc sheet	416	43	25	70-100
Wooden shingles	41	226	-21	40-70
Insulating glass Ug = 1.1	547	65	29	50
Plastic sheet	1099	63	52	25
Exp. polystyrene (EPS)	511	17	28	30
Mineral wool fleece	74	1.4	5.4	30-50
Perlite fill	187	2.1	11	no data
Flat plan tiles, titanium-zinc flashings	331	180	11	50
Concrete tiles, titanium-zinc flashings	288	155	4	50
Copper sheet	830	130	35	80
Bitumen sheeting & gravel	1355	38	40	25-30
EPDM sheeting & gravel	394	28	17	25-35
Reinforced concrete	650	83	45	70-100
Loam bricks	96	1.2	4.2	70-90
Calcium silicate bricks	517	14	56	90-100
Clay bricks	599	12	79	90-100
Plasterboard	97	50	1.2	40-60
Loam building board	84	2	-0.2	no data
Timber boards	40	281	-26	50-90
Veneer plywood	177	540	-23	50-90

(Source: Energy Manual; Sustainable Architecture by Manfred Hegger, Matthias Fuchs, Martin Zeumer, and Tommy Stark)

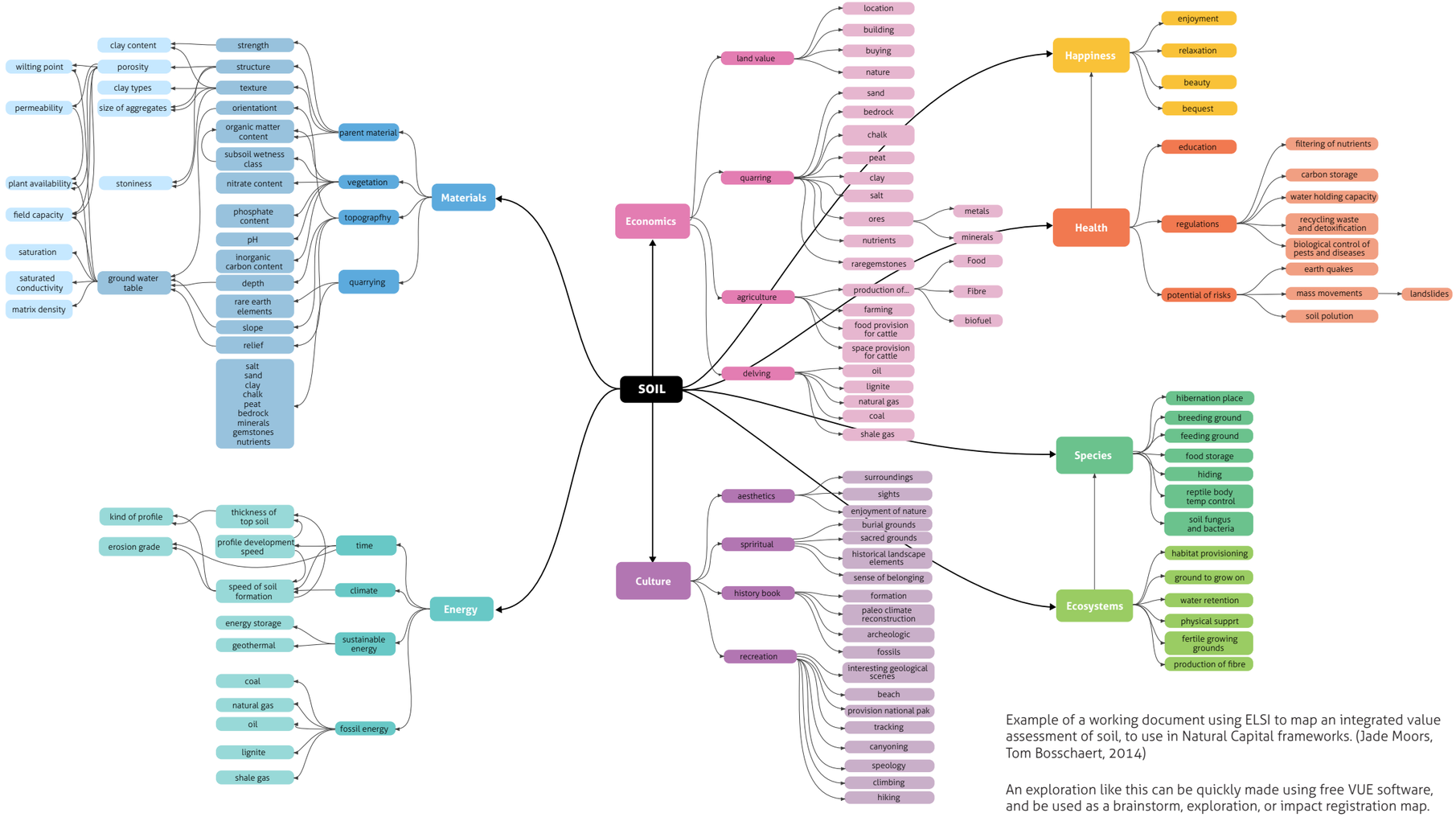
ECOSYSTEMS

ECOSYSTEMS

- Includes: Oceans, rivers, mountains, plains, air, climate, soil, swamps, lakes, forests, land use, etc.
- Reflects on: climate change, climate adaptation, ecosystem services, ecosystem restoration, natural capital

Our ecosystems are the bridges to life. They consist of 'dead' materials and cycles of energy through them, to create the conditions in which life can exist and flourish. They are the oceans, plains, mountains, rivers, and swamps that are our habitats. They are the grounds on which forests grow, the lakes where fish and insects live, the processes that clean the water we drink and provide the soil in which our food grows. They are the air we breathe, and the ozone layer that protects us from harmful rays from the sun.

Ecosystems have shaped over millions of years and are constantly moving, changing, and adjusting. The idea exists, launched in the 60's, that ecosystems are naturally in balance. But, as research shows, complex systems such as ecosystems are never in balance, forever changing, but they can be in more or less healthy states. What is true is that they can be upset and go into decline by changing some of their funda-mental operating mechanics. One of the most important ones of these of late is climate change. The main reason for this, science shows, is due to the influence of added carbon dioxide (and equivalent) gasses into



Example of a working document using ELSI to map an integrated value assessment of soil, to use in Natural Capital frameworks. (Jade Moors, Tom Bosschaert, 2014)

An exploration like this can be quickly made using free VUE software, and be used as a brainstorm, exploration, or impact registration map.

the atmosphere. Because of this, our global weather systems are changing, sea levels are rising, and habitats shifting. While change itself is not a bad thing, and part of the natural process, it is the rate of change that is problematic. This is now so fast, that species do not have enough time to adapt, and consequently go extinct. Our society also is not fast enough to adapt, with island nations already disappearing, and nowhere for their people to go. This fast rate of change causes not just the alteration of weather patterns, it causes them to become unstable, resulting in erratic weather conditions, and increased natural disasters such as hurricanes, and flash floods.

This process is underway and is not something we can suddenly stop. Complex interactions are occurring which may worsen or relieve this change over time, including the laying bare of permafrost lands in Siberia releasing extra greenhouse gasses, and increasing ocean acidification. What's clear is that we're facing a changing biotope on this planet. For some communities this may turn out to be worse than for others. Island communities need to prepare for rising sea levels to a degree where some need to entirely abandon their societies, such as the island of Tuvalu in the Pacific Ocean. For others it may make it possible to farm on lands that were too cold or dry to use before. What it does guarantee is a need for change and adaptation. These efforts are usually caught under the nomer of 'climate adaptation', and is supported by a number of international development organizations.

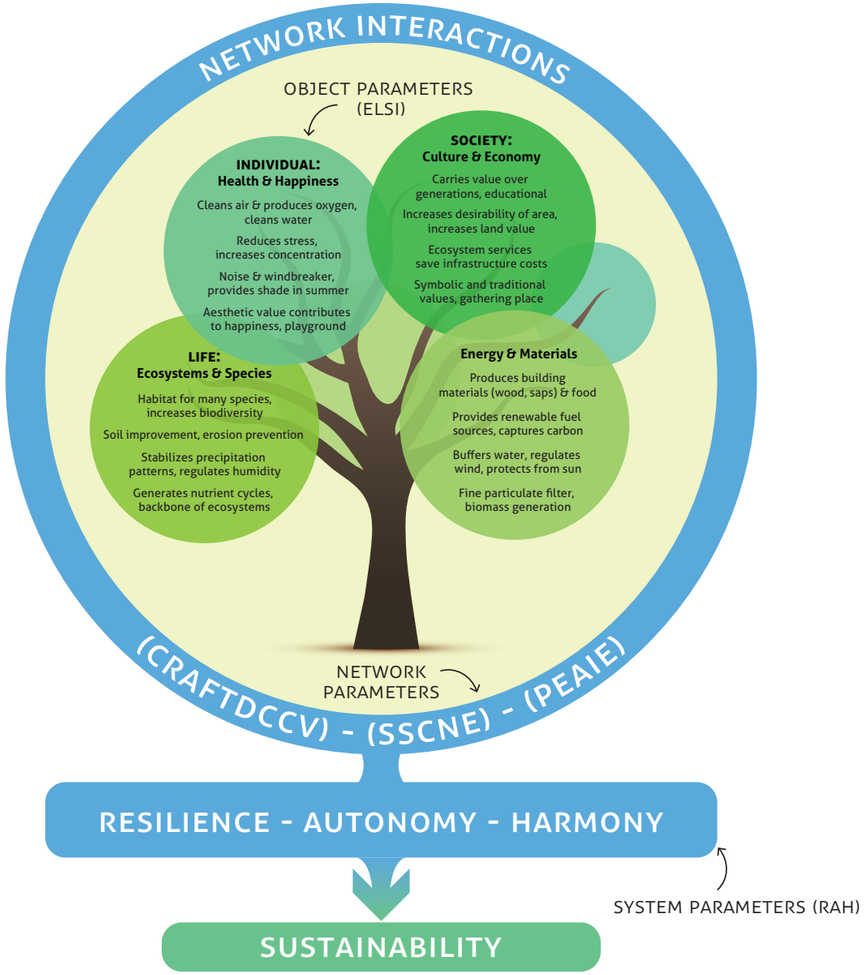
Ecosystems are the heavy laborers of our life support system. The services they provide to clean air and water alone are of such a scale that we could never replace them with technical means. Meanwhile, they create habitats for life which in turn provide services that bring us material resources, protection, and nourishment. While ecosystems are hard to value using conventional pricing schemes, they are of fundamental value to everyone, across borders and political spectrums.

NATURAL CAPITAL SYSTEM

A framework that is under development by the international community and gaining increasing support for its global adaptation is the 'Natural Capital' system. This system attempts to form a framework for the evaluation and quantification of the value that natural ecosystem services deliver, and to account for this on national and regional levels. A possible policy instrument derived from this could be an Environmental Profit & Loss (EPL) statement, tracked each year. For any action that takes away from the EPL, another action would be required to offset this with a positive contribution.

While Natural Capital has seen its fair share of debate on whether or not we can put a (monetary) value on ecosystems as a principle, the debate has come to a point where most participating parties agree that at the very least, putting a value of some kind on our natural resources is critical to prevent them from being used for nothing. While it's a given that not all value can be captured in this quantification, serious attempts are made at approximating it with some sensibility, which forms a foundation of a better understanding of the value of natural system to the economy, our culture, and our continued existence. See more about this in the 4.16 Natural Capital section in the Tools chapter.

SiD is useful in a Natural Capital process and its evaluation. It has been used to help unravel impact frameworks and value estimation for things such as soil, as well as impact mapping for green in urban environments.



Example of a natural capital quickscan on the value of a tree using SiD's indicator framework.



SPECIES

- Includes: Mammals, birds, insects, bacteria, amphibians, rodents, reptiles, fungi, trees, plants, weeds, etc.
- Reflects on: biomimicry, biodiversity, habitats, food, hygiene, invasive species, environmental ethics, etc.

Life on our planet exists in a multitude of species, believed to stem from a single origin. Traditionally, these species are categorized in five or six Kingdoms, including Animals, Plants, Fungi, Protists, Archaea, and Bacteria, of which the last three are all micro-organisms. We rely on these networks of species to provide the ecosystem services we've taken for granted in the last few centuries. We rely on them for food, water, medicine, and materials. We rely on them to make our environments habitable, prevent plagues and disease, and create the conditions to grow all our supplies in.

These networks are under stress. In addition, the disappearance of one key species may cause a cascade of species loss. For example, coral reefs are also called the nurseries of the oceans, because of their vital role in providing a protective environment for other species' mating and hatching. Their rapid disappearance due to ocean acidification (a consequence of rising CO_2 levels) is causing a rapid loss of life in our marine ecosystems.

THE VALUE OF PRODUCTIVE SPECIES

Species provide useful services for a wide variety of purposes. To switch to a bio-based economy, no other resources are as valuable as other species. Biological systems can process materials, create intelligent and efficient structures, and can provide a host of processing functions which our technical systems can't come close to comparing to. We can use the beneficial qualities of all these other creatures we share this planet with to shape a better society. This makes protecting biodiversity and researching ways to symbiotically co-exist with rich biodiverse environments a developmental priority.

Typically, when doing ELSI sweeps with teams, the Species section gathers the least ideas and interest. When doing brainstorms in most industries about potential values, problems and solutions, sometimes this section is entirely empty. This is indicative of how far we have removed ourselves from the natural world in our thinking, and it shows us how much opportunity we have left to explore there. Since one of our most pressing challenges for survival is our current massive biodiversity loss, this is highly concerning. Pay special attention in group processes to make sure Species and Ecosystems are explored sufficiently.

THE DIVERSITY OF LIFE

All life on earth is based on carbon, bonded with other elements, most notably oxygen, hydrogen, and nitrogen. From these basic building blocks an unimaginable richness and diversity of life sprouts beyond our wildest imagination, from the depths of our oceans to the highest mountain top. This diversity has grown through 3.6 billion years of evolution, on a planet that's 4.6 billion years old. Of those 3.6 billion years, mammals have only existed for about 200 million years, and the world's oldest existing life form is thought to be a one hundred million year old single celled Protozoan living in a lake in Norway.

Among this spectrum of life we humans have come to peek around the corner only 200.000 years ago. We evolved in an incredibly rich biotope where countless species interact, exchange and co-habitate. While most of us are ready to be awestruck and inspired by the rich diversity and ingenuity of life that surrounds us, our daily actions are also helping to rapidly kill it off. Between the different institutions that keep track of global biodiversity such as WWF and IUCN, the rate at which species are disappearing lies between 1.000 and 10.000 times the natural extinction rate. In some areas, like amphibians, almost 30% of all species are threatened with extinction, and 21% of all mammals. This all means we are witnessing the sixth mass extinction event since the birth of life. The main cause of this 6th event, science says, is human activity. This is not just bad for these species, it's bad for us.

TOOLS AND EXAMPLES

When looking at biodiversity, we have two clear challenges: to stop and prevent further harm to biodiversity and endangered species, and to start reconstructing habitats and reintroduce biodiversity in urban and degraded landscapes. For the first, an important tool is the IUCN red list of endangered species. This list is the global standard for species endangerment. The second does not currently have a readily useful tool, but various organizations, such as IUCN and WWF, are working on these in various communities of practice.

SPECIES COUNT

1

Can you guess how many bird species exist? And how many mammals? What about plants? Are there more fish than fungi species?

Here's a short list, with a rough approximation of the known and expertly guessed number of species, collected from various sources.

KINGDOM	KNOWN/ESTIMATED SPECIES
Bacteria	4.000
Protoctists (algae, protozoa)	80.000
Animals (vertebrates)	67.700
Of which Birds	9.000
Of which Mammals	6.500
Of which Fish	33.500
Of which Amphibians	8.000
Of which Reptiles	10.700
Animals (invertebrates)	1.272.000
Fungi	72.000
Plants	270.000
Total known species	**1.750.000**
Possible species (including unknown)	**14.000.000**



CULTURE

- Includes: Community, politics, law, art, education, tradition, living environments, language, etc.
- Reflects on: Sociology, ethics, philosophy, history, technology, demography, power, architecture, etc.

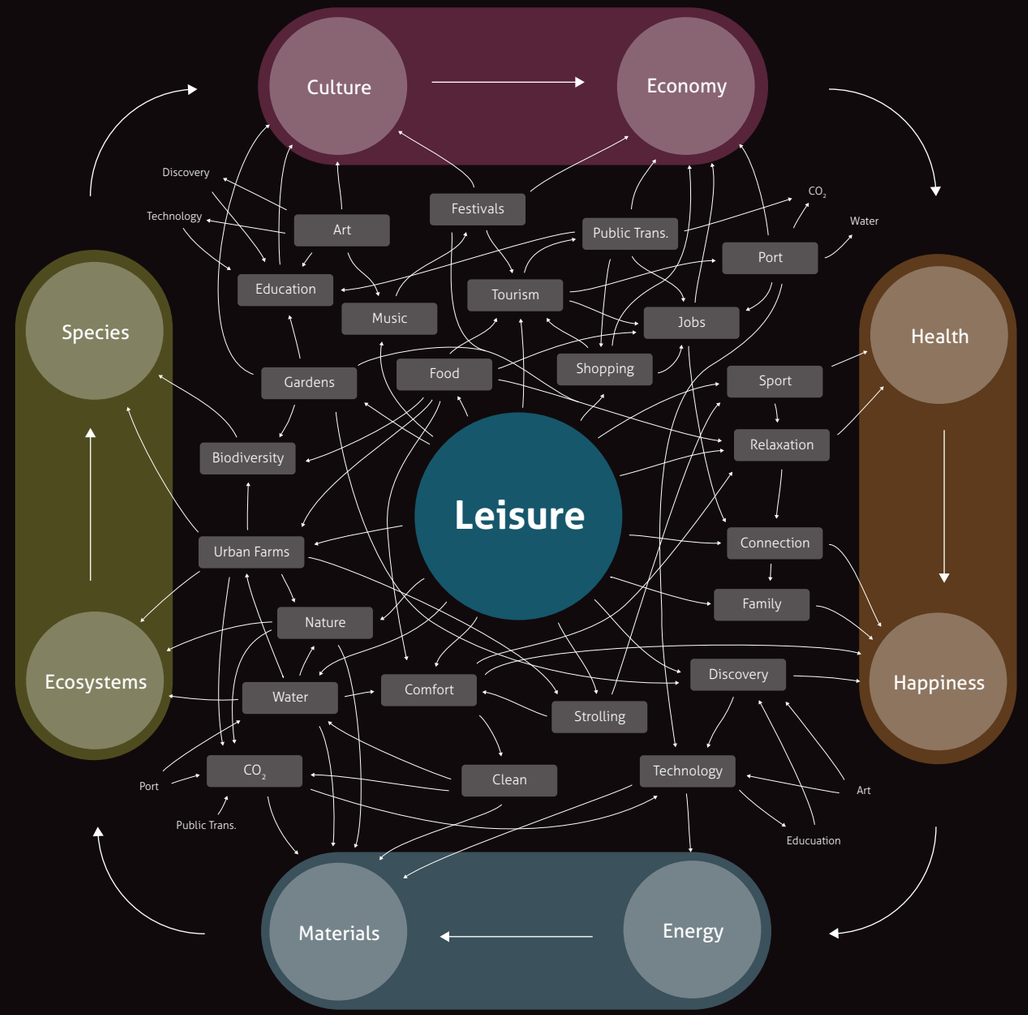
Culture is the collection of foundational interactions between us as a species. They include all the ways we act, interact, and exchange. Some of these patterns are evolutionary in kind and have grown over thousands of years, while others are new and rapidly evolving. Other species also have culture, which is easily seen in species we have empathy towards such as primates, but obvious species cultures such as ant and bird colonies also show us the rich culture of our evolutionary siblings.

In relation to sustainability challenges, cultural aspects impact many areas of development. These range from how we talk about the challenges, to the laws we make, the way we try to stimulate or enforce change, and the regulations and traditions that impact Harmony. Social justice challenges are present in every culture on earth and a driving force for many. Cultural aspects are also often present as an enabler or inhibition to changes in other areas of the ELSI stack. For example, the conservative culture of certain communities inhibit the implementation of more progressive sustainable solutions.

As we climb up the ELSI ladder, we find aspects that seem increasingly complex. While we're adept at dealing with issues on the material and energy levels (often engineering-related), in the culture section live elements that are subject to decades of debates and that can get fuzzy really fast. Because 'politics' lives in this area, it's the section most sensitive to warping from these forces.

Some of the most important themes in the culture category have to do with a networked understanding of how we exchange culture in society. When performing a network analysis, you can quickly see that knowledge sharing, in any form, is one of the most fundamental drivers of the creation and flourishing of culture. Primarily, of course, through education, which is the cultural equivalent to water and bread of a society, and an expression of fundamental 'connectivity' on the network level. Any culture that inhibits or needlessly restricts education, for example by budget cuts that impact quality or access to education, trades short-term financial gain for future societal decline. A systems analysis shows this as clearly as 1+1=2. Unfortunately, this seems to be all too pervasive a problem in many societies, which may have something to do with the typical short term of a political period of 4 to 5 years, while it takes about 10 to 20 years for an impact on the educational system to register in societal performance.

But education is not the only important aspect of knowledge exchange. If we think about the transparency parameter we can see that this is analogous to the access and availability of knowledge in the system. What is keeping knowledge from flowing freely and quickly to all people? This is impacted by, for example, intellectual property rights such as patents, as well as governmental and corporate secrecy. Because



Using ELSI to explore the concept of 'leisure' in the context of a more livable city of Rotterdam (Except 2013)

part of the knowledge exchange in society has been monetized (through patents) many areas have become inaccessible. This is a huge systemic problem when looking at something like medicine. This leads to a strong disenfranchisement of those without knowledge ownership. Because knowledge breeds knowledge, this has a spiralling effect. Thus, the open source movement, which strives for the free access of all knowledge, can be seen as part of the quest for basic human rights and equality.

Similar is the trend for the decentralization of knowledge, and with that, power. Knowledge is now more valuable than physical possessions, with the most valuable companies in the world now governed by companies dealing in data. Power is shifting its base from the ownership of property to the ability to receive, collect, manipulate, and broadcast data. Old hegemonies of material wealth are left behind, and new ones that control networks are flourishing. With the advent of the internet, new lands have been made available to humanity to re-order the power landscape. New opportunities await us to establish a more harmonious and free society with these new found opportunities.



ECONOMY

- Includes: Financial systems, transportation, employment, trade balances, legal entities
- Reflects on: Alternate currencies, value creation, business models, wealth distribution, globalization, sharing economies

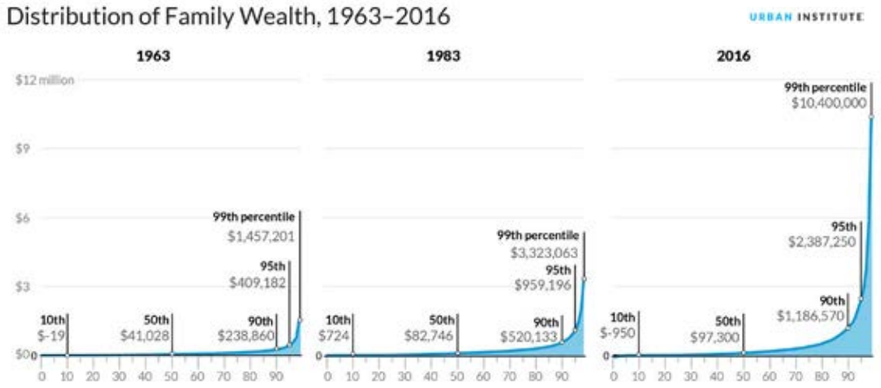
The economy section is the area that deals with all the interchange of goods and services among people and the other sections. This is the ELSI section that most people in the world are concerned about on a daily basis. If anything is beyond the scope of this book, it's an extensive discussion about all the issues and elements of the economy. Not because it's so much more complicated or important than the other sections, it's just the one humanity has spent most time fretting about. We are, as a species, completely obsessed with the management, maintenance, and performance of our patterns of exchanging resources.

Economy is the logistic nervous system of our society. It's entirely defined, controlled, and embedded in the cultural layer, but it's often treated as having a higher importance, which is nonsensical. Without culture we are nothing, and economy is as much a cultural expression of our society as art and science is. Economy is, difficult as it may seem, a collective choice. But, each and every individual is directly dependent on the patterns within economy and few have the resources to change this structure on their own. It's where our jobs are, our transport, and our infrastructure.

There are many themes in ELSI's economic layer that occur frequently when studying societal problems, but none are as pervasive as unequal wealth distribution and its causal cousin, poverty. These should also become apparent when conducting a Harmony system indicator inventory, especially the Power Balance, Access, and Inclusion parameters. If you make a causal loop map of any large societal issue, whether it's disease epidemics, terrorism, resource depletion or drug addiction, you will find poverty as a major driver. Providing solutions for poverty is therefore a systemic goal in and of itself.

Another pervasive theme in economy is the entrenched pursuit of growth as an economic goal. It's a typical example of a logical fallacy that growth is a precondition for a healthy organization or nation, which has nevertheless permeated economic textbooks for more than a century. No organism on this planet requires consistent systemic growth to survive and procreate. Growth in a finite space is always fatal. Eradicating the mechanisms of this fallacy is one of the big challenges before us in this century. It gives rise to many of the parasitic mechanisms that exist in our society today, including artificial inflation, which in turn can enslave a people into lives of infinite toil.

The most valuable component of economy is labor, and the most strikingly influential is, historically speaking, trade. Trade has pulled along culture as a driving force of cultural exchange and exploration. Jobs are the bread and butter of any economy. Jobs not only give people the means to live and sustain their bodies, jobs give meaning to life. Having the right to work, is having the right to a meaningful existence. This is of course only true if those jobs are fair and ethical. Through this fundamental value of being useful for society through meaningful work, the economy section feeds directly into the health and happiness of the individual.



HEALTH

HEALTH

- Includes: Medicine, food, sports, healthy environments, safety, shelter
- Reflects on: Longevity, nutrition, food access, obesity, life patterns, access to nature, environmental toxicity, aging, healing environments

This is the area that deals with our physical health and those aspects in our environment that affect it. We're increasingly concerned with our personal health, but this is not a new development. Throughout history we've seen flurries of health concern, some based on truth, some on superstition, and this is still the case today. Physical health and mental health are, as science continues to prove, closely interlinked. The Health and Happiness aspects of ELSI are therefore operating in close relation with one another. For example, stress, a decidedly mental factor, greatly affects physical health, and vice versa.

LEADING CAUSES OF DEATH

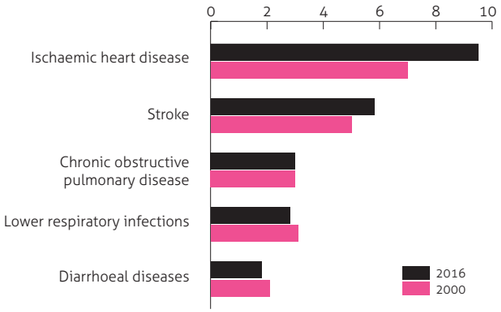
The leading cause of death, and rising, is Ischemic heart disease, also called coronary artery disease. Besides hereditary and gender related influences, the highest impact on these are diet (high cholesterol), cigarettes, blood pressure (stress), and lack of physical activity. Clearly, some of the greatest health issues of our age are related to nutrition and a sedentary lifestyle. In our industrialized societies there is plenty of processed food available everywhere, but fresh food has become hard to come by in many areas. It's either expensive or it's simply not there. The result is malnutrition, obesity, associated depression, and a plethora of related societal issues mostly in the disenfranchised layers of society (there's poverty again). The greatest threat to a human being isn't working environments, car crashes or war, but heart disease. There are colluding drivers for things like obesity, such as car-oriented culture, gaps in education and increasing commercial pressure to buy particular brand products (e.g.fast food chains, soft drinks), competing with affordable healthy products.

FIGHTING FOR CONTROL OF ONE'S OWN HEALTH

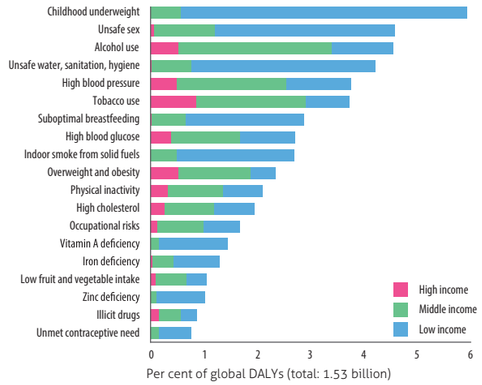
While historically the individual has mostly been held accountable for making healthy life choices, it's increasingly understood that there are systemic drivers that disallow or strongly disincentivize this. Not one individual can fight the power of uncountable corporations wanting to sell their product (often at all and any cost). Carefully analyzing everything you buy and consume, and understanding their net effect on your own health, let alone on the planet and others' health, is simply impossible. Health and nutrition are responsibilities that are as much shared as they are personal, and to effectively confront them can benefit greatly from systemic approaches.

Outside of the western world, access to fresh water is still one of the major health concerns. 1.5 million people still die of diarrhoeal diseases each year, linked directly to poor sanitation and access to clean water. These are similar numbers as those perishing from HIV/AIDS. While globally diarrhoeal diseases have been on the decline, with increasing scarcity of fresh water, we should ensure it does not revert.

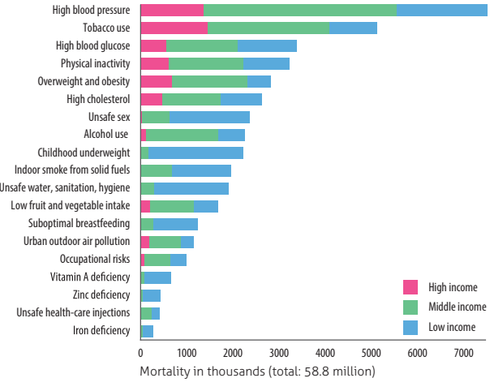
GLOBAL HEALTH STATISTICS, TOP CAUSES OF DEATH



Percentage of disability-adjusted life years (DALYs) attributed to 19 leading risk factors, by country, income level, 2004.



Deaths attributed to 19 leading risk factors, by country income level, 2004.



Source: Global Health Estimates 2016: Deaths by Cause, Age, Sex, by Country and by Region, 2000-2016. Geneva, World Health Organization; 2018.

As people move more into cities, with the resulting increase in density and size of urban environments, so does the rise of air and noise pollution. In an increasing number of global capitals air pollution is the number one negative health factor. Measures to improve air quality are constantly implemented, but since they tend to be performed on an object-level they rarely beat the curve of rising pollutuon. Air pollution continues to threaten the lives of billions of people in the world. As we gain increasing understanding in the effects of smaller particles, this problem seems to rise on the priority ladder. Associated to air pollution is noise. Noise (and vibration) is associated with increases in stress levels and subsequently developmental disorders and even cancer.

On a related note, living in cities, with less access to nature and a higher pace of living, is one of the reasons stress levels around the world are increasing. This is combined with mental factors, but physical stress associated with long working hours, high brain activity from processing the increased stimuli and messages we are confronted with are related to stress related illnesses.

No wonder that there's increasing interest in health related aspects in our daily lives. Healthy offices and living environments, healthy hobbies such as yoga and health diets and resorts, are increasingly gaining traction in the western world.

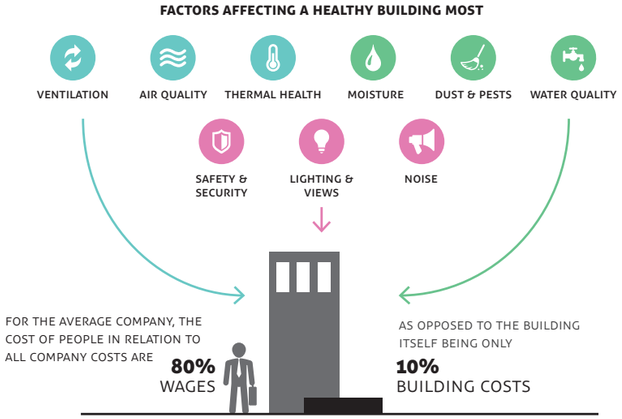
SILVER SOCIETY

At the same time, on average, we are increasingly living longer lives. This is good news for most people, and largely due to improvements in public health, nutrition and medicine. It also means that our population is aging. The 'silver age' is becoming a major societal challenge. How will we enable a flourishing society while a majority of us is no longer working? How do we develop environments in which we can live meaningful lives and can contribute, even after we've stopped working? How do we deal with the increasing pressure on our medical systems? Long term planning and innovation for the silver age affect nearly all developments, but they are not yet taken into account enough. Things are things to put on the radar.

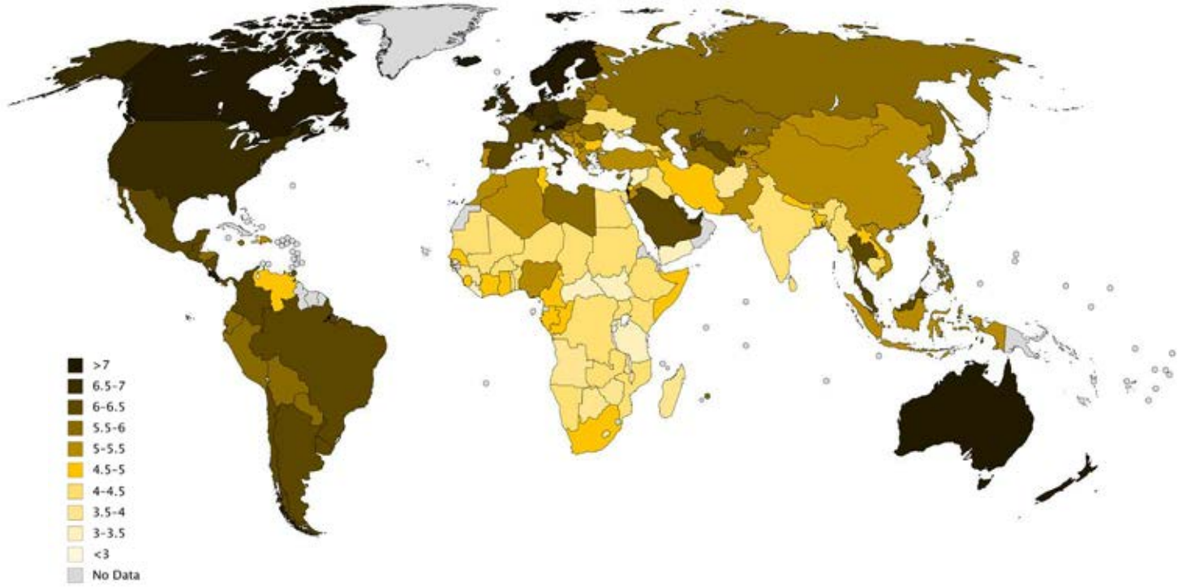
EXAMPLE: HEALTHY BUILDINGS PAY FOR THEMSELVES

We wanted to figure out what the return on investment of health and productivity measures for offices are. Except's science team collected data in meta-research about all aspects that may influence worker productivity. The diagram on the right shows that in a typical office, over 80% of the costs in that office are employee wages, and only 10% is office cost and upkeep.

Below, a table with performance increasing measures. In total, we estimate between 10% and 20% of productivity increase can be gained through health and wellbeing measures. This pays back the entire construction cost of a typical office in 10 years.



IMPROVEMENT ITEM	PRODUCTIVITY INCREASE %	NOTES AND SUGGESTIONS
Light	2,8 - 11,4	Natural light always better than artificial. Use wide-spectrum non-flickering LEDs, with min. 500 lux at the desk (pref. natural light), with personal control.
Outdoor view	6	View towards substantial nature
Vegetation	6 - 15	Use indoor plants, use of natural materials (i.e. stone, wood etc.)
Simulated nature	<1	If real nature is not possible, screens, pictures etc. have little positive impact
Colors	<1	Research is inconclusive about color use
Air quality	4,4 - 7	Mechanical ventilation with fine particle filter (e.g. carbon active), use of materials which do not emit VOC, min 10 liters/second of air supply per occupant.
Acoustics	5,4	Limit noise from outdoors, limit noise from mechanical systems, limit noise between working stations.
Thermal comfort	7	Summer: 23,5 – 25,5 °C, Winter: 21,0 – 23,0 °C, homogeneous temp. distribution, personal control / feeling of being in control of temperature set point.



Happiness score of countries according to World Happiness Report of Columbia University (2018)



HAPPINESS

- Includes: Stress, purpose, freedom, free time, social connectivity, self-development, biophilia, access to loved ones, self-expression
- Reflects on: human performance, creativity, imagination, suicide rates, freedom of speech and religion, access to nature, work-life balance

Happiness. Its position on top of the ELSI stack signifies that happiness is the driver behind the actions of each individual. What constitutes happiness varies wildly between individuals, cultures and stages of life, but there are certain universal drivers behind happiness that seem to hold true for most. These include free time to spend at our choosing, the ability to self realize, spending time with friends and family, and repeated time spent in nature.

As our society changes, so does our perception and the drivers behind the individual's happiness. We are, after all, a social animal, and our relationship to the group can largely affect our self image and feelings of self worth. This drives societal pressure behavior such as the pursuit of status or power, which is of all times. Other values shift, such as the perception of value of free time versus owning material goods.

Measuring happiness can be as easy as simply asking someone how happy they are, to involving carefully designed questionnaires. It's useful to know how happy people feel they are, but it's not always necessary to know how people perceive themselves to understand that various factors impact general happiness levels. There's different schools of thought about what drives our emotional well-being. Combining them gives us a good set of areas of interest for investigating the happiness part of ELSI. Let's look at a few of them:

Carl Jung listed five main factors for happiness[1]:

1. Good physical and mental health
2. Good personal and intimate relationships, such as those of marriage, the family, and friendships
3. The faculty for perceiving beauty in art and nature
4. Reasonable standards of living & satisfactory work
5. A philosophic or religious point of view capable of coping successfully with the vicissitudes of life

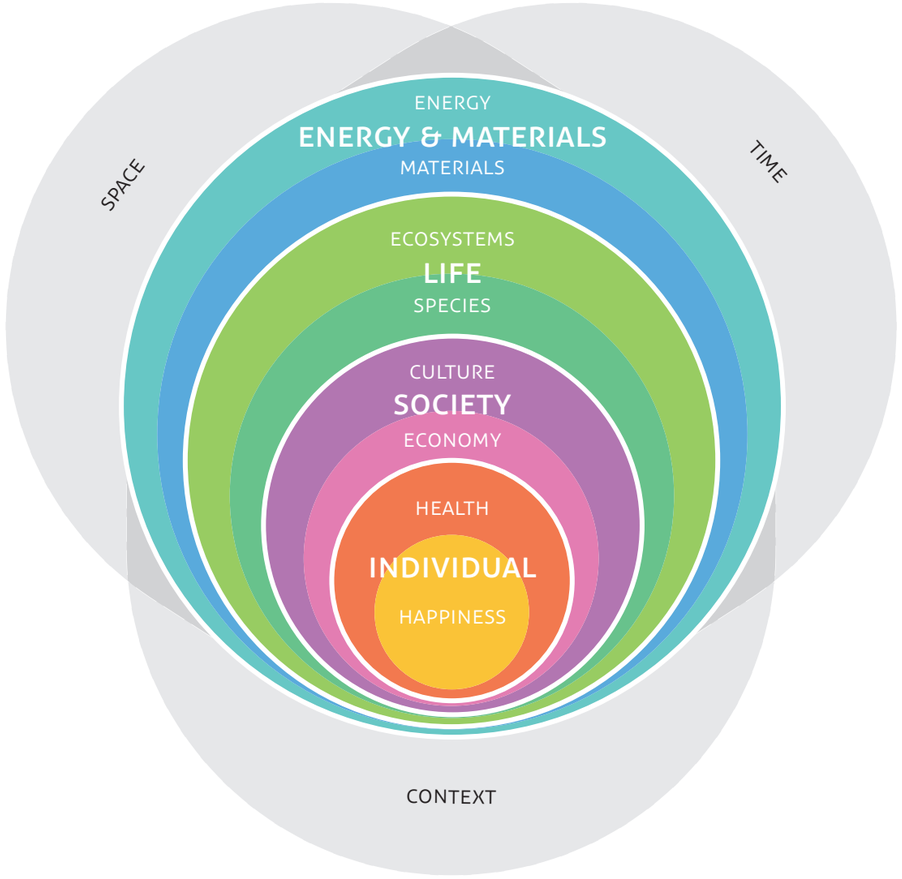
The World Happiness Report has six different factors that influence happiness[2]: Quite a different list.

1. GDP per capita
2. Healthy years of life expectancy
3. Social support (as measured by having someone to count on in times of trouble)
4. Trust (as measured by a perceived absence of corruption in government and business)
5. Perceived freedom to make life decisions
6. Generosity (as measured by recent donations)

Yet another perspective is offered by Dr. Roger Walsh,

1 From C.G. Jung Speaking, C. G. Jung, 1987

2 World Happiness Report 2016 Update, http://worldhappiness.report/



ELSI Rose

researcher in psychiatry[3]:

1. Exercise
2. Diet & nutrition
3. Time in nature
4. Contribution & Service
5. Relationships
6. Recreation
7. Relaxation & Stress Management
8. Religious & spiritual involvement

As these different lists show, happiness is elusive. Personally, having looked at a lot of these lists in the past, I often miss simple things like having some quiet time alone, a good laugh or the occasion to be silly once in a while. Environmental factors also impact a person's wellbeing significantly. This is especially true in working environments where people reside without having an option to leave or with limited ability to affect their environment. Things to consider include light, acoustics, comfort, temperature, humidity, colors and presence of nature. Research indicates that improving the quality of working environments increases people's working performance more than 20%.

Instead of trying to make a complete list of what makes us happy, we can also do the opposite, which is a useful way to find strong happiness drivers. We can all easily list aspects that would make us unhappy, for example:

- Imprisonment
- Physical pain
- Seeing loved ones hurt
- Stress
- Inability to express ourselves
- Disconnection from loved ones
- Suffering injustice done to us or loved ones
- Being ostracized
- Mothers-in-law

Again, it's a subjective list to say the least. I did not number this list, because it's easy to go on for a while. The point is that given a certain situation, you may encounter different factors that affect happiness. We're looking for a practical working set of topic areas. Happiness may be the biggest demonstrator as to why SiD does not have a fixed set of indicators or subcategories. It would never stop. But if you have a particular situation, for example, when redeveloping a neighborhood or creating policy for a company or government, it's easier to narrow down the topic areas.

Since Happiness is one of the main drivers of the actions of the individual, its here that we often seek for driving triggers that allow us to stimulate a system to make a change. If there's an action we'd like people to take that is preferable, for example, taking stairs instead of the elevator, happiness is an area we may look at. For example, we may develop a way to make the stairs more fun to walk on. For a great little video of a way to do this, search Youtube for a video on the piano stairs of "the Fun Theory".

3 Dr. Roger Walsh, Lifestyle and Mental Health, 2011, American Psychologist, Vol. 66. No. 7, 579-592

CASE STUDY: REDEFINING HEALTH

By Renske Kroeze
Psychology researcher & healthcare innovator



RE-DEFINING HEALTH WITH SID'S SYSTEMS LENS

For years, health has been viewed as a mere 'absence of disease', which is not really informative when trying to look at what healthcare is supposed to mean and be. In line with SiD's definition of sustainability, health can be seen as a state of a complex dynamic system. In this view, different internal and external 'objects' such as hormones, food intake, and exercise interact with each other on a network level, together producing some state of the 'health' system as a whole.

Specifically, in order to be able to speak of health, the state of the system needs to be resilient, which means that one can recover fairly quickly and sustainably after some imbalance. The system also needs to be harmonious, which in the case of a non-societal system such as a human body is inherent (not attacking itself), as well as autonomous, meaning it needs to be supplied with the right amount of resources to operate properly (food, water, air, physical exercise, sunlight, etc), and can freely move to seek more optimal conditions if required.

By stressing the need for resilience, and thus the ability to recover from an ailment, this definition recognizes that a person can experience physical or mental issues from time to time as part of "normal operations". This, as opposed to the traditional view to cure each ailment separately, is therefore more helpful in light of current trends in demography and healthcare technology. Moreover, treatment can be directed at establishing (long-term) resilience and not at mere symptom reduction. So, this view both clarifies what health is, and contributes to more sustainable ways of treating health related issues.

APPLYING SID TO (UN)HEALTHY PEOPLE

In line with this definition of health, we use SiD as a starting point in working towards resilient physical, mental, and social systems. I'll illustrate this by zooming in on mental health diagnosis and treatment.

Research has increasingly shown that mental disorders are not fixed entities, but emerge from interactions between different biopsychosocial aspects. On top of that, the 'objects' and network structures making up these mental health systems differ across individuals.

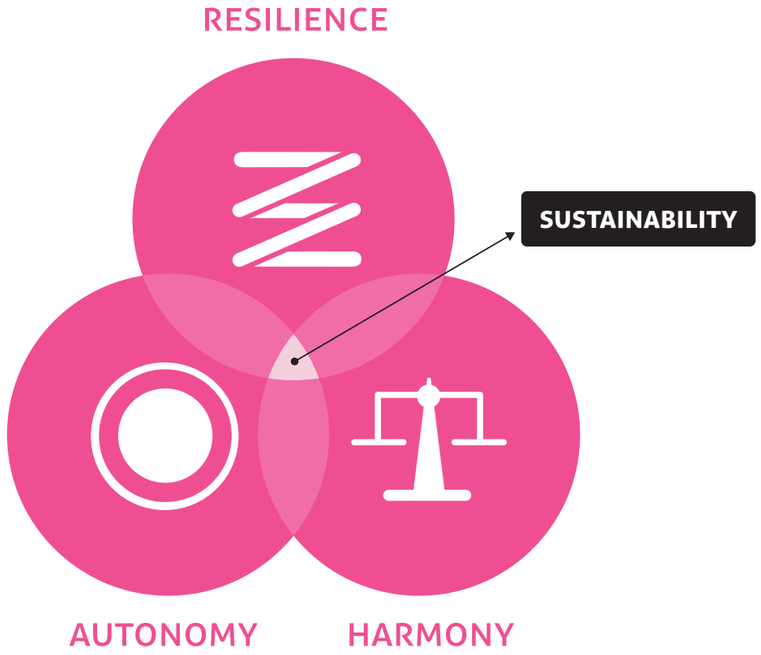
When taking the systemic nature of mental health into account, it makes little sense to diagnose people with certain 'mental disorders' and trying to fix these using a unified approach, which is currently the case. Using SiD-like methodologies to map the system helps to achieve better goals and better solutions. It goes without saying that SiD can be used in designing and improving other health related topics, such as cardiovascular problems related to lifestyle, or 'vague' chronic ailments that do not seem to have a simple cause. The resulting insights then consist of, for example, interrelations between mood, anxiety, genetic disposition, lifestyle factors, social environment, and protective factors like purpose and fulfillment, together making up a patient's mental state.

There are multiple ways of mapping this system, both qualitative and quantitative, which can function as an individualized diagnosis. Both bottom-up and top-down approaches of analyzing the system are then used to arrive at the right intervention to shift the state of the system of individual people towards a more resilient one. This can then include a variety of solutions in a 'roadmap', including medicinal, therapeutic, biophysical, psychological, behavioral and cultural aspects.

If the mapped system is not too big, it's possible to analyze the quantitative structure for most central objects that function as a leverage point in shifting its dynamics, and thus quickly find remedies. If it is too big to map, therapists and patients can use a top-down analysis approach such as SiD's climbing-the-hill approach to start discovering solutions in the form of iterative interventions. Roadmaps are drawn to infer whether the effect of the interventions have the desired effect, and 'the system' is evaluated and updated along the road of treatment. Currently, in psychological science, studies are designed that investigate possibilities of implementing such an approach in mental healthcare, and results are expected to be published in the coming years.

EXPANDING BEYOND 'SUSTAINABILITY'

To conclude, SiD can be applied beyond 'classic' sustainability questions onto other complex constructs in which sustainability is a desired goal. SiD can be used in designing and improving other health related topics, such as health systems on the meso level, i.e., healthcare organizations, cultural patterns affecting health, and global health systems on a macro level. In this way, SiD enables us to see the complex world as it is and develop actionable interventions to all kinds of systems to make them truly sustainable.



RAH system indicators

1.2.4 SYSTEM INDICATORS

The three main SiD system indicators inform us about the performance of the system as a whole, and together, they lead up to determining the sustainability of a system. The topmost indicator is a system's 'sustainability', and this includes all the other system indicators, as well as the network and object indicators. Sustainability is in turn informed by three main system indicators, called RAH, which are:

- Resilience
- Autonomy
- Harmony

RAH is derived from SiD's definition of sustainability. The complete 'deck' of system, network, and object indicators (SNO Indicator Deck), form the full set of measures that feed the evaluation of sustainability. A system is sustainable if it's Resilient, Autonomous, and in Harmony, therefore the system indicators are the 'pre-selection' to sustainability. These three indicators have their own characteristics and interactions, further discussed in chapter 2.5.

RESOLVING SYSTEM INDICATORS

The RAH indicators, by nature and by design, are broad. There's no uniform way of assessing them that holds true for all systems and situations, and they therefore require assessment on a case-by-case basis.

System indicators tell us something about the performance of the system as a whole, and are the highest order of evaluation that you can perform on a system. The system indicators together define a system's 'sustainability', and include the performance of all the network and object indicators 'below' them. System indicators are the most influenced by system dynamics of all the indicators, and when leveraged on subsystems, they affect both higher and lower levels.

The three system indicators are 'fed' by the network as well as the object indicators below, and also respond directly to one another. There is no fixed rule as to how the RAH parameters are connected to the network and ELSI parameters, but there are common occurrences. Using the rules of thumb and network parameter characteristics, it's usually straightforward to figure out the basics of how parameters and indicators are related given a certain system.

In the next section we expand on the characteristics of each of the RAH indicators, and in the chapter about the SiD network parameters we'll discuss the rules of thumb of how each network parameter typically influences the RAH indicators.

RESILIENCE



CONNECTIVITY REDUNDANCY AWARENESS FLEXIBILITY TRANSPARENCY DIVERSITY CENTRALITY COMPLEXITY VALIDITY

SYSTEM LEVEL: RESILIENCE

Resilience is a system's capacity to withstand (unexpected) external disturbances and its ability to return to a healthy state after suffering a blow.

Resilience is not to be confused with toughness or strength. For example, for purposes of personal self-defence, techniques which rely on agility and flexibility such as Aikido are more effective than those which rely on pure strength, such as body-building. The same goes for systems: agile, flexible, and adaptive systems are more likely to be able to return to a sustainable state than monolithic and tough systems.

There are many theories that have been developed and new ones in development about Resilience, and whole organizations that focus on it, like the Stockholm Resilience Center and the Resilience Alliance. Please note that the word can be used with different meanings in different professions such as psychology, engineering, and ecology.

THINKING IN RESILIENCE

Resilience is a powerful concept: the degree to which something can withstand unexpected occurrences. Resilience is key for ensuring continuity of a system in the long run. By focusing on resilience, you come to the insight that goals such as growth and profit lead down fragile pathways which, in the end, serve nobody. Replacing these with Resilience as a goal at the topmost level of decision making leads to profound improvements in system performance for all stakeholders, creates clarity where there previously was none, and leads to more effective strategies in the short and long run.

BEHAVIOR

Resilience is a complex system indicator, influenced by a wide variety of network and object parameters, which change depending on the circumstances and context. Resilience tends to be more important for the sustainability of the system as a whole. In general, and in virtually all cases, higher resilience is good. Resilience is highly susceptible to system dynamics, often more so than Autonomy and Equity. It is the most strongly influenced by the network parameters of the three RAH indicators, and less directly by ELSI indicators. Resilience responds to Autonomy and Harmony strongly, but not in a linear fashion. Increased Harmony usually leads to higher Resilience, and a very low Autonomy also hurts Resilience, although a very high autonomy can also cause a low resilience.

We'll look further into the relationships between the network and the system parameters more in the next chapters in the network parameter chapters.



Low resilience



Neutral resilience



High resilience

EXAMPLE: RESILIENCE IN CITIES

Cities have become the central framework to sustain human life. While growth may seem an attractive option for cities, considering the potential economic benefits, we are well aware that growth alone leads to undesirable cities. Applying resilience as a strategy instead of growth is a more effective means to arrive at both economic growth, and an actually flourishing city.

A city wanting to improve itself can see that growth isn't necessarily a good thing. Growth will fluctuate, and end. While a growing city increases resource flows, this can only be temporary, and eventually it will either shrink or run into a resource shortage. This is also because with increased size, resource consumption tends to grow in a non-linear fashion, as well as overhead costs for infrastructure and management. This means that ensuring quality of life, safety, and healthy living environments during growth is no trivial task. What will steer that, what is its target? And when growth ends, the challenge then becomes how to flourish in either condition of growth, while becoming resilient for the long run.

If the city focuses on resilience rather than growth, the result is, as a necessary consequence, a more diversely-mixed, flexible, and dynamic urban landscape. It will have less monocultures of office parks and suburbs (which eventually drive traffic congestion out of bounds). It leads to dealing differently with resource management, this costs in investment terms, but pays off in the long run with clean, healthy living conditions, lower utility and maintenance costs. It will deal with the uncertainty of fluctuation resource flows in the future, will restructure itself to allow for changes in demographics and lifestyles, and start to shape itself according to its inherent strengths. When implemented effectively, this leads to better living conditions for all inhabitants, creating a more attractive city, attracting more businesses and investment, and which then causes economic growth. The result is a different trajectory, that leads to a completely different, better performing city, while at the same time leading to better economic conditions. Rather than growth as a driver for economic wellbeing, resilience is used as the driver instead. Economic health is achieved through a different pathway, that simply regards economic growth as a side-effect of being a great, beautiful, healthy, and future-proof place to live and work.

Creating such as 'resilience' policy will automatically start to influence other areas of systemic concern as well, such as energy, sanitation, poverty alleviation, infrastructure, and cultural programs. For example, it leads to a city in which health is increased by means of biodiversity growth. It means reduced transport loads by smarter reallocation of workforce distribution. These are win-wins that aid to in concert, like instruments in an orchestra, help to achieve benefits that drive the larger goal. This way, a resilience driven strategy maximizes positive benefits on the United Nations SDG program, which helps to acquire investment funds and to achieve positive PR and worldwide recognition.

EXAMPLE: RESILIENCE IN ORGANIZATIONS

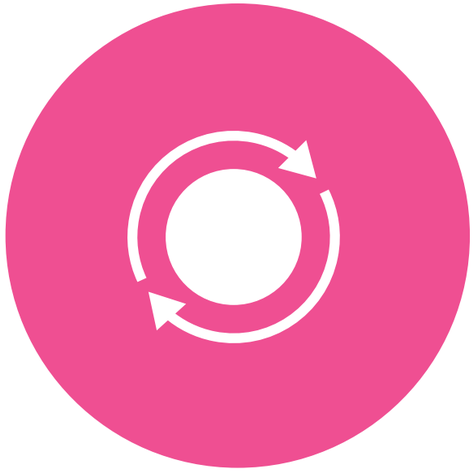
Let's have a look at what happens when applying resilience as a central strategy for an organization.

We can see the same pattern with organizations a we see in cities. For example, if a company, like most traditional companies do, focuses on maximizing profit and growth, it may succeed in doing so for a while. That is, until something unexpected happens which it did not prepare for (not unthinkable in our volatile economy), and it'll be costly to survive the unexpected blow. The most common method that is used to try to evade this is trend analysis, a form of predicting the future through historic analysis. Based on these trends, the expected outcomes are used as a forecast to strengthen the company where it's deemed to be weak. But, of course, reality doesn't necessarily follow the trends, because trends cannot predict the future. Because complex systems can't be predicted well, and can rapidly change states, this is a poor form of preparing for the future. Many companies can attest to this in the last few decade due to the economic crisis, and many can't anymore because they're now gone. If companies focus on resilience as a primary goal instead of growth, an entirely different strategy results. This strategy is based on how to ensure the company can use system dynamics to its advantage given any number of possible situations, by building its resilience to be healthy in the long run.

This may include aspects such as having a healthy, diverse, and flexible labor force as opposed to pure efficiency or growth as a focus for HR management. This allows the organization to quickly change its operations and be more resilient for rapid market shifts. Reducing its reliance on limited resources creates economic resilience, which can be achieved by for example switching to bio-based materials instead of fossil resources, taking control of the material cycle, or establishing an industrial symbiosis with supply and delivery partners.

This can be done by, for example, focusing on maximizing the company's value for society and embedding this value, so that the company becomes unmissable for society. For example, it may invest in better living environments, education, and closed loop resource flows rather than entering new markets or on saving labor costs. When a company becomes unmissable for society it has a healthier long term position, and a greater human capital base to carry it forward in rough times. This is something akin to the saying "If you focus on cost, quality goes down, but if you focus on quality, the costs go down.".

AUTONOMY





SELF-SUFFICIENCY



SELF-GOVERNANCE



CIRCULARITY



NETWORK SUPPORT



EFFICIENCY

SYSTEM LEVEL: AUTONOMY

Autonomy, or self-reliance, is the level of independence of the system from other systems on any level, including material resources, decision making, trade balances, etc. Autonomous systems are less influenced by what happens around them than dependent systems are, freer to follow their own decision trajectory, and can tune their mechanics to suit their own needs more accurately.

All systems are dependent on others to some level, which is not necessarily a bad thing, and it's rarely worthwhile to maximize Autonomy. After all, we're all living on this planet, and we're all dependent on the sun and the earth to supply us with the basic platform of life (suggestions for living off-planet notwithstanding). To increase the sustainability of a system it's usually an effective strategy to increase the autonomy of vital resource flows, network functions and system relations. For this, it then becomes necessary to focus on what these vital resources are, which is a worthwhile exercises in and of itself.

LESSONS FROM AUTONOMY

The Autonomy indicator is largely reliant on the physical world around us, affected mostly by the EL part of the ELSI stack. It's greatly affected by resource availability and the unequal distribution of resources on our planet. By investigating autonomy, we automatically discover local strengths and context-specific solutions to universal demands. This leads us to closed resource loops and cycles, reducing waste and increasing the recognition of value that lies within everything around us. This ties into themes such as the circular economy, blue economy, and bio-based economy.

What we learn from Autonomy is the necessity to discern between critical resources and those of luxury. Critical resources of a city, such as food, shelter, clean water, and power, are best to locally provided for, decentralized, adapted to local conditions, and closed loop. Doing so increases resilience and the ability for these needs to be provided in a context sensitive manner, minimizing externalizations such as pollution and injustice.

BEHAVIOR

Autonomy is the system parameter most directly influenced by the lower object parameters of ELSI. Resource cycles heavily affect systems in their ability to be autonomous. In addition, decision making structures are an important factor in autonomy, as well as the balance of interchange between neighboring systems.

Per resource, the scale of its optimal autonomy is different. For instance, it's feasible for small villages to capture and clean their own water, and valuable to do so. However, the same does not apply to building cars. Not every village needs its own factory, even though they may need cars (and then could use a garage). Autonomy needs to be balanced. This can be done by prioritizing essential resources as well as their frequency of use, and their cost of provision.

It is similar for policy decisions. Some decision types that are universal and slow to change, are best taken on a centralized level such as the European Union or the United Nations. These are likely to be few, but critical, such as the universal declaration of human rights. Local laws and conditions are usually best to decentralize as much as possible, to increase speed, decrease overhead, and to retain autonomy.



SYSTEM LEVEL: HARMONY

Harmony, or social justice, is all about fairness: to each other, to future generations as well as to all other living things. Harmony is a measure of tension inside of the system, when it is low, there's a chance for internal collapse through revolution or strife. Harmony touches on the fundamentals of human interaction, and provides the base motivation and conditions for people to want to be part of a system, to make it successful, and thrive in it. In evaluating Harmony, basic human rights come first, which is still a challenge in any global supply chain in the world today. For more complex social and interpersonal evaluations of Harmony, we can use areas of study such as ethics to help, including deontology and consequentialism.

LESSONS FROM HARMONY

History shows us that humanity has the capacity to be unimaginably cruel, both to itself and to other living creatures. We need to protect ourselves from our own dark side. This is what many governmental systems aim to do, to optimize our best behavior, while preventing our worst. Just as with Autonomy, Harmony seeks a state where there's a healthy playing field to achieve this. We're far from reaching that state. While we're protecting ourselves from our worst, we're also damaging fundamental freedoms that allow the best to surface. We can only go so far in protecting a group at the cost of the individual. At the same time, many structures within our society currently lead to a growing imbalance in power division.

Balancing power, and finding equitable mechanisms to steer clear of the atrocities that continue to plague our collective actions is a primary cause for any system hoping to be sustainable. After all, one can have a resilient, autonomous system built on the back of slaves, only serving to propagate the suffering of many, to benefit few.

What we see in western society today is a deep layering of hidden social injustice. While not apparent for most consumers, slavery and other gross social injustice is still very much part of this world. It is directly, but invisibly, fed through our consumer supply chains. Many products consumed in the western world are produced elsewhere, and harbor these social wrong-doings. However, they do not even need to injustices from far away. New rings of socially unjust working practices are discovered in the west on a regular basis as well. Efforts such as fair trade improve these, but it is a voluntary practice still in the minority, and for many types of work such a system does not yet exist. Therefore, tracking Harmony through the cause and effect chain is a critical component of working on sustainable systems.

Using the SiD framework by creating system maps of these influences can be a great help in tracking down dark spots, to shed light on them. In this way, you can help create increased social justice for whole sectors and product life cycles.

BEHAVIOR

In a world that is increasingly trying to be transparent, we may hope to move towards a world with greater social justice and harmony. Yet, some of this trans-parency also exposes much wrongdoing not seen before. At the same time, global wealth (and thus



power) is becoming more concentrated in ever fewer agents, which obstructs Harmony, and leads to rising tension. These rising tensions are palpable, and result in various systemic effects we can see on a daily basis. These include the Brexit process in the UK, the rise of the extreme right and populism in many western political systems, mass migration and at the same time reduced empathy for immigrants, and terrorism.

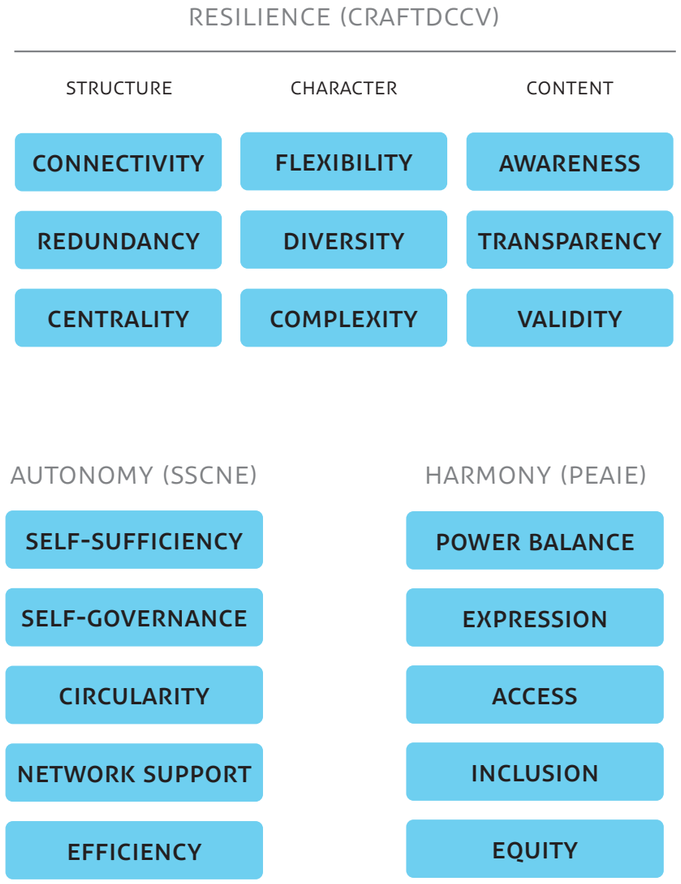
Harmony is primarily fed by the top layers of ELSI, such as cultural rules, laws, economic balances, and the health and happiness of those that are inhabiting the system. These object level aspects connect to Harmony network parameters, such as Balance of Power, and Equity. Besides Harmony's own network parameters, Harmony can also be affected by the resilience network parameters, such as awareness, transparency, and validity. Increasing these network parameters through law or policy will lead to increased Harmony in the long run.

Harmony is typically tracked in space and context for social justice issues of today. Mapping Harmony in time leads to questions concerning future generations, as well as learning from past mistakes.

FROM THE DARK TO THE LIGHT

Harmony is an immensely powerful aspect when used in the right way. If you internalize that Harmony is not only about preventing harm and to stop injustice, but about boosting positive developments as well, new avenues open up. We can achieve great systemic improvements when systems are tuned towards aspects such as happiness, balances between freedom and responsibility, and the support structures to guide these in a healthy way. These Harmony dynamics can make systems move by harnessing the internal tensions for good, by engaging internal willpower, passion, and fascination. In many cases, when smartly implemented, positive impacts on Harmony can be achieved in most projects with little effort, and a great return on investment.

Harmony can also be seen as a measure of how much each individual can strive for personal flourishing in a system. For example, if a company is able to channel the passion and dedication of its employees to create value, it will be a vastly more effective organization. Harmony's dynamics live deeply rooted in our society. It's fast-moving, and can shift focus rapidly. In the last decades we've seen issues such as poverty, gender equality, LGBTI rights, labor practices, and many more receive significant global attention, much to the benefit of specific communities and human rights in general. In this light, Harmony and Resilience go hand in hand, sharing the needs for transparency and awareness first and foremost in the path towards sustainable change.



1.2.5 NETWORK PARAMETERS

Sitting in between the system and object level, the network parameters are a powerful interface between the top-down and the bottom-up. The network level parameters help to unravel the complexities of the system level indicators, reveal complex system interactions, test and explore them, and find the object level drivers of these behaviors. This, in turn, gives concrete handles on finding the best intervention points to improve system dynamics. The network parameters also create a verbal construction set, allowing teams to specify and explore in detail where certain dynamic patters come from, or can be engaged.

Network parameters are on a higher level of abstraction than object level items. Because of this abstraction, it's easier to extract a universal of parameters for networks. This standard set is printed on the left page. While standardized, for each challenge, we still check if these fit or are relevant on a case-by-case basis, but they are a great start. You can also choose to use a simplified set.

The standardized network parameters in SiD are split into the RAH system indicators. Their names are acronyms, taking the first letter of each of their paramters. While their names are awkward, this may help you remember which paramters are in each set. The Resilience set is called CRAFTDCCV, the Autonomy set SSCNE, and those dealing with Harmony are called PEAIE. They've been derived from existing network science literature, and then changed, adapted, and refined in practice over about a 10 year period. On the next pages in this section, we discuss all parameters in detail, but first, we shortly look at the nature of these sets of network parameters.

The network-level is all about collection of connections. This means each parameter reflects on all of the relationships in the system related to that parameter. These relationships can then be split into the object level to be investigated in greater detail. For example, the resilience parameter of diversity reflects on the diversity of all the relationships in a system. You can split this 'diversity' network parameter further up with ELSI, to specifically look at the diversity of energy systems, or transport systems, financial relations, and so on.

THE PLAYGROUND OF SYSTEM DYNAMICS

On the network level we find more powerful systemic behaviors that remain hidden to us on the object level. On a network level we are no longer interested in a single flow, object, or element. It exclusively concerns itself with groups of connections throughout the system. The network is about 'how', rather than 'what'. For example, it matters more to the network-level that people can communicate instantly over long distances, rather than what's being said, or what device they use to communicate.

The network parameters can be observed from both the top-down as well as the bottom-up. From the top-down, they're evaluated on how they contribute to the RAH system indicators. From the bottom-up, they are constructed by looking at the various connections between areas of interest on the object level. Because they can be approached from both sides, they are extremely flexible. In addition, they derive much of their meaning and definition to the context of the challenge at hand. Combined with their flexible nature, the network level is often a playground for creativity.

QUANTIFYING NETWORK PARAMETERS

Network parameters are used most commonly in a qualitative sense. However, if need be, they can be used to construct quantitative simulation models using agent based simulation or other techniques. For example, a top-down evaluation of resilience, by scoring each CRAFTDCCV network parameter in a qualitative way, can also be investigated in a quantitative way from the bottom-up. Each separate ELSI element can be quantified and related with numerical analysis, in relation to each CRAFTDCCV parameter.

THE RESILIENCE SET: CRAFTDCCV

CRAFTDCCV is SiD's standard set of network level parameters for Resilience. The resilience set is the most powerful of the three sets in understanding system dynamics. Understanding these basic resilience parameters allows you to develop a natural feeling for networks in general, and assess what effect a certain action may have on the resilience of the system.

CRAFTDCCV consists of the following 9 parameters:

1. Connectivity
2. Redundancy
3. Awareness
4. Flexibility
5. Transparency
6. Diversity
7. Centrality
8. Complexity
9. Validity

There are other network parameters you can use for resilience, but in practice these are usually sufficient.



CONNECTIVITY



REDUNDANCY



AWARENESS



FLEXIBILITY



TRANSPARENCY



DIVERSITY



CENTRALITY



COMPLEXITY



VALIDITY

THE AUTONOMY SET: SSCNE

SSCNE are the five main network parameters that inform the Autonomy system indicator. Taking into account these five parameters gives you a good grasp of the aspects that influence the self-reliance of the system, such as resource self sufficiency, as well as the support it can provide for this to neighboring systems.

The SSCNE set lists as follows:

1. Self-Governance
2. Self-Sufficiency
3. Circularity
4. Network Support
5. Efficiency



SELF-SUFFICIENCY



SELF-GOVERNANCE



CIRCULARITY



NETWORK SUPPORT



EFFICIENCY

THE HARMONY SET: PEAIE

PEAIE are the five main network parameters that inform Harmony. These allow you to investigate to what degree the system has internal tension, or equilibrium within itself. These are the balance between peace and war, orderly and disorderly society, and pressure towards revolution and rioting. These are the hardest to quantify of the three sets, and the most influenced by social science. The PEAIE set consists of the following:

1. Power Balance
2. Expression
3. Access
4. Inclusion
5. Equity



POWER BALANCE



EXPRESSION



ACCESS



INCLUSION



EQUITY

COMMON NETWORK PARAMETERS

It's interesting to note that several network parameters are much more commonly used than others. 'Diversity', for example, has been used for decades as a field of exploration in the social sciences. Because it is an existing and widespread field of research, the knowledge about how diversity affects the dynamics of systems is better known than others. For example, it's widely proven that increasing diversity improves the strength of socio-cultural systems. Likewise, 'Transparency' is a common term in policy development areas, as well as in governance. The presence of more commonly known parameters helps us to see the power and wide ranging effects these parameters can have. But, we should take care to understand that this is not the case for all of these paramters yet. We're less knowlegeable about the effects and dynamics of a paramter such as 'redundancy' in the evaluation of a social system. This, we should however take care not to miss out on network parameters that are less familiar and which may in fact bear powerful dynamics.

MAPPING INTERDEPENDENCY

The power of each parameter becomes apparent when seen in the greater context of the system. For example, transparency of governance makes a country's system work faster, better, and increase Harmony's Equity parameter at the same time. Things that seem very complex can become rather straightforward when having the network overview at hand. You see also that the parameters tend to influence each other. Increasing one parameter's score is bound to affect other parameters. To use network parameters effectively, the trick is to create an analysis system that provides an overview of all the important outcomes. For example, using an excel sheet to list all the parameters, their area of influence, and giving them a qualitative score can give a quick overview of a system's dynamics. See page 276 for a table showing a qualitative network paramter analysis. This way you and your team can start to tweak the system and evaluate possible pathways for improvement.

CLARITY FROM NETWORK PARAMETERS

For many, the network parameters require time to get used to. Once you have them internalized, we hope you'll experience the clarity these beautiful tools yield. Within the network parameters lie hidden opportunities we can use to find radically better solutions for current societal problems. Some of these we've already discovered. For example, with the benefits that decentralized energy production gives to the autonomy and resilience of communities.

A BOX OF NETWORK GLASSES

A handy mental exercise to practice and help evaluate the effects of network paramters on a system is to imagine a box of eyeglasses. Each pair of glasses represents a network parameter and allows you to 'see' the network in a different light. For example, imagine putting on the 'diversity' glasses, and look through them at a system such as a village or a company. Look at all the elements you see in the village, and what 'diversity' may mean to this. While you're doing this, also imagine pushing the parameters to an extreme. For example, when investigating diversity, picture a village - all the houses in this village may be identical, or each may each be unique. How about people's ages, professions, and so on? By zooming into diversity, elements it comprises of appear and in themselves help you understand the impact these elements have on diversity. Practicing this way is a quick and easy way to get a grip on the effects of network paramters on the dynamics of different systems.

LEARN TO SEE THE LIGHT

Network parameters are most helpful for strategic decision making where complex systems are involved. You can easily un-stuck yourself when faced with complex situations, once you've become adept at recognizing and interpreting the network parameters. Learning how the parameters affect one another in a system tells a great deal about a system's overall behavior, and allows you to instantly see possible effects of a certain measure, strategy, or policy decision. Because of its power and value, it's worth to stress that it is worth practicing this for a while. To get good at it, try doing it on a daily basis. Practice looking at the network parameters on any complex system you come across. For example, while waiting at the train station, take the imaginary box of glasses with you, and apply them to whatever you see. What do the parameters mean when thinking about the train network? In the supermarket, think about the supply chains of the products, and the operations of retail stores. Think about all the bikes you see, and the transport network in the city. Use them when looking at a city park, natural systems, political networks, business relations, wherever you see them. Before you know it, you can start to 'see' the behavior of complex systems intuitively.

QUANTIFYING NETWORK PARAMETERS

The network parameters can be used to physically measure the performance of a network, if you attach formulas to each indicator. This is useful to get to grips with patterns in systems that feel counterintuitive, and computer programs can also help to better understand these patterns. Remember the lessons of complex systems when you do this though: you can model to learn about the system's dynamics, but you cannot model to *predict* complex systems.

To start quantifying, you can do this either by hand, or use more advanced agent-based modeling or systems modelers. Some of these are discussed in the tools section. To start working by hand, you can determine a simple formula to each network parameter, given a certain context. In the exercise on the next page we show some ways to do this for the resilience set.

If you need some help with this, there's a wealth of knowledge out there on how to do quantitative network analysis. Wikipedia is a good starting point for finding formulas, just type in the network parameters name, and you'll often be able to find suggestions for formulas. For example, the Wikipedia article on Centrality lists five distinct ways of measuring this.

On the next page are two simple examples, one from a bottom-up network approach, using a numerical approach, and one for a top-down, qualitative approach.

BOTTOM-UP NETWORK EXERCISE

Imagine a social network. Let's call it Numbernet. Numbernet can be used to connect to friends online. Now, do the following three things:

1. Only considering the social network aspect (not the technical aspects): go down the list of 9 resilience network parameters one by one, and determine what simple formula would be useful to inform each network parameter.

2. Do the same, but now only considering the technical aspects (devices, servers, etc).

3. Point to the network parameters that are likely to influence the success of the network most.

EXAMPLES

› **Connectivity**
The total amount of users multiplied by the total amount of connections between all users.

› **Awareness**
The number of users that will see a message of importance that is posted by a single user in a 24 hour period.
- or -
The time it takes for an important message to reach 90%+ of the network's users.

› **Redundancy**
The number of devices a single user can access the network on.
- or - The number of backup servers for each critical node in the technical system

› **Flexibility**
The time it takes to make or break connections between users.

› **Transparency**
The time it takes for a message to travel from one user to another.
- or -
A calculation of all messages multiplied by the amount of people allowed to see the messages, divided by the total amount of messages.

› **Diversity**
The total amount of users divided by the different types of users in a certain chosen category (age group, nationality, etc).

› **Centrality**
The median number of connections per person divided by the average number of connections per person.

› **Complexity**
The total amount of users multiplied by the total amount of connections.

› **Validity**
The total messages transmitted to users divided by the network's consensus (or scientific consensus) of the validity of the messages.

TOP-DOWN NETWORK EXERCISE

Take an imaginary country, which we will call Billistan. Conjure up an image of a small country with a few dozen towns about a few hundred years ago and see which resilience network parameters you can influence by adding a modern technology, or policy measure. Do this for all the network parameters.

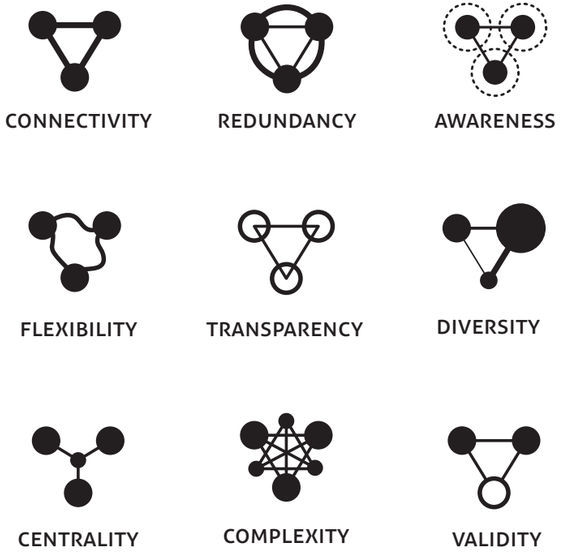
NEWS: CONNECTIVITY AND AWARENESS
Imagine that there is no form of news propagation in Billistan: no radio, TV, newspaper, or otherwise. This means the 'connectivity' network parameter is low, and subsequently also the 'awareness' indicator of Billistan's network is low. Its effect could be, for instance, that one town within Billistan will only hear of another town's failed harvest if someone from one village happens to pass through and deliver the news to the other village. This may result in famined villages collapsing, while they could have been helped by other towns (and in return help with something else the next year). So, we can conclude that this reduced connectivity and awareness reduces the resiliency of the country as a whole. Adding a news network to Billistan increases its connectivity and awareness, and if the news stays true (validity), it will withstand something like famine better, and thus increase its resilience. This comes at a cost of efficiency, because some people need to dedicate themselves to making news, and can no longer produce resources.

EFFECTS OF CENSORSHIP
In another example, consider an oppressive political system which censors bad news. This lack of transparency produces a great disparity between perceived awareness and reality. Consequently, this reduced awareness harms resilience. Censorship reduces the transparency of the news to such a degree that bad news is not allowed to be reported, and the actual awareness value of the news is reduced. In this case, it may be even though of as worse, because perceived awareness and actual awareness may diverge, possibly reducing the effort to increase awareness.

DIVERSITY OF EDUCATION
Consider a different resilience network parameter - diversity. If Billistan has a low diversity of education, social class, and background, it's conceivable that there is great consensus in opinion and perspective. This in turn likely generates a single echo chamber which jeopardizes resilience. Diversity often positively contributes to resilience. For example, a diverse population provides varied know-hows that could make or break its emergence through a crisis. Diversity in life-styles and population demographics increases resilience through disease-resistance, increased creative power, and flexibility.

THE RESILIENCE NETWORK PARAMETERS

CRAFTDCCV



RESILIENCE NETWORK, CRAFTDCCV IN DETAIL

The resilience network parameters concern the whole of the collection of objects and their inter-object relationships, in time and space. These nine holistic network parameters look at the composition of the network, and together they help to determine a system's resilience. In this next section we explain the meaning of these parameters and some of our experience with what they mean for creating a resilient state of a complex dynamic system.

The 9 resilience network parameters are:

1. Connectivity
2. Redundancy
3. Awareness
4. Flexibility
5. Transparency
6. Diversity
7. Centrality
8. Complexity
9. Validity

In some cases, it helps to subdivide these 9 parameters according to types, as follows:

STRUCTURE
These three parameters mostly deal with how the network is structured: the amount of connections, and the network's (physical) structure.

1. Connectivity
2. Redundancy
3. Centrality

CHARACTER
These three parameters most often deal with the character of the system's network; how fast it can react, and the diversity of its composition.

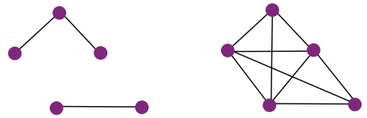
4. Flexibility
5. Diversity
6. Complexity

CONTENT
These three parameters reflect on the content of information traveling around the network. To what degree nodes are aware of this information, the speed of transfer, and truthfulness of information.

7. Awareness
8. Transparency
9. Validity



"For every complex problem there is an answer that is clear, simple, and wrong." - H. L, MENCKEN



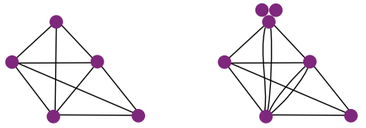
CONNECTIVITY

Connectivity is the level at which the nodes or agents in a system are connected to one another. It's a very basic network property.

The characteristics and consequences of Connectivity are usually easy to figure out; counting your friends is easy, and if you have more friends, you have higher chances of people coming to your birthday party. If there's more roads between cities, travel times will be shorter overall, and possibly more efficient. Of course, each connection comes at a cost, and depending on the cost, the Connectivity property of a system may reduce or increase Efficiency, and thus Resilience and finally Sustainability.

HIGH OR LOW?

In most cases you want a system to have a high level of Connectivity. If connection cost (and management) is not a limiting factor, it's usually best to have as many connections as possible. The quality of these connections, of course, also matters, which is covered in the other indicators.



DIVERSITY

Diversity indicates the different types and connections the network has. Diversity is often important to have a system withstand changes in environment, have a level of self-resolution and increase inventiveness.

Diversity is leveraged on both the types of nodes, and the types of relations between each node.

HIGH OR LOW?

Diversity is often a desired property in a system. Especially larger systems suffer when the Diversity is too low. Diversity is often a property that wants to be balanced: not too high, not too low, but in a comfortable middle, possibly err on the side of more than less. Imagine a warehouse filled with a single product: if the demand for that one product goes down, the company that owns it suffers quickly. If the warehouse had a lot of different products, its risks would have been spread, but its management would be more complex. Similarly with people in an organization: more diverse people increase the ability of an organization to respond to challenges, and have a broader platform of experience and perspective. Too much Diversity may lead to fragmentation and poor cohesion of a system, as well as low Efficiency.



COMPLEXITY

Complexity is a network parameter combining the amount of nodes, the amount of connections and the network's Diversity. In that sense, it is a compound indicator, but its qualities are so fundamental that we've included in as a base indicator for networks. Network Complexity governs a wide range of effects that are important in virtually all cases.

Complexity is also an emergent property of systems in general, one which is paired with the law of diminishing marginal returns. This important network effect, described by Joseph Tainter in his book The Collapse of Complex Societies (1988), has proven to be a major reason for human societies to collapse. This leads us to adopt a general strategy of 'decomplexification'. Since other network properties such as Redundancy and Connectivity tend to drive up Complexity, this parameter can explicitly serve as a check and balance element, much like the Efficiency parameter.

HIGH OR LOW?

For a given outcome, it's desirable for the network complexity to be low. A high Complexity usually makes a system fragile, especially if the complexity rises above the beneficial limits of the size of the system (diminishing marginal returns). This means that there's usually an optimum of system Complexity that lies somewhere in between its minimum and maximum properties.

FLEXIBILITY

Flexibility determines the ability of the network to form new connections, and to reroute or 'bend' existing connections. It's a measure of the 'elasticity' of the network, with an important time component: how quickly can connections be (re)established, and at what cost? How far outside of the required parameters can a system operate before it fails? Flexibility is dependent on time. A system may be able to form new connections easily, but how long does it take to do this?

HIGH OR LOW?

Generally speaking, Flexibility is a good thing. It's one of the important supporters of system resiliency and allows faster changes. A flexible system can more easily move itself into an optimal position. Awareness is necessary for a system to change when it is needed though, therefore Flexibility is often dependent on other system qualities such as Awareness and Transparency.

Flexibility is also often related to Redundancy and Diversity. For example, if there's a low Diversity in disciplines in a company, the company can't be very flexible on its delivery performance on a certain task, because it doesn't have the know-how and expertise. Similarly, a city can't house a new generation of people with different living requirements if its housing stock is limited in Diversity, and cannot be converted quickly, where Flexibility relates to the convertability of the stock.



REDUNDANCY

Redundancy is a straightforward indicator that measures the level of repetition of nodes and relationships in the network. In societal systems, there's always a redundancy present. In technical systems, Redundancy is often built in to increase reliability.

HIGH OR LOW?

Low Redundancy leads to a fragile system, which can easily fail due to the breaking of a single critical component or connection. High Redundancy has a positive influence on Resilience, but also reduces the Efficiency of a system, increases Complexity, and may affect other parameters as well.

Efficiency is usually not a goal in itself, but rather a means to an end. Therefore, if a system is sustainable it does not matter what its Efficiency is, and it's preferred to have higher Resiliency than Efficiency. It follows that a certain degree of Redundancy is usually a good thing.

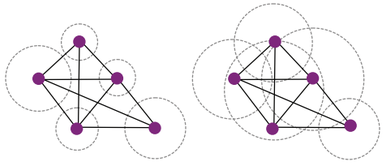
Redundancy in itself is rarely a goal, but its effect on the Resilience system indicator is large. For example, combined with a low score on the Centrality indicator, Redundancy is a major driving force behind decentralized power generation. Combined with Diversity Redundancy supports Flexibility.

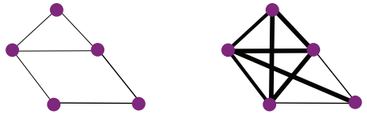
CENTRALITY

Centrality measures the extent with which a system is reliant on particular critical node(s) within the network. In other words, it gauges the structure of a network and gauges what form it has, from a star-shaped form with high Centrality, or a flat hierarchy organic shape with a low Centrality. It is a highly influential aspect that can change the behavior of a system radically. In any network, Centrality plays a role on some level. Much has been written on Centralized vs. Decentralized systems, and many mathematical models exist to evaluate networks on their Centrality, and their consequences.

HIGH OR LOW?

Centrality is interesting, because its effects shift quite radically depending on the size of the network. For small networks, a highly Centralized system is often efficient, fast, and reasonably reliable. That is, if the central nodes are Redundant and Flexible enough. But, when scaling up the system Centralized networks become brittle, have low resiliency, and are not efficient anymore: they lose most of their beneficial properties. This already measurably happens on the scale of small to medium sized organizations. Small organizations, from one person up to 50 or so, stand to benefit from some from of Centralization and hierarchy in the node structure. Beyond this, it quickly becomes rewarding to adopt a less hierarchical, and less centralized organizational structure.





AWARENESS

Awareness measures the reach of information between nodes within the system. A node may be in total oblivion (a complete disconnect), or it may be aware of only the information its own surrounding nodes have, its own sub-networks, or it may have a complete awareness of the entire system, and so on. Note that Awareness may be high even while Validity is very low, as in the case of propaganda. Awareness often relates to Transparency whilst Validity refers to truth.

HIGH OR LOW?

A system with a high level of Awareness is able to respond faster to events in the system. Entities in the system can respond sooner when they are more aware. The third braking light in cars is an easy example. This light can be seen through the windshields of other cars, and alerts drivers further down the road sooner.

Higher Awareness in social and cultural networks can foster greater innovative capacity within the system. In another example, low Awareness negatively impacts the Resilience of a system, since those agents that do not know about the best ways to respond to critical events may make uninformed decisions and make the situation worse. An example is what happened at the Chernobyl nuclear disaster. Even the highest officers at the facility were not aware that the emergency stop procedure could make a situation worse, and cause a meltdown. This is what happened eventually.

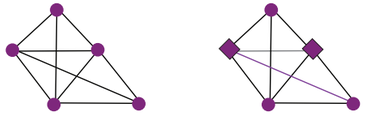
TRANSPARENCY

Transparency is a measure of the connection speed between nodes in a network. Speed may be affected by layers of transmission and/or opacity. For example, hierarchies require clearance from each subsequent level for information to filter down the chain, hence hampering speed. In the case of opacity, a bureaucrat may deliberately prevent civilians from gaining insight into governance.

HIGH OR LOW?

Low Transparency within a system implies difficult information transmission between nodes. Systems with low Transparency therefore have a slower reaction time than a high Transparency system.

High Transparency seems beneficial across the board. In technological systems, the network throughput speed is often a limiting factor for the performance of the entire system. In governance, social, and cultural domains, Transparency also directly impacts the network parameter harmony. Take for example a corrupt government that takes advantage of lack of transparency to cause division between groups of people. Using propaganda to create fear for immigrants, for example, has an adverse impact on Harmony.



VALIDITY

Validity is the truthfulness of information transmitted in a network as reflected on the objective observations of all of the nodes in the system. Measuring Validity may provide a pivotal insight into a system or society's health. Validity plays an important role in societal systems where Transparency and Awareness also interact to interchange information. In technical systems, validity will be analogous to the reliability of information transfer, or subsequent corruption of information.

Another interesting use of Validity is in the form of 'true costing'. This is the practice of determining a monetary value for all externalized factors, in order to make a more 'truthfully' weighted economic decision. Natural Capital and True Pricing are forms of this. An economic or financial decision is less valid if some factors have not been considered.

HIGH OR LOW?

In most cases one would want the Validity of a system to be high. This means that the information that's passed on from one agent to another is 'true' according to the evaluation of their peers, as well as uncorrupted from its originating source. A small amount of corruption of information may be healthy in any system, however, to keep the error-checking systems healthy, active, and alive.

RESILIENCE PARAMETER VARIATIONS

There are other useful indicators to analyze Resilience. Most of these have something to do with a spatial or temporal mapping of the network, and could be captured in an accurate mapping of the above indicators in space and time. For instance, the indicator 'Reach' is used often in existing research on system dynamics. Reach can be effectively covered in SiD's system by mapping a combination of Awareness and Connectivity parameters in space. An indicator such as 'Transmission speed' can be captured by mapping the Transparency indicator in time. Otherwise, specific indicators can be used for specialized network analysis situations. Examples of other parameters we have used are:

- Coherence
- Accessibility
- Sensitivity/Responsiveness
- Entropy
- Rigidity/Sturdiness

Usually, these aspects can be found in a combination of the CRAFTDCCV parameters, but it may be useful to add or replace parameters where the need arises.

THE AUTONOMY NETWORK PARAMETERS

SSCNE



SELF-SUFFICIENCY



SELF-GOVERNANCE



CIRCULARITY



NETWORK SUPPORT



EFFICIENCY

AUTONOMY NETWORK: SSCNE IN DETAIL

The system indicator of Autonomy is naturally more associated with the physical, such as the availability of power and the recycling of resources. As with all the system and network parameters, these influence each other across the board. E.g. a more decentralized system affects Resilience greatly, but may also affect Autonomy. The following parameters are useful to evaluate Autonomy, in addition to those for Resilience.

› **SELF-SUFFICIENCY**
The measure to which the system can fulfill its own basic needs and beyond

› **SELF-GOVERNANCE**
The measure to which the constituents of a system can govern themselves

› **CIRCULARITY**
The measure to which resources in the system are, and can be re-used, in a closed loop

› **NETWORK SUPPORT**
The system's ability to support neighboring systems in case of calamity

› **EFFICIENCY**
The amount of agents and assets contributing positively to the system in relation to their cost.



SELF-SUFFICIENCY

The most important indicator of autonomy is self-sufficiency. Self-sufficiency relates to the self-production of elements that are vital to a system's operation. For example, when talking about a town, we refer to elements such as drinking water, the required power for essential operations, food, and so on. A system is self-sufficient if it produces these in large enough quantities that when supply from the outside world is cut off, it can continue to operate. There may be a term limit to this. It's possible to measure self-sufficiency in time. For example, if a town can survive with its resources for one year before its grain or water storage is depleted, its self sufficiency is that one year. While that may be a great achievement in our current society, one year can be considered reasonably low in light of things we might be facing, in terms of drought, crop failure, storm flooding, etc.

As noted before, Autonomy and Resilience can bite each other. Too high of a level of Autonomy may impact connectivity, flexibility, or other network parameters and thus undermine Resilience. For human communities, in order for that not to be the case, self-sufficiency should focus on the essential required resources. These are not just water, food, and power. These also include, for example, the capacity for managing waste, public order, basic health treatments, basic economic operations including work and value exchanges, communica-

tions, and essential public transport, as well as cultural expression and social connectivity. And, of course, the capacity to maintain and service these elements, and provide training for their continued operation. The other extreme, of things that are not part of it, are those that are not vital to operations or are of such complexity that their decentralized distribution would lead to large resource losses. For example, while having transport vehicles is of high value to a town, and a repair station for them may be considered an essential item for self-sufficiency, every town having its own vehicle factory is excessive in terms of resource utilization.

It helps to conceptualize self-sufficiency in light of unexpected calamities. The autonomy of a town should be high enough to support its own basic operations indefinitely in case of most unexpected calamities. The network of towns could then support the non-essential elements. A country, conceptualized as a network of towns and settlements, increases what are 'basic requirements' to all essential operations of a country. For example, while a single town may not need a university as an essential basic service to continue to operate (people can go to another town for it), a country as a whole certainly does (there needs to be one for all the town to be able to get to). Therefore, the self-sufficiency of a resource or a system is intricately bound to an understanding of its scale and its relation to the network.

SCOPE OF SELF-SUFFICIENCY

It is often helpful to define a scope and the degree with which self sufficiency should be reached. This scope determines which services are included in the set of basic resources. This then determines the living standard in times of need. Again here, the scope should not be in excess, to avoid ostracizing the community. A scope that is too low though may threaten self-sufficiency, or the capacity for network support.

The degree of self-sufficiency has to do with how long, or to what extent items in the scope are self-sufficient. For example, when making a plan for a self-sufficient housing neighborhood in the Netherlands, we decided that food, electricity, heating, water, and waste were in the scope. For food self-sufficiency, we determined that its degree of self-sufficiency was to provide the essential need for basic nutrient intake for all its inhabitants in case of total disconnect from the rest of society for a period of at least 3 weeks.



SELF-GOVERNANCE

This is the ability of agents within a system to determine their own actions, especially concerning the basic resources that make up its self-sufficiency set. For example, the ability of a town's local population to be able to make their own decisions concerning their water supply, power, food production, etcetera. For a company, this may relate to employees having the authority to make their own working environment workable, and to have a say in the basic resources and parameters of production.

Self-governance has a strong relation with Harmony's 'Power balance' and 'Equity' parameters. Self-Governance focusses on forces of control from outside that may be acting on the system. The parameters inside Harmony focus on the interrelations of the agents inside the system.



CIRCULARITY

A system's Circularity is the degree with which its (essential and non-essential) resources are reused within the system. A system whose resources retain its value and quality when reused requires less replenishment from outside its system. Consequently, the system becomes self-reliant and efficient. Circularity is a panacea for imminent material shortages, pollution generation, and waste production.

Circularity is measured against the degree to which resources are, and potentially can be used in a circular way. Circularity seeks a healthy balance, because not all resources can be re-used, and it is not always desirable for all materials to be reused. Circularity also encompasses value retention or transition that resources undergo during their life cycle. Consider a town that recycles its drinking water (from its water fountain) into grey water. This is a case of down-cycling, as the water by means of its transformation, deteriorated in value. On the other hand, value retention is evident in the case of toner cartridges that are designed to be disassembled, refilled, and returned to the store shelf. The same goes for products. If a product-life cycle recycles a piece of plastic only as throwaway plastic bags, it is degrading the value level of the resource, and while it's recycling, it's not actually all that circular of a system.

Circularity is a factor that has received much attention in northwestern Europe, under the approach called

the 'Circular Economy'. Because of this attention, more existing tools are available for circularity than for other parameters. See the tools section for more explanation on the Circular Economy.

LEVELS OF CIRCULARITY

Circularity is expressed in lower or higher levels of preference, as can be seen in the SiD Rocket diagram on the right. They are categorized from the best to the worst:

- Super-use
- Direct re-use
- Refurbishing
- Remanufacturing
- Recycling
- Waste

This same idea can be found in other frameworks used in the field of Circularity, such as the Waste Hierarchy / Ladder of Lansink (diagram below), and its counterpart, the more popular Circularity mantra of Reduce, Reuse, Recycle.



While circularity commonly applies to the lower ELSI stack tiers (energy & materials), it is equally relevant to the higher ELSI stack domains (life, society, individual).

In fact, interesting connections can be established with the upper ELSI stack domains. For example, household waste used as a building block for a local vegetable garden improves food production awareness, and the community's wellbeing by means of better nutrition and biophilic exposure.

MEASURING CIRCULARITY

There is a variety of tools available to measure circularity, for example the 'Material Circularity Indicator' of the Ellen MacArthur Foundation. This basic formula uses the following inputs:

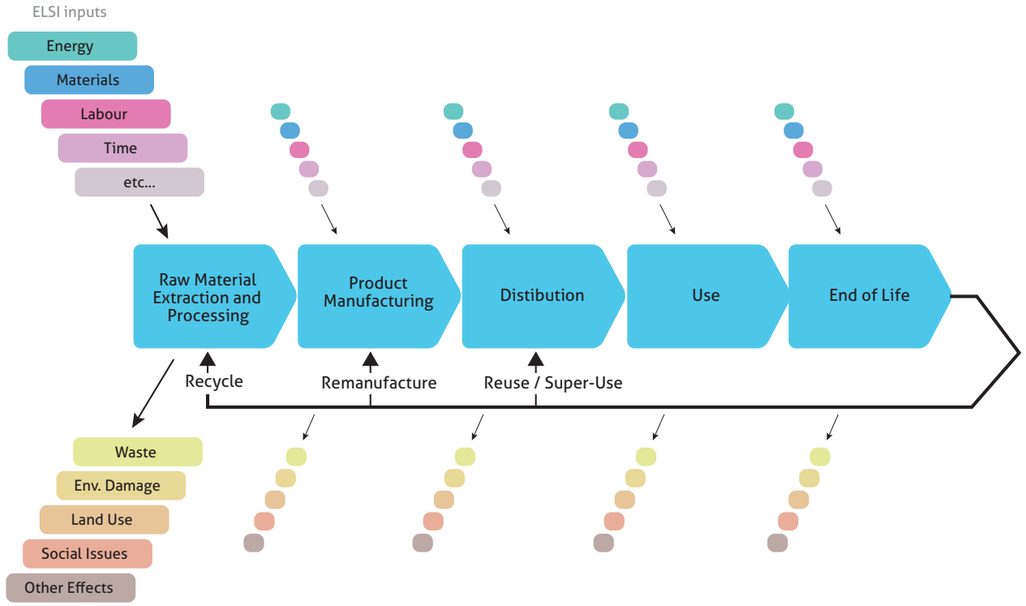
- Input in the production process: How much input is coming from virgin and recycled materials and reused components?
- Utility during use phase: How long and intensely is the product used compared to an industry average product of similar type? This takes into account increased durability of products, but also repair/ maintenance and shared consumption business models.
- Destination after use: How much material goes into landfill (or energy recovery), how much is collected for recycling, which components are collected for reuse?
- Efficiency of recycling: How efficient are the recycling processes used to produce recycled input and to recycle material after use?

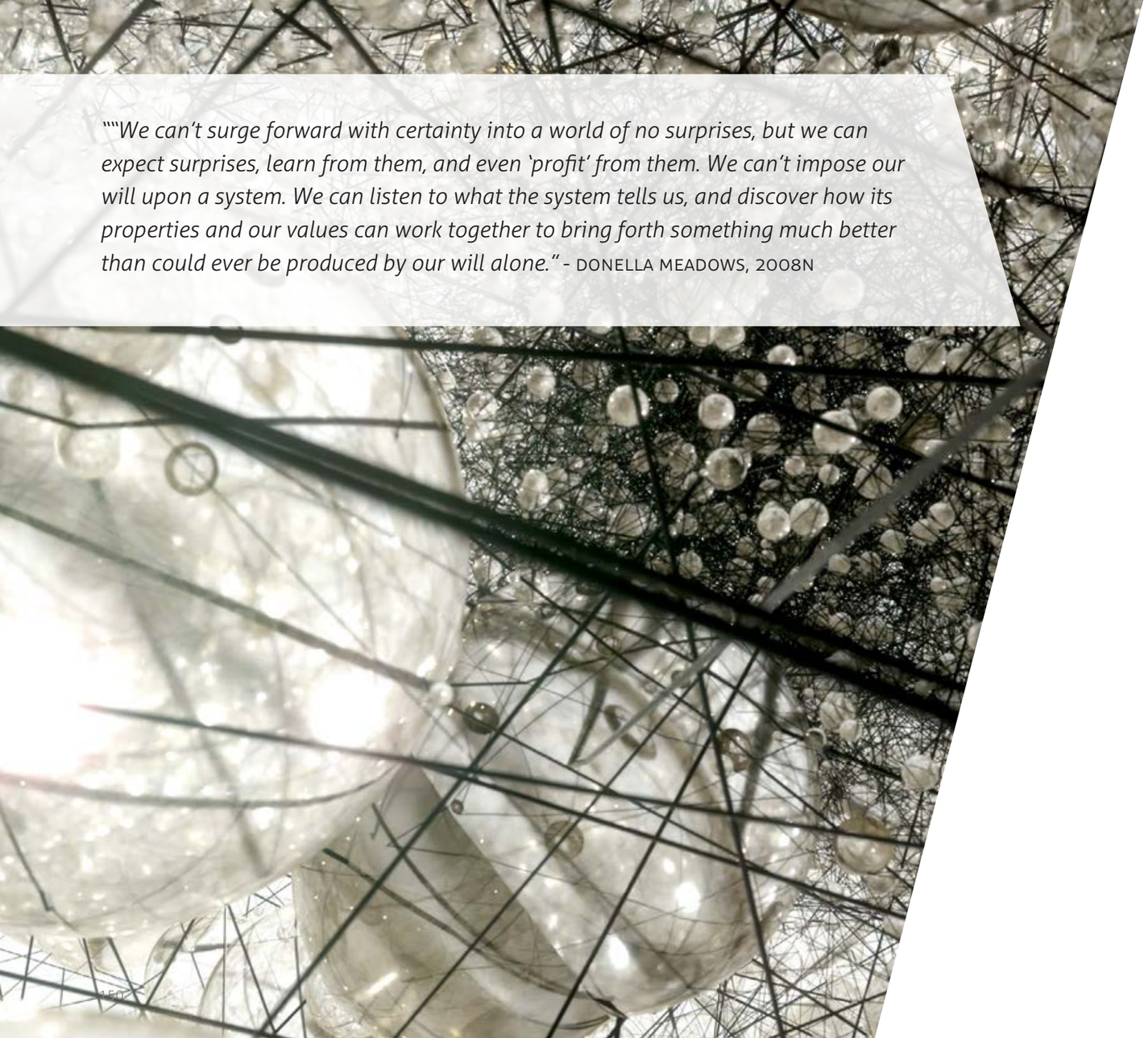
For more information on developing specific indicators for material Circularity, see the free publication CIRCULARITY INDICATORS, An Approach to Measuring Circularity", Ellen MacArthur Foundation, 2015. Please note that these standardized indicators do not (yet) take into account the full spectrum of ELSI's categories.

SID ROCKET

This diagram is a generic representation of the stages of an object's life cycle through a system. It shows the main steps of the object's life cycle in the blue arrows, and the required inputs and impacts at each step. When investigating a life cycle, each of these is detailed to make an assessment of the costs, impacts and benefits of the cycle as a whole.

It's helpful in establishing the necessary autonomy for various services and indexing impacts of an object within its system, and to observe the different stages of circularity.





""We can't surge forward with certainty into a world of no surprises, but we can expect surprises, learn from them, and even 'profit' from them. We can't impose our will upon a system. We can listen to what the system tells us, and discover how its properties and our values can work together to bring forth something much better than could ever be produced by our will alone." - DONELLA MEADOWS, 2008N



NETWORK SUPPORT

Network support measures to what degree the system can provide support to external systems in times of need. In a sense, it is a sister indicator to the Redundancy network parameter. It measures the ability of the system's resources covered by the self-sufficiency scope to be delivered to neighboring systems to support shortfalls in their operation.

We'll get to specific system dynamics later, but it's good to note here that the system dynamic Law of Decreasing Marginal Returns is strong in this one. As a network of systems starts to break down, each individual system's capacity to support failing neighboring systems goes down with it, until the entire network becomes brittle and collapses. A high rate of Network support in a system is therefore not just nice to have as friendly neighbors, but a primary sign of a healthy system. This can then also be seen as a feeder of Resilience to external systems. A Network support capacity of zero shows that the system can only take care of itself, which usually means it is at the brink of its own capacity to survive.

If Self-sufficiency is low, Network support can become negative. Then, the system relies on external systems for the supply of critical goods and services, and burdens those systems around it.



EFFICIENCY

Efficiency is a measure of how well a network is servicing its intended goal compared to the resources it needs to achieve this performance. Efficiency in itself is not a goal, but when comparing systems, this parameter is useful for finding optimization strategies. Note that a highly efficient network may not be a resilient one, and Efficiency and Resilience may be opposed at times.

Typically, you want Efficiency to be high as high as possible until it starts interfering with the other parameters that help to establish a high Resilience. It's often easy to improve Efficiency by reducing parameters such as Redundancy and Connectivity, but that usually reduces Resilience. A focus on Efficiency can therefore be dangerous, especially when it has been made into a goal, which it should never be. Efficiency in itself should never be a goal for a sustainable system.

THE HARMONY NETWORK PARAMETERS

PEAIE



POWER BALANCE



EXPRESSION



ACCESS



INCLUSION



EQUITY

HARMONY NETWORK: PEAIE IN DETAIL

Harmony is a measure of internal tension in a network. It takes into consideration social justice, as well as the rights of not just humans but also of other organisms. Below, the five Harmony network parameters are listed, followed by some frameworks to help evaluate them.

› **Power Balance**
Who controls what happens, and influences decision making? Including distribution of assets; who controls the resources and wealth.

› **Expression**
Who can talk, who is heard, and what can be said openly? Including freedom of expression and/or repression of perspective or opinion, commitment to transparency and voluntary free flow of information.

› **Access**
Who can access important information, resources, education, etc., and to what extent?

› **Inclusion**
To what extent are people and all other life considered valuable in relation to each other? Including civil and political rights, economic, social and cultural rights, gender and race equality.

› **Equity**
To what degree do those that have specific needs have those needs met equitably?

JUSTICE AND HUMAN RIGHTS FRAMEWORKS

In 1949 the UN department of Realization of Economic, Social and Cultural Rights suggested to use a set of indicators to measure and track progress for human rights goals for the first time. If you work on projects where human rights and/or equity are important, such as national policy or corporate strategy, you can use the below frameworks to help inform the Harmony parameters. A few of these are:

› **Universal Declaration of Human Rights (UDHR).**
The basic 30 articles, fitting on one sheet of paper, that was adopted in 1946 by the 56 nations in the United Nations. A minimum baseline.

› **UN 2012 Human Rights Indicators: A Guide to Measurement and Implementation.**
A comprehensive and freely available framework for the evaluation of human rights. Useful for evaluating nations, regions, governments, and large organizations and their supply chains.

› **Natural Capital**
A body of thought, work, frameworks and indicators attempting to quantify value of natural resources and ecosystem services, to protect and expand them.

› **Human Spaces Report**
A way to measure and implement nature's inclusion into the workplace.

› **EU Social Justice Index**
28 quantitative and eight qualitative indicators, distributed across the sections of poverty prevention, equitable education, labor market access, social cohesion and non-discrimination, health, and intergenerational justice.



POWER BALANCE

Power balance reflects on how the resources that give agents power to act, over themselves and over other agents, are distributed. When applied to the ELSI stack, you'll see that these resources can be numerous, including physical resources such as water, energy, and land, but also nonmaterial things such as information, decision-making agency, capital, and in some cases, other agents (slavery, farming for plants and animals).

Power balance has a large influence on the tension within a system, and thus, on Harmony. For example, an oppressed population revolting to overthrow their despots triggering strife, death, and destruction, which consequently result in the collapse of that society.

Power balance is often dynamic and shifts over time. The preeminence of access to food and natural resources as the main currency of Power balance has been overtaken by access to and control of information. In this day and age, developed societies prize information not just merely for survival but also for superiority. Few people in the developed world can function anymore without internet.

Typical areas of interest to investigate here include forms of government, voting rights, wealth and asset distribution, and agent's decision making power over themselves and others.



EXPRESSION

Expression is about how agents can and do communicate with one another. The resilience parameters of Transparency and Awareness deal with an important part of this equation of the network as a whole, and Expression allows deeper investigation on issues such as freedom of speech, repression of particular issues or groups of agents, and commitment to Transparency and voluntary free flow of information.

A high degree of Expression is important for a good Harmony in a system. This means that most means to purposefully curtail Expression, either in form or content, will likely harm a system. Not just the level of basic Expression (which agents can talk freely, what subjects are restricted) is important, but also the reception of Expression (who or what is actually heard). This also may be related to the 'Validity' resilience network parameter: if there is full freedom of Expression, but Validity is low, a system will have tension. But, with high Expression, the system may find ways to correct this low validity itself.

If Expression is high, and Access is low, there may be a bias in who actually gets to benefit, use and reap the benefits of Expression, and also give rise to tension.



ACCESS

Access focusses on the level with which agents in a system can access critical assets, information, resources, education, etc. In societal terms, this may also include the ability for agents to travel to other places (power of passport), and physical Access to places of (free) education and information exchange.

For instance, a person who has official access to higher education may be financially prohibited from pursuing it. In this case, it can be said that Access to higher education is low. Access therefore is defined in terms of participation rights and/or capacity (being able to participate if willing).

Restricted Access to valuable resources for large groups of agents may produce tension and destabilize a system. Circling back to the education example, the effects of educational deprivation may be evident only in the next generation. Similarly, correcting Access issues may take at least one generation.

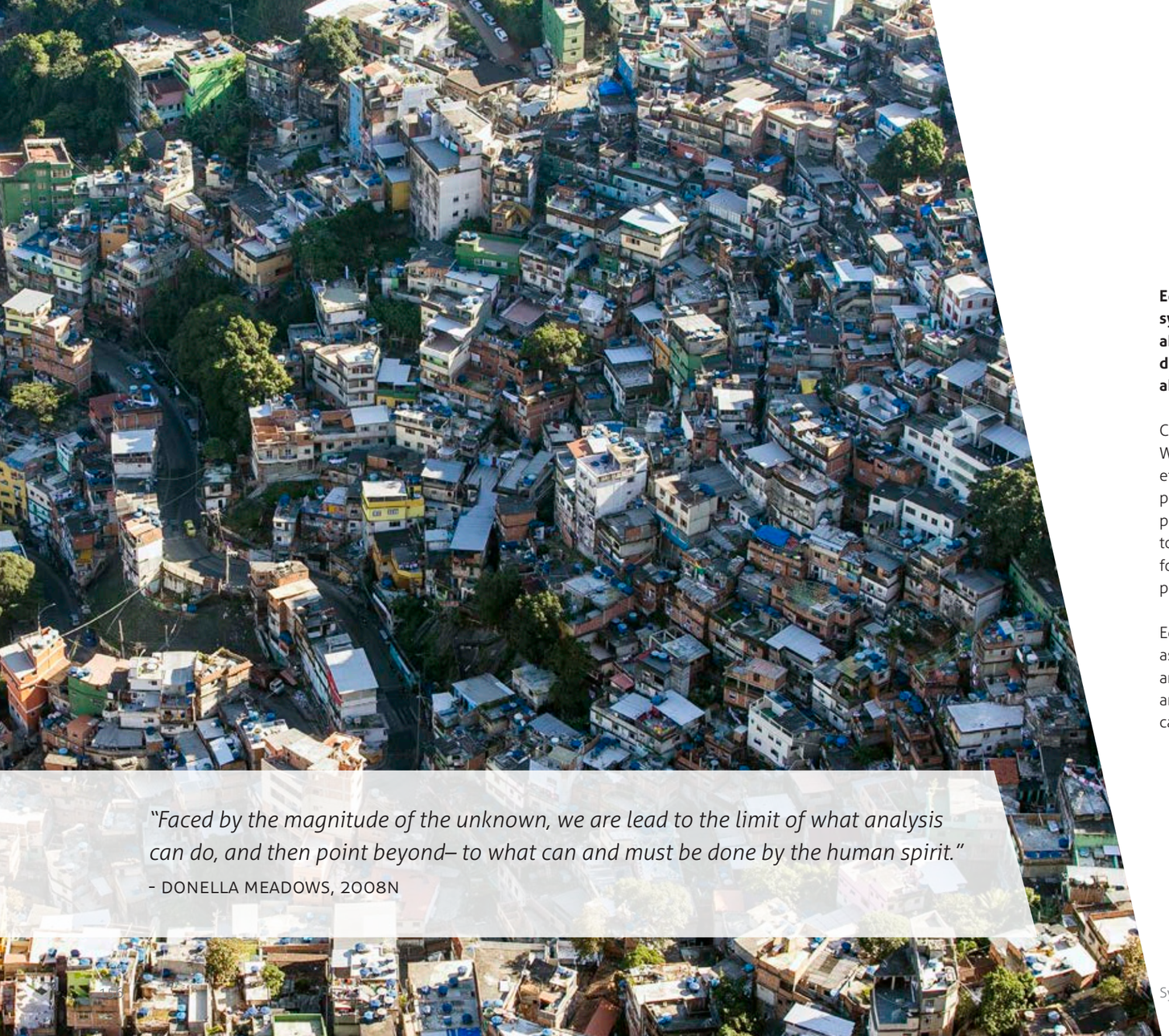


INCLUSION

Inclusion is a measure with which agents in a system are included in the general set of laws, regulation, or cultural habits to which rules of ethics apply. This reflects on slavery as well as discrimination, and more broadly about all living things, the rights of organisms beyond human society.

To exemplify this, we can look at the development of society over the centuries. In the Old World, only men of good standing were included in the so-called 'ethical set'. Women, children, slave men, and all other living things outside of man, were considered possessions that a man of good standing could do with as he pleased. Murder was considered with gravity only when men of good standing were implicated. Over time, more agents were included in the ethical set. In ancient Egypt for example, infanticide came to be outlawed. However, it was legal to keep children as slaves. Through the thousands of years that followed, women, children, and to some degree animals, have gained more inclusion into the ethical set, although the degree of inclusion is unevenly distributed around the world. While slavery is now officially illegal in all countries of the world, prison slavery is still allowed even in some states of the USA, and practices akin to slavery are still widely present.

Inclusion can also be used as a measure of fairness within organizations, for example, to see what rules apply to what agents in an organization.



"Faced by the magnitude of the unknown, we are lead to the limit of what analysis can do, and then point beyond– to what can and must be done by the human spirit."

- DONELLA MEADOWS, 2008N



EQUITY

Equity measures to what degree agents within a system have their needs met, according to their ability. This is different from equality, which distributes equal amounts to each agent. Equity is about fairness in distribution, not equality.

Consider the mundane matter of access to buildings. While provision for disabled persons (handicap ramps, etc.) typically cost more than provision for able-bodied persons, it is nevertheless important for disabled persons to have equal access. Equal access here points to the usage rights of buildings and its relative facility for users with different needs. Literally, creating a level playing field.

Equity is a fundamental property of any society. Equity as a parameter serves to evaluate distribution of power and resources, freedom of speech, access to resources, and inclusion. Ethical considerations matter significantly in Equity.

ETHICS AND THE APPLICATION OF HARMONY

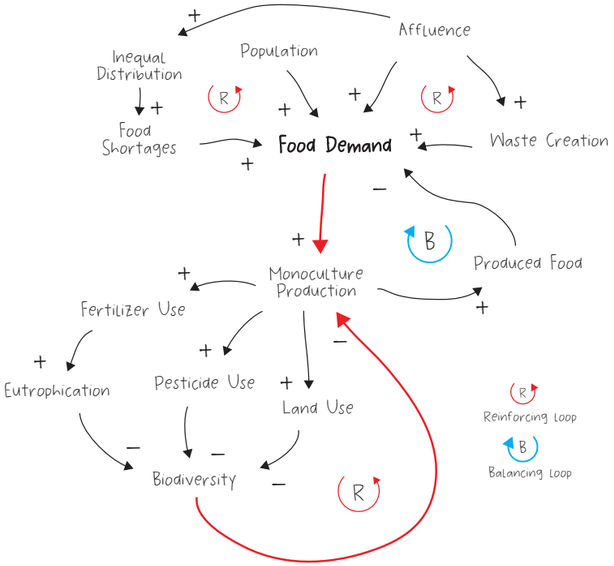
In applying Harmony parameters to evaluate a system, you may encounter situations in which it is useful to have a debate in the team about ethics. Having a language to talk about ethics, we've found, is helpful in navigating these discussions. In order to support this, we've added a section on ethics and some main frameworks of thought in the tools section (4.12). This may also appeal to those of you reading this with a general interest in philosophy and the progression of ethical frames of mind over the centuries.

EXAMPLE: A SYSTEMIC LOOK AT OUR FOOD SYSTEM

In this example we look at the global food system in a rough review of the global problem, through a systemic SiD lens.

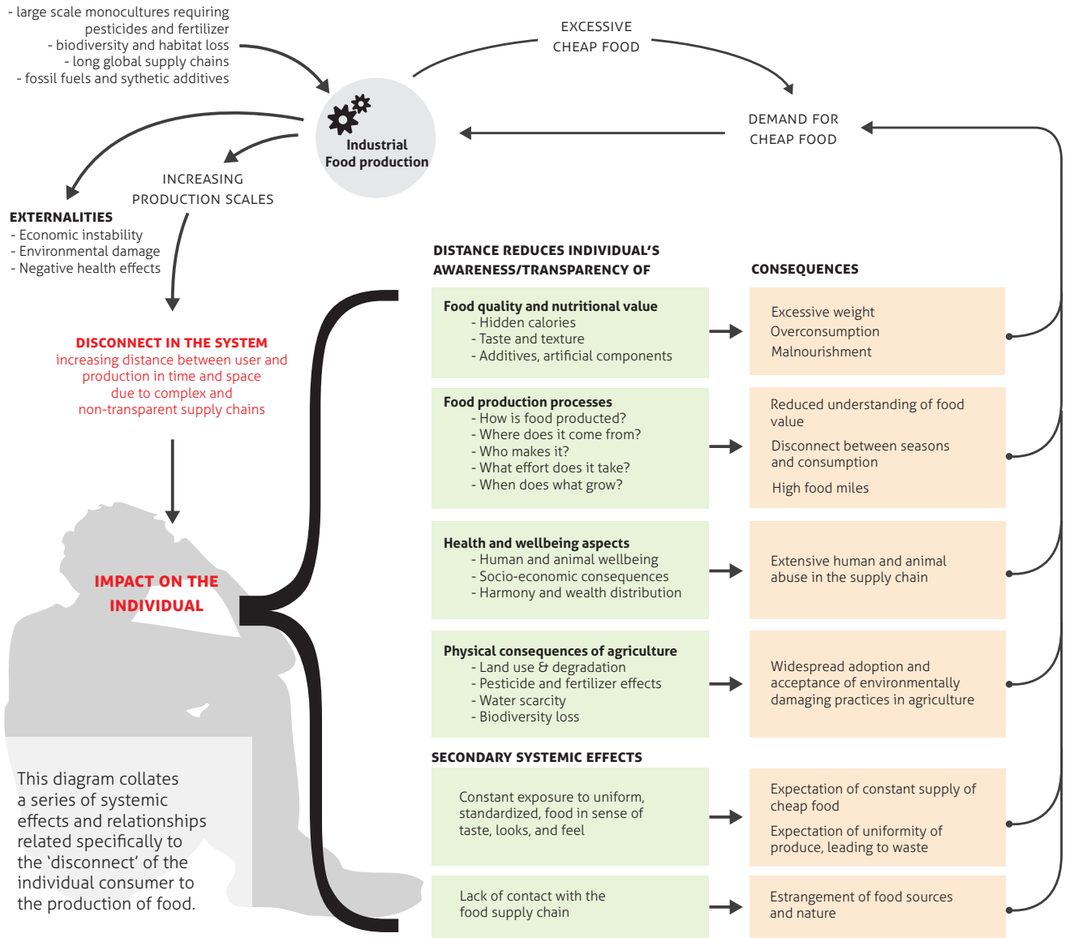
THE PROBLEM WITH FOOD

What is the issue? Our world population grows. With a growing world population comes a growing need for sustenance. Compounded with this is an increase in food consumption per capita, which makes for an exponential demand pattern. This increase of food consumption per capita is largely due to an increasing affluence of the world's population. The more comfortable we are, the more we consume and waste (a system dynamic to keep in mind). This increase in food demand leads to increased land use for agriculture, and also usurps other scarce natural resources. Water is scarce, and its use is increasing in agriculture. We're also running out of mined phosphate and potassium for artificial fertilizers, and without these fertilizers, production capacity is significantly diminished. Our industrial agriculture practices also leads to massive ecological damage, biodiversity loss, and pollution. These, in turn, reduces agricultural resilience, making food harder to grow. While members of the wealthier parts of our society can eat well, fresh food has been replaced by cheaper processed foods for many marginalized populations around the world. This impacts our global health and wellbeing, and creates so-called food-deserts, where fresh food isn't available at all anymore. This is a hidden harmony risk waiting to explode. What a hairball of a problem; where do we even start?



One way to start analyzing such a compound problem is by using causal loop maps. You use these to trace systemic relations back to their source, and see which factors affect the whole system. In the last few years, we've done this exercise and analyzed a variety of perspectives, and collected research around the globe from organizations doing the same. A highly simplified causal loop map, merely for the purpose of exemplifying such a map, is printed above. This shows some simplified major influences on the food system. Let's have a look at some of the major dynamics in this system.

EFFECTS OF THE DISCONNECTED CONSUMER IN THE FOOD PRODUCTION AND CONSUMPTION SYSTEM



ENOUGH FOOD, BUT DISTRIBUTION IS UNEVEN

It is possible to produce plenty food for the current world population, but the food is not distributed equally. This leads to some people having an abundance of food, and others starving. The primary problem as it stands is therefore one of distribution, rather than production. This makes this challenge centrally locked into the 'harmony' system area, requiring, for example, policy changes. Policy change, however, has never been a safe bet for global solutions, not in the short or in the long term. This is especially true since we've not managed simpler challenges such as to globally eradicate poverty, establish gender rights, and so on. It would be more resilient to also try another approach.

LIMIT TO PRODUCTION POTENTIAL

An easy thought would be to just increase agricultural production to meet the increased demand. Unfortunately, we can't continue to grow production the way it is organized now. We are limited by, at minimum, three planetary boundaries on an object level: a depletion of concentrated phosphate and potassium used in artificial fertilizer), depletion of agricultural land, and the decreasing biodiversity through agriculture. Water is also becoming a major issue in many countries in the world, and agriculture uses more than 80% of it globally. All of this limits our capacity for scaling up current production. Sustainable production needs to reduce water use, reduce land use, eliminate fossil fertilizer use, and increase biodiversity rather than harm it.

THE REALITY OF MONOCULTURES

One of the prime causal sources of the global food problem is a strategy we have steered our agricultural production industry into: monoculture production. In principle, growing food is a productive use of natural resources. This doesn't have to be harmful. However, to boost our production we resorted to monocultures, which means growing a single crop over a large area. During the industrial revolution we sought ways to boost our food production, and monocultures were the answer we chose, globally. Once we entered that pathway, it was hard to go back, and the scale of farming has been increasing ever since. In SiD language, monoculture agriculture is a perfect example of an extreme case of increasing efficiency and centrality, by means of reducing diversity. This has as a consequence that the system is unbalanced to become extremely non-resilient and non-autonomous. Monocultures also separate themselves from their natural context, which is essential to their (one-directional) success, however ultimately makes the agricultural system behave more like a machine than a natural cycle. As a result, monocultures show all kinds of associated systemic issues.

As the agricultural system is increasingly under pressure, these issues are coming to light. For example, because monocultures have the same crop planted over large areas, the same nutrients are taken up from the soil, and are not naturally replenished. In a diverse ecosystem, this would happen naturally. Therefore, this requires artificial fertilizers to replenish them. Because these large single cropped areas are a walhalla for pests that like those plants, these pests flourish and multiply

SID SNO QUICKSCAN - INDUSTRIALIZED FOOD SYSTEM / AGRICULTURE (AGR)

NEGATIVE	POSITIVE	
• Resilience is crticially low, agriculture (Agr.) can be main cause of system collapse in the next decades	• If used as a resilience tool, Agr. can help support resilience of most other industries & cities	RESILIENCE
• Agr.'s poor autonomy causes the timeframe for exhaustion of primary resources at 20-30 years	• Agr. can be entirely autonomous, even help other essential services exist through network support	AUTONOMY
• Serious harmony issues along life cycle, incuding slave labor, unequitable distribution, power balance	• In essence, Agr. can be extremely harmonious, symbiosis with nature has inherent benefits	HARMONY
• Severely over-centralized, un-diverse, inflexible • Highly non-self reliant, poor circularity • Critical issues with equity, power balance	• Agr. has leverage to change the world's network • Awareness and transparency are slowly increasing • Global inequality is improving	NETWORK
• Malnutrition causes mental health issues • Native populations displaced by agr. industry	• Food is a major source of happiness for many • Potential to use food as a lifestyle changer	HAPPINESS
• Decreasing health through industrialized food • Pesticides cause ailments & other health issues	• Healthy food is the basis of a healthy life • Increasing awareness on food related health	HEALTH
• Increasing populations live in "food deserts" • Agricultural work inadequately paid	• World's largest industry, US$1,3 tril, >1 bil jobs • Investments in Agr. multiply across economy (SROI)	ECONOMY
• Global industry eliminates local food culture • Consumers disconnected with food systems	• Food continues to define the cultural landscape • Food sustainability awareness helps overall sust.	CULTURE
• The single major source of biodiversity loss • Causes majority of animal rights abuses	• Not much positive here...	SPECIES
• Largest land-use and ecosystem impact • Largest industrial contributor to climate change	• Some agroforestesty & permaculture rising • Potential for climate mitigation & adaptation	ECOSYSTEMS
• Massive use of fresh water globally (+80%) • Depleting fossil potassium and phosphate	• Bio-based Ag. products can replace other fossil materials, helping global sustainability	MATERIALS
• Uses considerable (fossil) fuel • Major global use of energy	• Can generate power e.g. through biomass • Potential to become energy positive	ENERGY



POLYDOME
Shown on this page are some images of Polydome, a concept for a high-efficiency polyculture agriculture system, designed to optimally grow in a greenhouse. Polydome combines the efficiency of modern agriculture with zero pesticide and fertilizer use, and a resilient growing system. This project is developed by Except as a pathway for highly sustainable food production for both urban and rural areas (Except, 2011).



in monoculture areas. To counter this, the industry makes heavy use of pesticides. These then also kill other (beneficial) creatures, which reduces biodiversity, and causes environmental damage. This damage in turn reduces the resilience of the ecosystem, reducing the capacity for natural pest control, and reducing soil fertility. Consequentially, this negatively affects production and yield. Some of these relations are expressed in the causal loop diagram above, showing that biodiversity loss and monoculture agriculture have a negative feedback loop that reinforce each other.

Monocultures also have a large impact on transport networks. They produce a single crop in large quantities in a single place. Because local demand cannot absorb such concentrated production, produce has to be shipped to far away places, sometimes in cooled, energy intensive containers. This requires an extensive distribution network. For this we pay a price in, among others, additional land use, energy, air pollution, and time (reducing the quality of the food). The network also needs to be maintained and supported by large industries, which reduces local ownership and control (autonomy).

To conclude, on a network level, the highly centralized and non-diverse food production system is driving a systemic lack of resilience and autonomy. The system dynamics that follow as a result cause a negative causal loop that is reinforced by the system.

WHAT TO DO?
This is a systemic problem that requires a systemic intervention. It cannot be solved by merely adjusting one of the drivers, such as waste, affluence, or simple efficiency. To feed the world, we need to do several things at the same time: to increase output while negating negative effects. We also want to avoid all these negative, reinforcing systemic effects. The interventions should work within our system boundaries, which in this case are close to being met in the form of various resource limitations, including available land.

One way to reduce negative effects and increase efficiency is to use agricultural systems that are diverse, decentralized, and aimed at sustainably producing crops efficiently. Instead of using monocultures, we could use polycultures. Polycultures grow food in diverse natural systems, by making use of ecosystem services and symbiotic effects between species. Some examples of polycultures are permaculture, and agroforestry.

Another contribution to solving some of the systemic issues is to design locally closed loops of energy and material cycles between production, distribution, consumption, and the re-use of waste. This reduces resource use significantly, and lowers environmental damage, which result in a boost to autonomy. Polycultures also naturally use seasonal variability, and local climate niches to provide for a diversity of food throughout the year. This aspect also engages consumer awareness, expectation, and appreciation. This is another relevant topic that we won't go into here, but is worthwhile investigating as a systemic driver.

Polyculture systems such as permaculture are tried

and tested on small scales, but they are not used to provide large scale food production on an industrial level. There's still much to learn on how to achieve this. Currently, Polycultures demand all manual labor, which is inhibitive to the efficiency needed. There are promising developments in robot automation which hopefully negate that argument, such as the Pixel-farming project in the Netherlands. With Pixelfarming, a farming robot can plant and maintain polycultures.

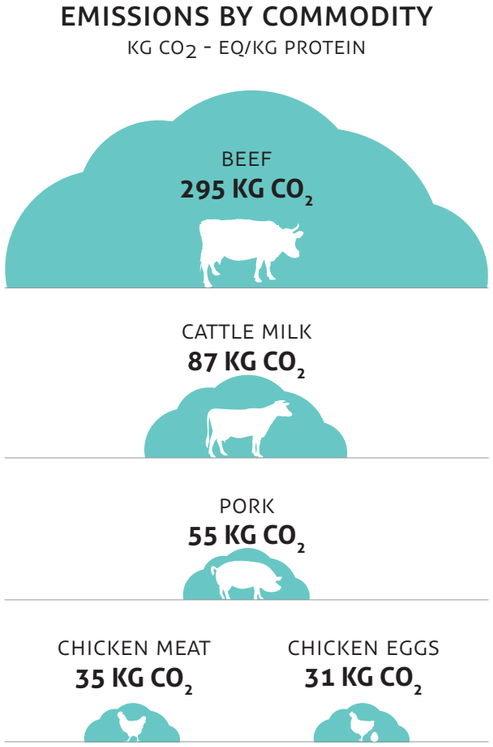
EXAMPLE: POLYDOME

As a result of the insight that polycultures provide a major improvement opportunity, Except invested in the development of a professional polyculture agriculture system. It is focused on greenhouse production, and it's called Polydome. A team of scientists, designers, and developers built up a database of knowledge from existing polyculture efforts, and from this Except developed a concept for efficient polyculture production in greenhouses. The aim is to grow efficiently using no pesticides or artificial fertilizers. As a polyculture, it produces a wide variety of food, and recycles wastes from the community back into the system. It's designed as a biodiverse and highly productive agriculture system that helps with a part of this global food challenge. As great as it may sound, it is still in its infancy. It provides hope, but there is a long way to go before polycultures become a competitor to current industrialized food systems.

In addition to polyculture's early development state, we need more solutions to tackle the problem. Some crops cannot be grown in polycultures, such as cereals. For these, organic production, with crop rotations and other means of production without artificial fertilizer is required. Decentralizing production of these crops is also important, and to design these in closed resource loops as well. The result of these measures is a lower output of production, but at least a sustainable one. As a direction of development, this has a potential to be a significant answer, but mature solutions are not there at the moment. There's many questions and challenges left for this direction.

CHANGE IN DIETS

So far, we've only discussed agricultural systems in general. However, the nature of different agricultural systems differ drastically. In our diet, we see a vastly different impact depending on what we eat. By now, most people know that animal products are generally more impactful than vegetables (see diagram on the next page). The general rule of thumb is, the larger the animal, the higher the impact. This difference is significant, with a kilo of beef having nearly ten times the negative impact in land use and CO_2 production than a kilo of chicken. This may suggest that cutting all animal husbandry from our food system would be the best solution, but that's not the case. Wanting everyone to become a vegetarian is probably a practical impossibility within the time frame we require these solutions, but it's also systemically not the optimal choice. Animals have a useful place in our agricultural system, although less so than currently the case. For example, certain grasslands cannot be used for any meaningful edible crop production. But, they can be used by grazers such as cows or goats, and in that way, still be productive



Global emission intensities by commodity. All commodities are expressed in a per protein basis. Averages are calculated at global scale and represent an aggregated value across different production systems and agro-ecological zones.

SOURCE: FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, AUGUST 2019

for milk and (some) meat. Also, certain lands can be used for animal food production, but not for human food production, also increasing the potential for some beneficial animal husbandry. In addition, goats and chickens are great organic waste processors. Things that are not food for us anymore, can be food for them. To close resource loops in society these types of organic wastes can be processed by chickens and goats into products for human consumption, such as milk and meat, but also into fertilizer that close agricultural loops.

By slowly changing the global diet away from its current heavy meat consumption, for example to 30% of its current use, we can reduce impacts and increase food efficiency by more than 50%, helping to bring us into the future. A shift in diet, together with switching to polycultures, together are major systemic solutions to move to a healthy global food system.

ADDRESSING FOOD WASTE

Looking at the causal loop diagram, we see a couple of other options. One way is to combat food waste, and to try to counter the relationship between affluence, increased waste, and consumption. Global food waste amounts to so much, that all 815 million hungry people in the world could be fed 4 times over with it, according to the FAO.

Combating food waste is currently mostly done through 'end-of-pipe' solutions such as making restaurants and consumers be more aware of the problem, and to adjust their behavior (increasing awareness). While this is useful to a degree, it is a systemically weak approach. Moreover, more systemic issues of food







A design for a sustainable desert agriculture on infertile land, using only salt water and sunlight as primary sources. (Except, 2019)

waste lie upstream in food distribution, processing, and packaging. For example, food is wasted in distribution because imperfections cause food to be disqualified for retail sale. Each food system has its own waste characteristics. For example, in low-income countries, food waste mostly occurs in the early stages, during production and transport, before it reaches the consumer. In sub-saharan Africa this can amount to as much as 83%, and consumers there only waste 5%, says the World Resources Institute. In North America, however, only 32% is lost in pre-consumer stages, and 61% is wasted by consumers. Each system requires its own specific approach.

There's other factors involved in waste reduction as well. Agricultural trade agreements can cause large market shifts. These occasionally cause food to be dumped to maintain prices in large quantities, or overproduced because of perverse subsidies (and subsequently wasted). Usually, trade agreements only look at economic effects, but the effect they have on waste and long term investment of production facilities can be tremendous. Furthermore, farmers are pressured on a price level by powerful retailers that enforce low prices. This causes a reduction in the ability of farmers to innovate, invest, and be flexible in their methods and offer. On a network level it's therefore often the middlemen that control the systemic problems of the food challenge, and not so much the consumers at the end or the producers at the start of the chain. This means systemic leverage can be found there, and a systemic solution that affect these relationships will have far reaching effects.

CONSUMER AWARENESS

Lastly, there's a large causal issue that drives up food waste and lowers awareness, which has to do with the distantiation of consumers from the source of their food. Growing up in industrialized societies makes us believe milk and bread come from a factory. This lack of awareness creates unnatural purchasing habits, and an unhealthy understanding about both nutrition and relevant consumer power. In the diagram at the start of this chapter some of these dynamics have been outlined. Increasing awareness as a solution through pure information sharing is beneficial. That said, it is a weaker method, as a result of a lack of leverage on the system. A more helpful tool in this process is to reintroduce food production in our daily life. This connects both ends of the system, creating a more direct feedback loop, which takes leverage away from the middlemen.

A possible practical solution to help in this challenge is urban agriculture. Producing food inside of cities is not a solution to significantly contribute to the world food supply, due to its low efficiency and high cost. But, it has another role to play. Systemically, urban agriculture reconnects us with nature, and the sources of our food more effectively than an awareness program would. Urban agriculture can use wasted and degraded spaces, and introduce niche species that can thrive on other waste streams, such as mushroom production on coffee grinds. Urban agriculture has the ability to perform secondary services as well, such as water retention, waste processing, and filtration, in addition to increasing urban biodiversity. This makes urban

agriculture an example of how a holistic view makes something that is at first glance economically uninteresting, into something that can be a major systemic contributor to the global food solution. Capturing this value can be done, as is shown by various urban agriculture brands around the world.

ALTERNATE FOOD SYSTEMS

The global food system is huge, and complex. Each country, region, and food system has its own challenges. In our work we've been studying a variety of alternate food systems. We designed vertical agriculture towers for Shanghai in 2006. These are skyscrapers that are used for food production for a significant part of their floor space, mixed with residential, offices, entertainment, institutions and services. We explored how food production in urban contexts can be profitable, while using it to drive up real estate value, to clean river water, improve urban air quality, and provide quality jobs for rural migrants. This project was one of many that caused scepticism in 2006, with many procaliming this could never be a reality or profitable. Now, we see the first vertical agriculture towers rise in Asia and the Middle East,

Another interesting example of alternate food systems is for desert climates. Desert climates traditionally have few food producing opportunities. Therefore, in the middle east, most food is imported, to over 80% in some countries such as Egypt and Saudi Arabia. In much of this part of the world, hot desert climates prevent normal field agriculture. The agriculture that is performed there are a huge drain on available fresh water, which is already in short supply for normal consumption. This means that fresh food, including salads, tomatoes, and cucumbers, need to be flown in with airplanes on a daily basis. The footprint of this food provision system is off the scale. For this, special solutions are required.

For this desert climate, for example, we developed a special closed greenhouse system that is designed to keep the heat out, the water in, and use only renewable water and energy sources. With this system, we save more than 99% of water use compared to field agriculture, and grow local, healthy and sustainable food, It uses only sunlight as a power source, and sea water to power the system. The added benefit of food production in the desert is that we can use land that is infertile otherwise. Desert food production adds to rather than taking away from agricultural land use on the planet. It also provided local, high quality labor. In addition, it proves to be a lucrative business, by capturing value from a major part of the supply chain.

Growing fresh food in the desert in this way helps the system in a variety of ways. On a resilience network level, it reduces the complexity of the local food supply chain, helping to increase resilience of local communities, boosting food security. It also increases diversity of local industries. It supports autonomy by establishing local resource based production using renewable resources. Lastly, it supports harmony, by providing fair wages for valuable agricultural work, as well as training for individuals, by expanding their access and inclusion.

CASE REVIEW AND EXERCISE

As the length of this section shows, looking t the global food system through a systems lens is enough to provide many lifetimes of research and innovation. We hope it shows a bit of the power and insight using SiD as a lens gives you on such a subject.

In the light of reviewing the use of SiD for this case, we've hoped to demonstrate a variety of aspects. First, the use diverse system maps to explore and review the challenge, including a rough causal loop map, a SiD SNO Quickscan, and a custom context map exploring the dynamics of a specific aspect (consumer disconnect, in this case).

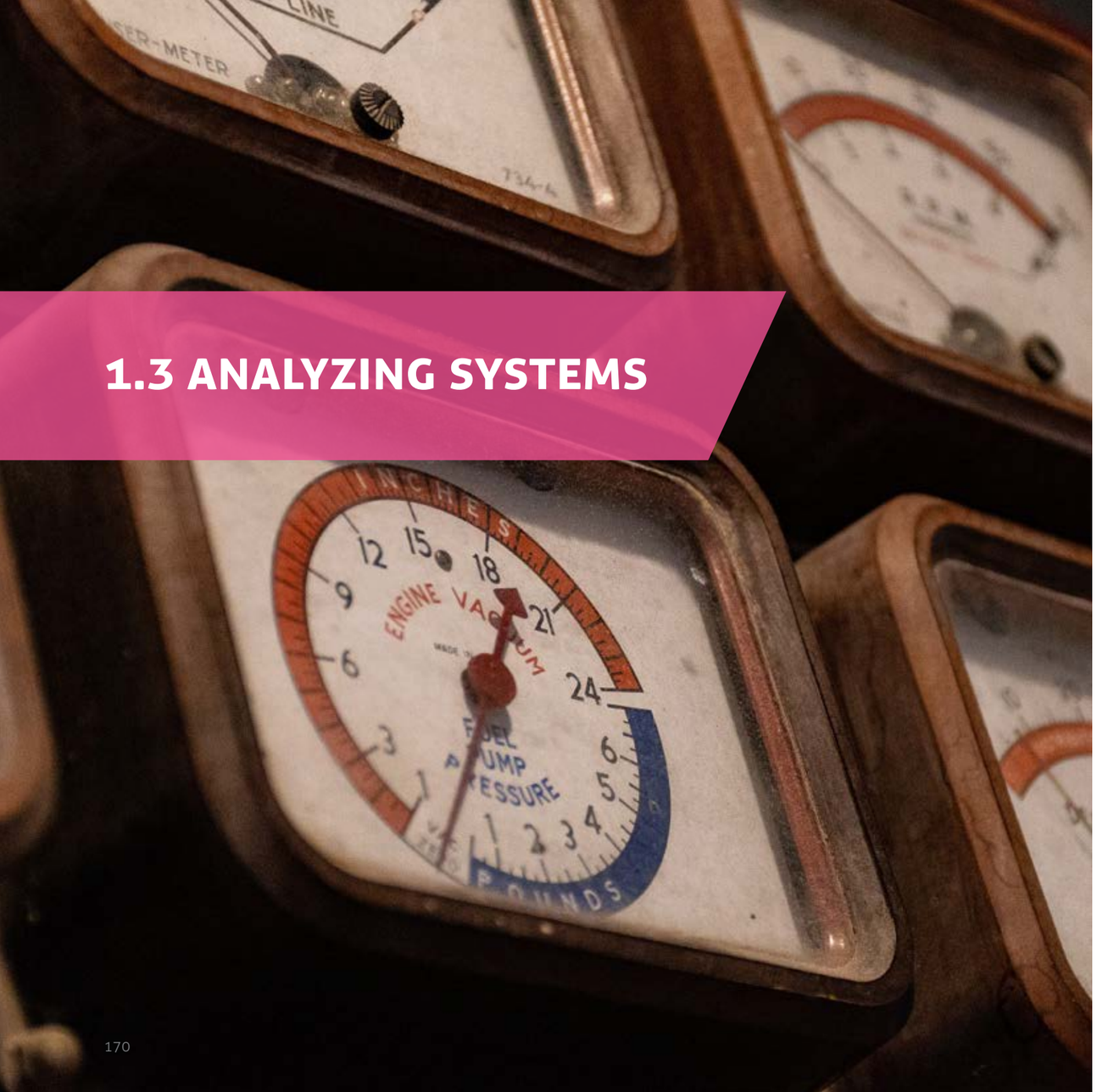
We hope that the usefulness of using system maps as a form of analysis, focus, and communication for complex societal challenges is apparent. While the causal loop map on the first page of the case is simplified beyond acceptability in any formal research, it helps to introduce the main dynamics of the challenge, and as a recipe for the discussion to follow. The SiD SNO Quickscan diagram shows a practical way to review and summarize the general systemic negative and positive effects of a situation, on all three levels of abstraction.

In the text, we have referred to various network parameters, and their effects on system indicators.

EXERCISE

This review is far from complete. The industrialized food system is more complex than we have shown here. As an exercise, or as a means of further research and training, consider the following:

1. Develop an expanded causal loop map
2. Identify aspects of the map where you see an opportunity or are inspired to investigate further
3. Execute a SiD SNO Quickscan on this aspect
4. Highlight a particular system or network challenge, and focus on this to formulate solutions



1.3 ANALYZING SYSTEMS

1.3 ANALYZING SYSTEMS

One of the purposes of systems thinking is to be able to analyze the nature of systems and derive meaningful conclusions from them. Understanding system dynamics and their consequences is a nice start, but a clear analysis structure helps tremendously in wading through what may seem an impossible task at first. Knowing that numbers can take us only so far doesn't make the job of working with systems any easier. We found that by approaching the system from three specific aspects, you gain a comprehensive foothold for insight. These three aspects are thinking through dimensions, thinking through scales, and thinking in the full spectrum.

The three aspects can be written as follows:

1. Analyzing in all dimensions when trying to understand the system:

   A. Map the system in space
   B. Map the system in time
   C. Map the system in context

2. Analyzing each dimension in scales:

   A. Spatially: local, surroundings, world
   B. Temporally: past, present, future
   C. Contextual: 1st, 2nd, 3rd degree

3. Analyzing the full spectrum (for instance using ELSI/Network Parameters/RAH)

As an example, in a matrix, it can look like this:

	Large	**Medium**	**Small**
Space	Global	National	Local
Time	50 years	5 years	1 week
Context	3rd (System)	2nd (Network)	1st (Object)

In the descriptions above, where the word 'analyzing' is used, you can also use the word 'mapping'. Mapping is analyzing using graphical means. In theory, to make a full analysis, we can make at least 72 maps (3 dimensions x 3 scales, x 8 ELSI layers). That's unworkable. Therefore, in practice, we combine maps, and it's rare to make more than 10 maps. We'll discuss mapping further on.

1.3.1 THINKING IN ALL DIMENSIONS

Systems exist in the full realm of our reality. They grow in time, occupy space, and are connected to other systems on a variety of levels. That's why we analyze systems in the Time, Space, and Context dimensions for a full understanding of the system. Because a full overview of the system is important to prevent new externalizations, we need to evaluate our actions in all three of these dimensions. Let's look at these and start with the easiest one: Space.

SPACE

When we're talking about spatial development, such as sustainable urban redevelopment or architecture, many of the spatial components are familiar. They are the maps and drawings the designers work with. Usually these maps only show the direct physical properties of a design. Using SiD, we map quite a few other properties as well, such as the flow of resources, movement of people, value relationships, and ecosystems in space.

For most projects, the presence of a spatial analysis is obvious. For existing sustainability analysis applications, the spatial component may be less obvious. For example, a Life Cycle Assessment (LCA) is a standard sustainability impact assessment method for products (see the tools section for details). In a typical LCA, spatial relationships are usually not considered. Performing an LCA in a SiD process challenges you to start mapping spatial relationships as well. For example, when you're evaluating the impact from exhaust particulates from combustion engines on human respiratory systems. You'll find that there's a big difference in impact in rural areas versus densely populated areas. This may cause you to score the use of combustion engines for agriculture differently from those inside of dense cities.

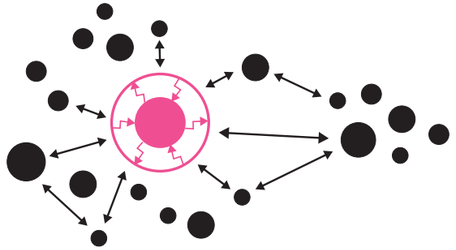
Space, like time, is a universal dimension that needs to be explored in conjunction with time and context for all SiD projects. Usually, even in the built environment, space offers unexpected possibilities that you can use to enhance the solution and increase a project's performance economically, socially, and ecologically.

TIME

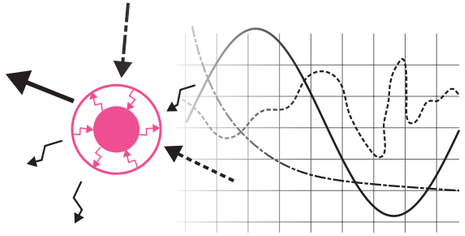
As mentioned, sustainability is a state of a 'dynamic' system. Of course, dynamic behavior is an aspect that can only be expressed in time. The state of a system is not permanent, and no solution is for ever. You are never designing a static solution, you are designing a solution that is fluid over time. As systems go through various cycles, usually more than several at the same time (think day and night, seasons, stages of maturity, etc.), they respond differently. For instance, it is important to realize that an action that was a great support of the system in its growth phase might damage it in its maturity.

We don't need to be as abstract at this; there are many tangible reasons to map time in any project. For instance, most projects need to be funded and the investors will ask when they'll get their returns. Mapping the economics of a project in time is therefore a common practice. In policy development, time is often a significant component of its structure, rollout process, and development path. It is desirable to extend the mapping to other properties as well: the material cycles, the social impacts, and so on, for each problem at hand. Moreover, we should extend the timeline to beyond the start and finish of the project. We need to monitor its effects in the future, as well as track its reasons for existence in the past, in order to learn from,

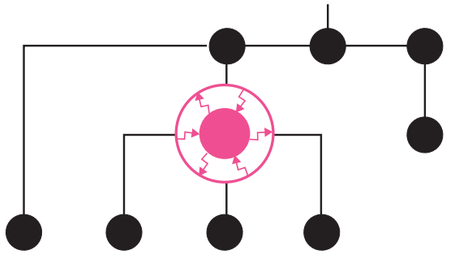
SPACE



TIME



CONTEXT



and adapt to, any periodic patterns that may be present in its environment.

Time is therefore one of the universal dimensions of SiD that needs to be explored. Time, being so ubiquitous, can escape our understanding to some degree. The time dimension is, in our experience, most valuable if we learn to identify, observe, and register it. Time is a great asset, with the understanding that it is the scarcest of resources available, even more so than space. Therefore, compressing time and increasing development speed is a challenge in any project.

CONTEXT

The context dimension is the dimension that most eludes definition. We can, however, refer to another word that has many of the properties of the context dimension, which is 'meta'. As with meta, context describes everything that is separate from time and space.

One can object that everything should be mappable in space and time. While that's correct, it can be exceedingly difficult to do so. For instance, imagine mapping your family history in time and space. While it would be possible, the result would likely be both hard to read, and difficult to make. Opposed to that, making a simple hierarchical family tree graph is simple and clear. Context gives us an extra dimension to map in, parallel to space and time, which frees us from spatial and temporal mapping restrictions. In this way, it becomes a potent tool that is much more intuitive to use (and comprehend).

Context is often related to investigating the components and relationships of a system separated from the restrictions of time and space. By doing so, it can show relationships that were not apparent before. This is a valuable result, since sustainable system design is mostly about generating an understanding about the relationships between agents in a system. It is in the context dimension that we can visualize the system in a way that may provide new relational insights. We can do that in any way we choose it to be helpful. Temporal maps are often graphs of sorts, and spatial maps often approach the traditional idea of a 'map', locking our understanding and freedom of exploration. The context dimension is effectively a 'free' system mapping dimension, that allows most creativity, and in turn, insight to be gained.

As alien as context mapping may sound, it is more common than you might realize. Causal loop diagrams, for instance, are an excellent example of a context map. Diagrams of organizational structures (organograms), and even electrical circuit diagrams, are mostly context maps. Other basic examples include a grocery list, an encyclopedia, or even a life cycle assessment spreadsheet. See page 276 in the method section for context map examples.

This leads us to say that the context dimension is the dimension in which the totality of the system analysis can be best looked at. In fact, because an understanding of the whole system is so important to SiD, we generated some specific tools for context mapping that help to make this part insightful and enjoyable to do. That will be discussed at various points in the Method, Process, and Tools section.

If this has piqued your interest, you can jump ahead to section 2.2, page 259, which covers system mapping in the Method section.

1.3.2 THINKING IN SCALES

We use Space, Time, and Context as our main dimensions for investigation. Now, we need to divide these up into relevant scales to ensure a comprehensive look at the system. We can find essential system relations and dynamics in both critical details and gargantuan patterns. The scales for space and time are easy to imagine: your desk vs. the world, and centuries, vs. a day. For the context dimension, the scales are not so apparent, but extremely useful. In this section, we review the scales of each dimension, with tips on how to get the most out of the scale segmentation.

SMALL	MEDIUM	LARGE
SPATIAL		
House Table	City Continent	Country World
TIME		
1 day 1 hour	1 month 10 years	1 year 100 years
CONTEXT		
direct direct	1st degree all indirect	2nd degree complete

SPATIAL SCALES

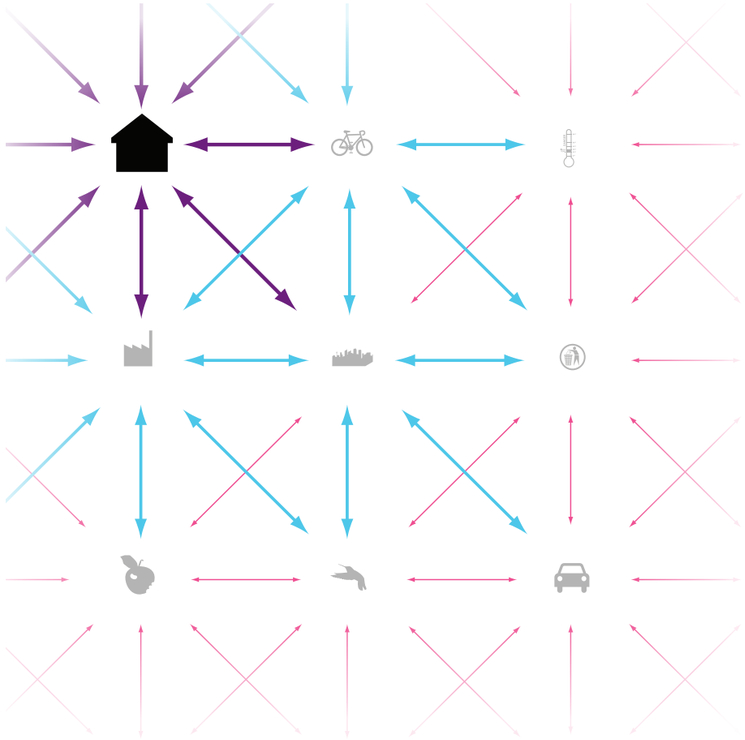
When mapping a system it is helpful to include a variety of spatial scales. When looking at the redevelopment of a building, for instance, it makes sense to map on the scale of the direct neighborhood to figure out its stakeholders, potential sources for recyclable materials, and so on. After this, mapping the city district, the state, and perhaps its influence on the world may provide remarkable insights on the influence of that particular redevelopment. In practice, 3-5 scale steps are sufficient for the spatial dimension.

TEMPORAL SCALES

In time, it makes sense to look at the past as well as the future. Looking back, for any aspect of a system, shows us how the system has behaved before, which we can learn from in trying to look forward. History is the best teacher we have. It's easy to look back, much easier than looking forward in time. Make use of this wherever you can. The level of detail, and on which time scales you map, depends per subject. Determining the relevant steps is a matter of experience, and always slightly overstepping your comfort zone. The typical division is hours, days, weeks, years, decades, and about 50 years before and after.

CONTEXTUAL SCALES

Here is one to wrap your head around: scales in context. While abstract, scales in context can give insights that space and time are unable to do. Context maps plot relationships within a system. Context map scales relate to which degree you trace the relationships. For example, when you map yourself in your family context, and you draw your family tree, the scales in this context refer to how many steps you go back in family



1st degree

2nd degree

3rd degree

relationships. For example, parents are 1st degree, grandparents are 2nd degree, etc. Depending on the context, you may regard these direct relationship steps as relevant scales. In the case of larger systems, scales refer more to a level of magnitude of relationships. For example, when regarding context scales for a multi-national company, the first level may be the company itself, the second level be the company and all its primary suppliers and customers, and the third level all people affected by the organization.

The Global Reporting Initiative (GRI) uses a standard for supply chain context scales. This helps organizations in prioritizing which parties to include in supply chain sustainability reporting. The GRI distinguishes three main tiers. Tier one is all of the departments of the organization itself, tier two is tier one plus all its primary suppliers, and tier three all of tier one and two, plus all the rest of the suppliers in the chain. As you may imagine, the complexity and density of information in this tiering is exponential in complexity. See the tools section on page 411 for more info on the GRI.

SCALES OF IMPACT

Scales of impact refer to different orders of magnitude of impact that an action can have, in relation to the contextual scale they have an effect on. Understanding these scales on a fundamental level helps create insight into some critical system dynamics.

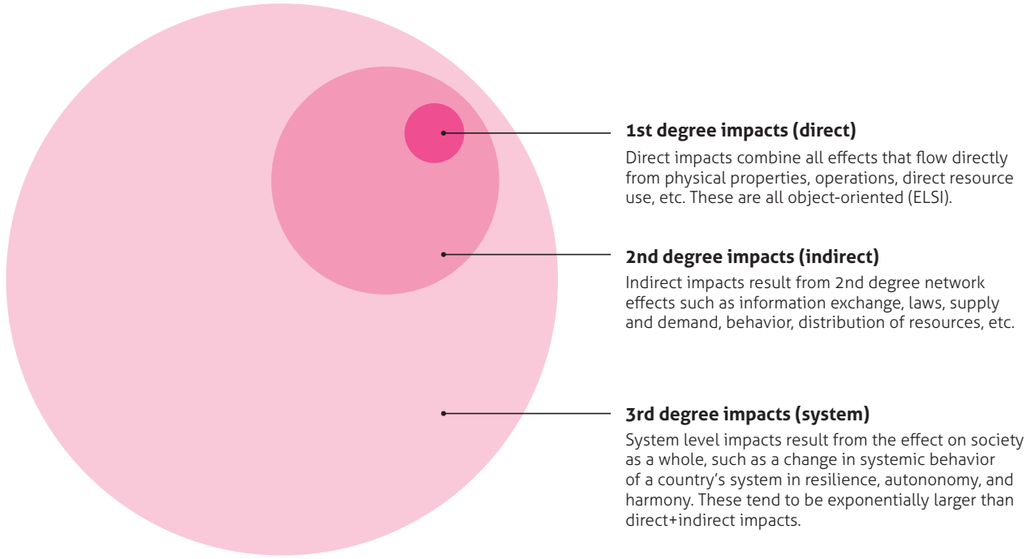
We name these scales of impact as follows:

1st level: object level, mapping direct impacts
2nd level: network level, mapping network impacts
3rd level: system level, mapping system impacts

Most people will be comfortable thinking about first level impacts. The increased electricity as a result of turning on a light switch is a good example of a direct impact. Direct impacts are found in practically all sustainability tools and impact assessment methods. These impacts have been the foundation of reasoning for deciding how to act for most of human development. First level impacts are easily quantifiable, and we can easily decide upon and what we can measure. On the other end of the spectrum we have system level impacts. These impacts are thoroughly embedded within the complexity of the system, can act over long time spans, and are rarely quantifiable. However, they are where sustainability of a system manifest itself. It is also where the largest positive impacts can be found, and therefore should be the ambition of genuine intervention.

1ST LEVEL – DIRECT IMPACTS

Direct impacts are effects that are directly and materially linked to a certain action. They mostly allow themselves to be measured objectively in purely quantitative data, such as amount of kWh, temperature,



and GDP. A large set of these indicators, such as those used in Life Cycle Assessment (LCA), can give a reasonable overview of the overall direct impacts of an object. While these are relatively easy to quantify, they tell us little about the influence an object or action has on the actual system, such as societal resilience, social justice, and other qualitative aspects.

2ND LEVEL – NETWORK IMPACTS

The second impact level is the one that sits in between the object level and system level, and is related to the effects of and on the network. This level lists the impacts that are a result of the direct relationships between objects. For example, by building a school far away from a residential community increases the transport movements between the two. That is a network effect. This network effect in turn causes object level effects, in the form of the energy used by this transport, emissions, and time spent traveling. Other examples of network level effects are the increased connectivity of people due to social networking websites, availability of food in an area due to the distribution of its agricultural industries, and so on.

3RD LEVEL – SYSTEM IMPACTS

This third level is at an abstraction level where system behavior can be perceived. In this scale the systemic behaviors that govern our past, present, and future live. These are effects such as the long-term resilience of a society, the educational value of a certain action, the adaptive capacity of an agricultural system, and so on. While harder to express and usually difficult (if not impossible) to quantify, third level impacts are by far the largest and thus essential to focus on in our goal setting. System effects always have a large influence on the entire set of network relationships and all objects within.

WHAT TO MAP IN THE SCALES?

We want to avoid the pit-falls of band-aid sustainability solutions that end up making matters worse, such as the ones we were looking at earlier on in this chapter. An effective way of doing this is to investigate on what level the effects of interventions we plan on taking will play out. When the effects are only, or mostly, in the first degree, there's a good chance that this will not have a significant beneficial effect in the long term. As a general rule of thumb, you may consider that you'd like to have at least one strong positive network effect for any intervention. Preferably, you create a strong positive systemic effect, but that is not always achievable.

EXAMPLE: SYSTEMIC SCORING OF HOUSING CONSTRUCTION



On the left a table with six construction types (for housing) is laid out, ranked in SiD's SNO structure. This is a simple scorecard used to quickly evaluate different scenarios or concepts. This example shows how you can use SiD's structure to quickly evaluate effects on a system on all three levels.

The scoring performed here can be done in about an hour, given that the person doing the scoring is both familiar with the subject matter (in this case sustainable housing scenarios), and the SiD system. Scoring starts at the bottom, starting with more simple object level impacts, towards more complex aspects on top. What is scored for each area is the contribution made to (or subtracted from) the system that the subject is in. In this case, for example, it is the contribution to the city that this house would be constructed in. This causes, for energy, the contribution to the system for average new house construction to be negative (red), since a normal house, at time of writing, takes a substantial amount of energy from the system. This is why it is colored red. The same goes for materials.

In this example, all construction types have a negative contribution to ecosystems. This is because all houses consume a certain amount of land. The contribution of the more sustainable strategies is less, since they take into account other ecosystem impacts such as climate change. The systemic urban catalytic construction type on the right is part of a sustainable neighborhood and/or city design approach, and cannot be reached by a single house construction alone.



1.4 COMPLEX SYSTEM BEHAVIOR

1.4 SYSTEM BEHAVIOR & DYNAMICS

We have discussed systems consisting of a set of objects and their interrelations. Systems are dynamic, respond to influences from the outside and inside, and exhibit behavior whose causes cannot be reduced to single objects or connections. The cause and effects of these system behaviors can not easily be distinguished. They can, however, exhibit patterns that allow you to understand and work with systems effectively. These patterns are often 'emergent', meaning they arise out of their mutual interaction and not due to any particular object or connection alone. The complex emerging behavior of systems is called system dynamics.

Studying system dynamics allows insight and understanding in dealing with systems in the real world, be they political, technological, biological, or of another nature. Because system dynamics of real-world systems cannot be predicted accurately, it's most useful to gain insight into system dynamics on an intuitive level: After a while, patterns will emerge naturally, and you'll be able to detect opportunities and problems on a system level. Sometimes this can happen within seconds after studying a system or intervention.

THE SYSTEM BEHAVIORS ZOO

In this section some common system behaviors are assembled. These you may encounter 'in the wild', and detecting them helps you recognize patterns in complex systems. The collection in this book is not an exhaustive set. There are a few important ones to be aware of that surface often in sustainable development. The system patterns mentioned here contain some of the fundamental insights we need to absorb to move forward into this century.

IN A NUTSHELL: SYSTEM BEHAVIORS

Below a quick summary of seven system behaviours that are useful for understanding sustainability. They are aexplaiend in more detail in this chapter.

There's many lot more than therse seven. If you're working in a group, or in an educational setting, it's worth exploring what others you can come up with.

› **Catastrophic Shift**
Complex systems have the habit of, once triggered, changing unpredictably fast. After these incomprehensible drastic changes, there is tendency for systems to stabilize themselves in an equilibrium (attractor state).

› **Rebound Effect**
The rebound effect is a universal systemic behavior that occurs when a change in the system triggers secondary side effects that counteract the intended change. It may be triggered through unfortunate delays in feedback, psychological effects, economic mechanisms, and many others that result in reducing the performance of a system.

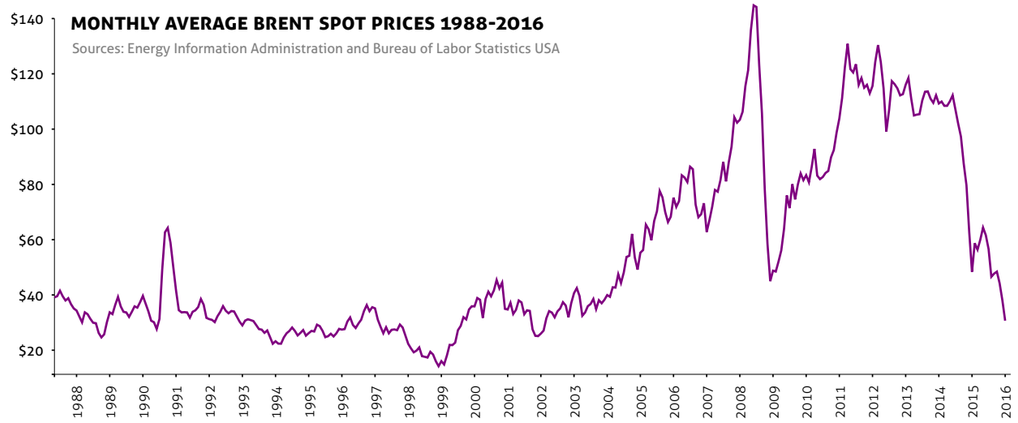
› **Exponential Effects**
An exponential effect occurs when one parameter in a system influences various other parameters in the system, which add up causing the system to respond with an exponential change the same or other areas.

› **Law of Diminishing Marginal Returns**
This law, best known from economics, is a general rule that applies to all systems. The rule states that for each single unit of production that is increased, the return of that unit is slightly less than the one preceding it. This causes growing systems to hit a ceiling of efficiency at some point, after which efficiency actually starts to drop, until the system collapses under the weight of its own overhead.

› **80-20 Rule**
This rule of thumb, also called the Pareto Principle, states that roughly 80% of the effects of systems are caused by 20% of their causes. This is not a law, but it is applicable to many situations in virtually all systems, on all sorts of levels, be they natural, societal, or economic.

› **Historical Momentum**
A large system that has been operating for a long time often becomes rigid in its patterns, even if those are non-physical and could change on the fly. This 'historical momentum' is a primary target to overcome when aiming for societal transition effects.

› **Tragedy of the Commons**
Tragedy of the Commons is the depletion of a common resources shared by a group of people, even though each member of the group was aware this depletion worked against their personal and shared long term interest.



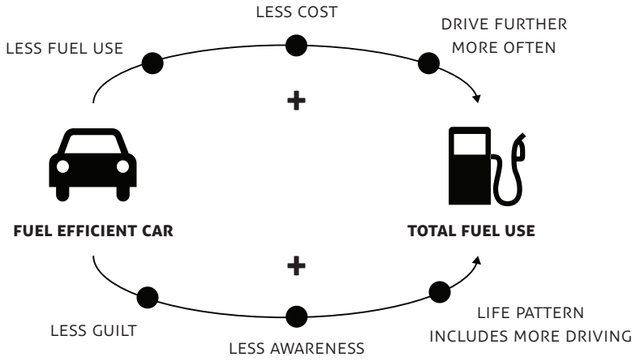
CATASTROPHIC SHIFT

It's easy to think of big systems, such as our society or geological processes, as slow and lumbering beasts that only change over long time spans. Nothing could be further from the truth, though. Complex systems have the habit of, once triggered to change, changing very quickly indeed. Natural systems are a good example of this. Earth formation occurs over long time periods, but more often in series of violent shocks than in gradual steps (earthquakes, volcano eruptions, hurricanes, avalanches, etc). Similarly, rapid changes in sociological contexts often result in riots and/or revolution, and in economical systems with sudden and sometimes unexpected market crashes.

Behind these unpredictable drastic changes, there is a tendency of every complex system to stabilize itself in an equilibrium (attractor state). If the external stress or internal tension in the system are not high enough to cause a catastrophic shift, it will keep on stabilizing itself in these attractor states. However, when these pressures on the system reach a certain threshold, the system may suddenly switch to another attractor state without prior warning, very rapidly.

In some cases a system that is in a state of transition may be considered as being unstable. Which direction it may go, if uncontrolled, may not be clear, or even seemingly logical. Understanding the dynamics and properties of the system may lead to insight into where its 'next' stable state may be in order to prepare for a potential sudden change. Or, when aiming for a sustainable state of the system, this could be used to find leverage points to transform the attractor state to another, sustainable, attractor state.

EXAMPLES
Geological: Earthquakes, avalanches, volcanic eruptions. Social: Riots, terrorist attacks, trend booms, market crash.



REBOUND EFFECT

The rebound effect (or take-back effect) is a universal systemic behavior that occurs when a change has been made to the system, for instance to improve its efficiency, and unpredicted counter-behaviors diminish, counteract (backfire), or spin out of countrol the system's response. In economics, the rebound effect refers to the situation when an intervention intends to save spending costs by reducing prices, but this being counteracted by an increase in consumption. The result from lower prices is partly or even completely offset by excess spending.

The rebound effect can occur in time, space and context simultaneously and can be particularly destructive to policy decisions. Rebound may be triggered through unfortunate delays in system feedback, psychological effects, economic mechanisms or others. The rebound effect can be seen in all layers our society, and often leads to corporate and government decisions that are doomed to fail. In sustainability development fields, it's been particularly studied in the area of the energy transition: higher energy efficiency paradoxically drives energy consumption up, and by that offsetting all or part of the expected saving.

This system behavior is a primary culprit for the unfortunate reality that simply gradually improving the efficiency of our existing systems in society in a step by step, evolutionary way, we won't be able to make a significant reduction in resource use.

EXAMPLE

In 2000 a specific car was introduced which claimed significant environmental benefits (~20%). A rebound effect occurred when the buyers of these cars were already environmentally inclined, and the users of these cars subsequently felt less guilty driving this car as opposed to another. As a result they started driving it more and faster, resulting in more impact than the efficiency improvements gained.

EXPONENTIAL EFFECTS

One of the elementary mechanics in any complex system are exponential effects. An exponential effect occurs when one parameter in a system influences various other parameters in the system, which in turn multiply, causing the system to respond with exponential change in another area. Complex systems typically have a variety of properties that behave exponentially.

The exponential growth curve is, like many other system effects and behaviors, a basic fact of life. Biological organisms mostly grow exponentially before they 'plateau', and environmental impacts such as melting of land ice has exponential effects on the climate. Exponential effects are therefore to be expected everywhere. However, most people's intrinsic feeling about system behavior is based on linear relationships. The result is that off-the-cuff predictions and intuition about complex system behavior often misses their target by a long shot.

> *"The greatest shortcoming of the human race is our inability to understand the exponential function."*
> -Albert Allen Bartlett, Physicist

Using the SiD network parameters you can often find patterns between the individual parameters that are exponential in nature. For instance, the size and efficiency of a system is invariably exponentially linked to its complexity. Because complexity usually feeds into the resilience indicator in various ways, scaling a sustainable system often has significant impacts on its sustainability (negative or positive).

LAW OF DIMINISHING MARGINAL RETURNS

This law, most known from economics, is a general rule that applies to all systems. The rule states that for each single unit of production that is increased, the output for that unit is slightly less than the one preceding it. This causes growing systems to hit a ceiling of efficiency at some point, after which it actually starts to drop, until the system collapses under the weight of its own overhead.

This system behavior is particularly insidious for large systems. Archaeologist Joseph Tainter, in his book 'The Collapse of Complex Societies' analyzes dozens of civilizations through time, and makes a compelling case that all societies are subject to this rule, and that all societal collapse is due to societies reaching and exceeding the top of this curve, from the Mayas to the Romans. Counteracting the effects of the curve requires a reduction of a system's complexity in whichever way possible, or a resource efficiency jump on an exponential scale. Since the complexity of a system is usually linked directly to the number of agents within a system, this is very difficult to achieve without reduction in size.

EXAMPLES

Imagine a village that relies on wood from a nearby forest for its primary material and energy needs. As the village grows, it needs more wood. For each lumberjack that's added, the group of lumberjacks grows, the trees to cut are further away, and the efficiency per lumberjack goes down a little bit. This keeps going until the point where each lumberjack added still brings in extra wood, but brings down the efficiency of the whole. If they keep growing and adding lumberjacks, they are going to run into the point where everyone's a lumberjack, and then run into a shortage and collapse.

A solution is to start harvesting coal instead, which has higher energy per unit. Coal requires a larger organization, mining operations and logistics, but at the start it will suffice. As the town keeps growing, the coal system will suffer the same fate. The easy coal on the surface will deplete and they have to dig deeper for more. The system behavior repeats itself until they have to jump to oil, and so on.

Interestingly enough, this system behavior explains a lot of our society's predicament and is one of the most compelling and irrefutable arguments against continuous growth. The only way to stop this cycle is to stop growth.

> *"Anyone who believes exponential growth can go on forever in a finite world is either a madman or an economist."*
> - Kenneth Boulding, economist



THE COBRA EFFECT
British India tried to get rid of cobras by offering a reward for captured snakes. Locals started breeding cobras and giving them to the government to collect the reward. The British found out and stopped the program. The breeders then released their snakes causing the population to increase. The cobra effect occurs when an attempted solution to a problem makes the problem worse as a type of unintended consequence.



80-20 RULE
This rule of thumb, also called the Pareto Principle, states that roughly 80% of the effects of systems are caused by 20% of their causes. This is a general occurrence more than a law, but it's applicable to many situations in virtually all systems, on all sorts of levels, be they natural, societal, or economic. It was named after Vilfredo Pareto, who discovered that 80% of the land in Italy was owned by 20% of the people, and linked that to his realization that 80% of the peas in his garden were carried by only 20% of the pea pods. This systemic behavior is useful to anticipate planning and organizational needs for complex projects.

EXAMPLE
It's often the case that in a complex project 80% of the time invested in completion is caused by 20% of the work (the tweaking stage). Subsequently, 80% of the costs incurred with such a project lies in finishing touches and detailing.



HISTORICAL MOMENTUM
Old dogs can learn new tricks, but it requires patience and effort. Complex systems seem to have an ingrained collective memory. Even if all the preconditions for systemic change in a city or country are met, and public will and intention is there, historic momentum can cause a system to change very slowly. This can frustrate agents that are working towards change, increase the required energy to make it change, and endanger the process. Big systems change slowly. To overcome historical momentum, one can search for positive exponential drivers to overcome it and accelerate the transition. Also, sometimes a system needs a 'transition boost', a short moment of excessive impulses to help the system over this historical momentum bump.

EXAMPLE
Grampa knows he shouldn't use the football trophy of his grandson to ash his cigar but after so many years of habitually doing this, he still can't help making the same mistake over and over.



EXPERIENCE AND LEARNING CURVES
This system effect is related to the pattern that emerges when a complex system has to repeat a certain task. This effect states that with each iteration, the task requires a little bit less effort, until it reaches its lowest plateau. It holds true for individuals as well as large complex systems with many agents. The experience curve can be seen as a positive system effect that may be able to counteract the law of diminishing marginal returns in some cases, if a significant dedicated social learning process is involved, such as in professional manufacturing or education. It may also be used to expect a decrease in running costs of projects over time where the staff needs to go through a particular learning curve. The result of this well-known system effect is that project managers often define a certain lead-in time or break-in curve for complex projects before they're running up to planned efficiency.

TRAGEDY OF THE COMMONS

This social system effect has been named after the 1968 article of Garrett Hardin, in which he explored the depletion of a common resources shared by a group of people, even though each member of the group was aware this depletion worked against their personal and shared long-term interest. We see the tragedy of the commons effect grow in strength as systems increase in population. Small groups, with controlled efforts, can manage the effect to a large degree, but it requires a continuous investment of effort to do so. The tragedy of the commons effect is a potential reason why a certain degree of centrality in management, and rule and decision making, is necessary in any system.

EXAMPLE

In addition to the use of natural resources like rivers and lakes, the tragedy of the commons can also be seen in small systems. In shared housing situations the dishes may be a shared commons that is constantly at risk. If one person doesn't do their dishes and leaves them on the kitchen table, it will quickly accumulate those of others who also then feel they can ignore their responsibility, until that one flat mate posts a passive-aggressive note on the kitchen door calling everyone to order. This will help for a while until it starts again several weeks later.

SCALE DEPENDENCIES

More of a general rule than a behavior for complex systems, but worth mentioning here, is that behavior is linked to the scale and composition of a system. A change in scale by an order of magnitude causes systems to behave differently. We see this in biological systems, such as with populations of bacteria in biodi-gesters, but also in business organization and Because systems with scales that are different in size are bound to exhibit different behavior, solutions that work on one scale level may not work as well, or, in fact exhibit the exact opposite behavior when implemented at other scale levels. management, as well as economic and cultural systems.

In addition, systems that change in size have to move through various adaptive stages to deal with their new scale. This can cause significant friction that has to be accounted for. This is why companies that grow too fast often fail.

EXAMPLE

For example, adding a connectivity improvement in a small company, by let's say introducing a simple private social network, may help to increase the resilience of the company. But, when applied to a large company, the amount of increased connections and its consequential burden may hamper the company more than it gains.

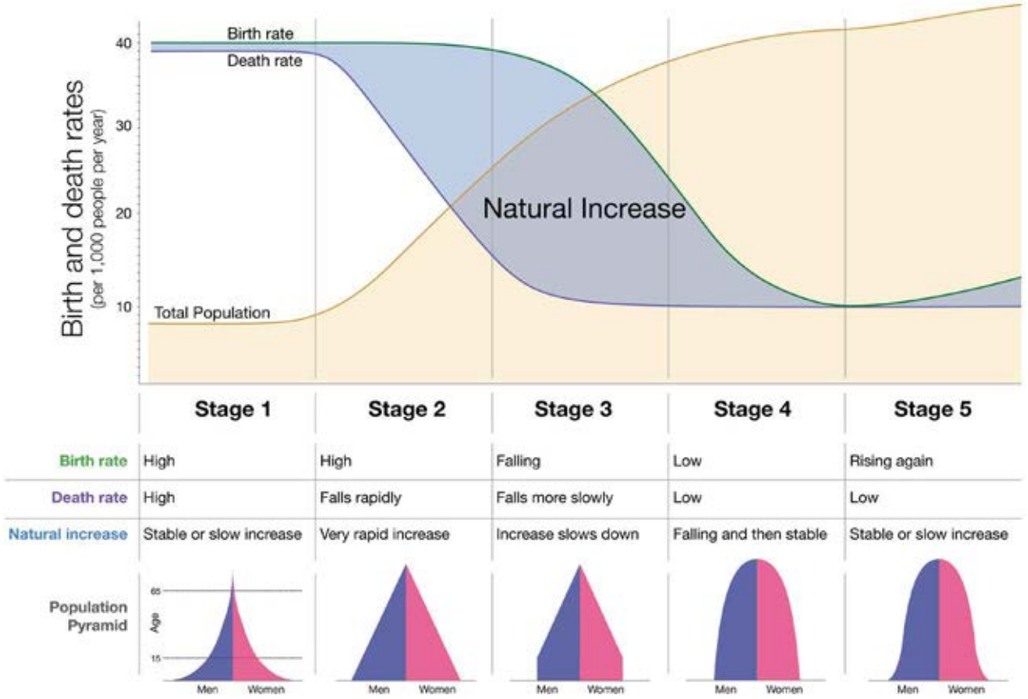
When relying on a function in a complex system, such as the water filtration capacity of a wetland, one should take into account that scaling size by orders of magnitude will not automatically yield the same scale in performance.

TRANSITION EFFECTS

A system that is in transition will exhibit dynamic effects that can be counterintuitive or even detrimental to the performance of the system, while unavoidable to the desired end state. These transition effects can have huge impacts over time, as various aspects of a system are out of sync with each other in moving towards its new state.

EXAMPLE

An excellent example for a transition effect is the Demographic Transition Effect (DTE), as identified in 1929 by Warren Thompson, an American Demographer. DTE describes the large increase in populate of a country in when moving from a pre-industrialized state to an industrialized one. In the industrialized state, the country has a lower death rate due to better access to medicine and hygiene. However, the subsequent drop in birth rate lags behind the drop in the death rate, creating a large surplus in population in its period of transition.



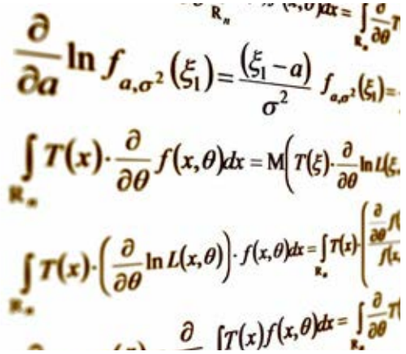
Graph depicting DTE and population growth dynamics, by Max Roser

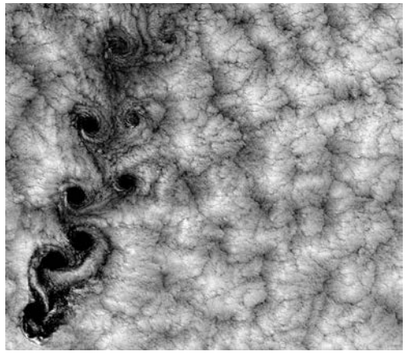


1.5 IMPROVING COMPLEX SYSTEMS

1.5 IMPROVING COMPLEX SYSTEMS

Now that we have a vocabulary for the anatomy of systems, and an idea about system dynamics, we can have a look at how to go about changing complex systems. The SiD method, in the next chapter, describes how to go about setting goals, finding solutions, and making action plans for achieving this. In this chapter, we discuss some of the underlying theoretical elements that are useful to make on your own, to understand why you're doing what you're doing. To begin, we discuss two different ways of thinking about what 'system thinking' really is, then we talk about how you can plan for transitioning a system, and why we're making the roadmaps the way we do, and finally, we close with some general tips for system optimization before we head to the more practical SiD method chapter.





Classic Systems Thinking	Complex Systems Thinking
Reductionistic	Holistic
Piece by piece	All at once
Numbers	Patterns
Digital	Analog
Bottom-up	Top-down
Finite elements	Infinite elements
Prediction	Understanding
Exact	Global
Proof	Insight

1.5.1 COMPLEX SYSTEM THINKING

In the world of sustainability we can see a split between two different ways of thinking about systems. The first one is a prevalent one, the reductionist form of thinking (piece by piece) that relies on numeric processing in modeling system dynamics. The second one, which is newer and less practiced, is a holistic (all at once) approach. It uses pattern recognition to understand system dynamics. Both of these approaches are useful, have their strengths and weaknesses, and, if properly matched, strengthen each other. Within SiD, both approaches are used simultaneously, and each has a particular role to play. It helps to understand these two ways of thinking and be aware which approach fits in what category, and what their strengths and weaknesses are.

THE REDUCTIONISTIC APPROACH

Reductionism is the dominant approach in (sustainability) science, and forms the basis of most tools that are available, such as Life Cycle Assessment. Virtually all policies, business strategies, and plans for cities and industry are created by using this approach. It follows a standard 'business administration'-like pattern, and is a bottom-up form of thinking, which is a direct result of reductionist thinking stemming from the Enlightenment movement.

In a reductionistic mental framework, reality is understood by breaking it down into small enough components. Each component can then be fully understood individually, and measured, calculated, accounted for, and predicted. The reasoning goes that if one fully understands all the individual components, there's understanding of the whole. The reductionist approach relies on math, logic, and often results in technological interventions to create solutions. It is heavily dependent on the left hemisphere of the brain, known for verbal reasoning. Most professional fields and educational material in schools and universities use a reductionist approach. Consequentially, most people feel more comfortable with a reductionist type of thinking than with holistic thinking. The reductionist approach is vital for engineering and evaluating processes in reality. The argument for reductionist thinking is that if we can break things down to the point where we are confident about what we know, we can build these pieces on top of one another until we understand everything. In a mechanical sense, that is true. In a complexity thinking sense, however, it is not.

When applied to complex systems, the numerical confidence of reductionist thinking creates a picture of reality that is distorted. While seemingly accurate, it leads attention away from what's really going on. As mentioned earlier, the objects and their interconnections in a complex system create dynamics that cannot be reduced to the sum of their parts. Consequently, these systems can't be modeled well, are impossible to predict, and any attempt at doing so distract from approaching the issues at hand. Therefore we also need the holistic approach.

THE HOLISTIC APPROACH

This approach looks at systems from a top-down perspective and focuses on patterns within systems behavior that are emergent, instead of on the individual components. It accepts that systems are complex (non-linear), and therefore modeling individual components and simulating their behavior is only an academic exercise made to increase our understanding, but never useful to predict. Instead, the holistic approach embraces the complexity of systems, and seeks to understand their large-scale and long-term effects and behaviors. From this insight, it endeavors to find strategies that act on the whole and take advantage of emergent patterns and behaviors that may not be fully understood, but known to exist.

Holistic thinking requires observation and analysis of patterns in complex systems. For this, we rely more on the right hemisphere of the brain, which is responsible for understanding and seeking patterns in the world around us. The human mind is the best pattern recognition tool we have, and this makes the holistic approach fundamentally a human process. Our brains are also vastly superior in pattern recognition than we are in reductionist qualities such as math and statistics, nevertheless we need to cater to its specific qualities in order to make use of this pattern recognition power.

The strength of visual pattern recognition lies in our brains. Because of this, the holistic approach relies on visual maps and tools in order to support this visual processing, and help us understand the patterns that emerge. This is why system mapping plays such a vital role in SiD. This is inherently a process that takes place within the individual brain. Yet, by cooperating, the patterns recognized by one person can be transfered to another to quickly increase the groups insight. By combining different mindsets in a team, multiple perspectives scan for different patterns, and the process is greatly enhanced.

This holistic approach is part of a form of science that is somewhat 'fuzzy' in nature, such as complex systems theory and probabilistic logic. Therefore, it can be confusing to those used to traditional 'hard' reductionist ways of working. Nevertheless, a holistic approach can be more powerful, accurate, and faster than a reductionist approach, if applied in the right situation and context, with the right tools and experience. In the end, we need both to really optimize our approach.

COMBINING REDUCTIONIST & HOLISTIC THINKING

Since neither of these approaches by themselves are perfect, we need both ways of thinking to achieve successful sustainable solutions. We usually start with a reductionist approach to begin exploring the system. We use it to test its boundaries and investigate the nature of its components, on familiar grounds. From there, we rise to the network level where complexity starts to manifest itself, and complex behaviors emerge. Here we can use tools such as big data, sociology, and system dynamic analysis to feed our understanding. We then proceed to the system level, where the holistic approach informs us about the behavior of the system as a whole, which brings oversight, clarity and solution pathways.

These solutions, often defined in the abstract system-level, are then interpreted on a network level, after which they can descend into the object realm, where the reductionist approach can help us test the solutions in reality. In this process, both approaches are essential to a successful innovation cycle. In some projects they may come closer together than in others, and one approach may be dominant to another. The point is, that in synthesizing both bottom-up and top-down understanding of the system, our minds can create new connections and come to solutions that otherwise would have never emerged. Within the SiD method we define the goals with a holistic approach as much as possible, and try to perform the evaluation of these goals using reductionist methods.

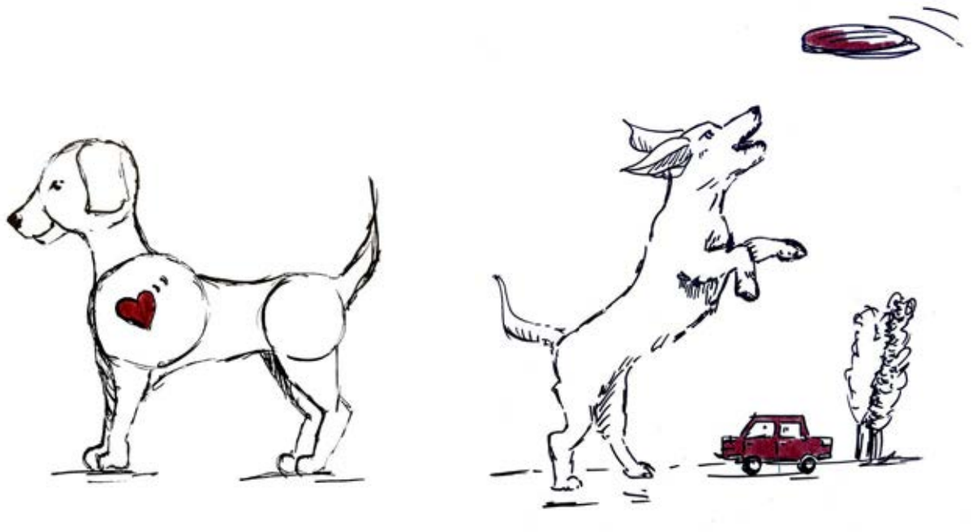
PREDICTING VS. UNDERSTANDING

An essential difference between reductionist systems thinking and holistic systems thinking is their confidence and capacity for prediction. In the reductionist model one assumes that everything around us can be modeled and predicted, if only the model is refined well enough. In our assessment, this is a red herring. Complex systems cannot be predicted in the ways reductionist approaches make them seem. Such an assumption can lead to decisions that may endanger the future of whole organizations, or countless lives, and is inherently irresponsible.

A good example of unpredictability of complex systems is the weather. Despite our technological advances, we've not been able to accurately predict the weather beyond a few days. If you've ever found yourself in the park with a picnic basket running from a sudden downpour, despite carefully checking the weather a few days before, you know that even these few days of prediction can be a hit or miss. The inability for us to accurately predict weather is because the weather is a complex system. Its infinite variables make its behavior so dynamic and intricate that it defies prediction. Also, it is a chaotic system, meaning that a very small trigger can lead to big consequences in just a few days time. This cannot be tracked or predicted, so the overall system's behavior is always unpredictable. Yet, we can say with some certainty it will not snow in July in New York City. Therefore, we can never really predict weather with certainly, but we can certainly understand its overall nature and character.

Therefore, rather than modeling to predict, we model to understand. It is the understanding of the properties and idiosyncrasies of complexity that allows us to create systems that are better suited to adapt themselves to changing, unexpected conditions. Each system is different, therefore we need to adapt our analysis to each situation. For this reason there are no fixed formulas or rigid analysis frameworks in SiD.

EXAMPLE: LUBAS THE DOG



My favorite example to illustrate the difference between the reductionistic and holistic approach is by imagining man's best friend: a dog named Lubas. We want to provide for a healthy and happy life for Lubas, just as we wish for society. Lubas, like society, is a complex system. When we look at a complex system such as a city or large organization, we typically analyze it in a reductionistic way. If we would do that with Lubas, we would analyze him bottom-up by investigating each of his individual components such as his legs, head, and digestive system. We would measure his heart rate, his metabolism, and check his blood levels. In our analysis we would go deeper and deeper, until we reach the point where we analyze his countless molecules and mechanics of his body and brain. Then, we try to predict his behavior based from the sum of these findings, and use this to define actions that make sure he is and remains healthy.

This reductionistic approach is useful to try to help Lubas if he is sick or injured, to narrow down where the problem may be, but for the majority of common situations, especially when Lubas is healthy, this is not a useful approach. Regardless of how deep you study Lubas as an object, you cannot predict what Lubas's state will be a few days from now, nor what he will do. Consequently, it's not the first thing you'd want to do when you want to keep him safe, healthy, and happy. Doing this analysis is also time-consuming, costly, difficult, and requires knowledge and resources to do.

The alternative to this is a holistic systemic approach. In a holistic systems approach, we zoom out from Lubas to have a total look at him in his living environment (the system that Lubas inhabits). We treat Lubas like a black box and map the things he interacts with, what goes in and out of him, and make maps of his movements during the day through the house and garden. Literally, top-down maps of the house with his movements would be useful. We track his responses to stimuli, such as giving him a treat, in behavior charts, and causal loop maps. In essence: we study his character and behavior more than his physique. We may learn that Lubas likes to chase loud cars, chew on soft red things, and eat chocolate. Learning this, we may decide to close the garden fence at all times to keep Lubas from running into the street, and to keep any red soft precious objects on a high level where he can't reach them. We need to be especially careful not to leave chocolate lying around the house, since that's often harmful to dogs. Learning Lubas's behavior allows us to take preventive measures, as well anticipate his and our own wellbeing. We still can't predict exactly where Lubas might be at any given time, but we can create a healthy environment that anticipates the most common occurrences.

For most people, the holistic way to deal with Lubas is the most logical one. If you have a pet, you'll agree that you won't check your pet's blood pressure every day to detect if he's doing alright. You do this when you suspect something is wrong from its holistic behavior. This is something we can also do with society and cities. But, we have to learn how to observe their behavior first, and develop the tools and perspective to do so. This can be done with system mapping and analysis, and an integrated perspective. While this may seem complex and much work at first, in reality it saves significant time and effort.

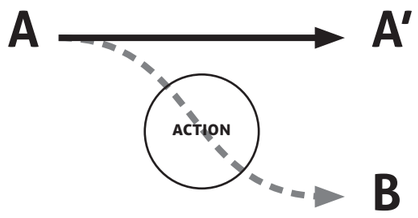


Figure 1

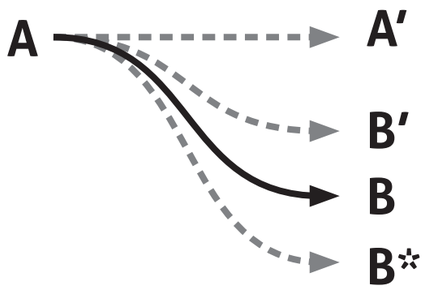


Figure 2

1.5.2 TRANSITIONING SYSTEMS

Once we understand how a system can be moved to an improved state, to increase its sustainability, we need to figure out how to get it there. We hardly ever work with newly created systems, most systems we operate on have been around for a long time. Thus, the transition of the system from its old state to a new, desired state, becomes the challenge. In this section, we talk about the language and approaches used to understand systemic transitions, using a long term roadmaps and short term action plans. This chapter reflects on societal systems transition theory, and highlights a few of its main concepts. We'll discuss the need for goal adjustment to arrive at the right place, transition actions, and some common tools. For more in depth theoretical discussion on transitions, see the reading notes at the end.

GOING FROM A TO B: OVERSTATING YOUR GOAL

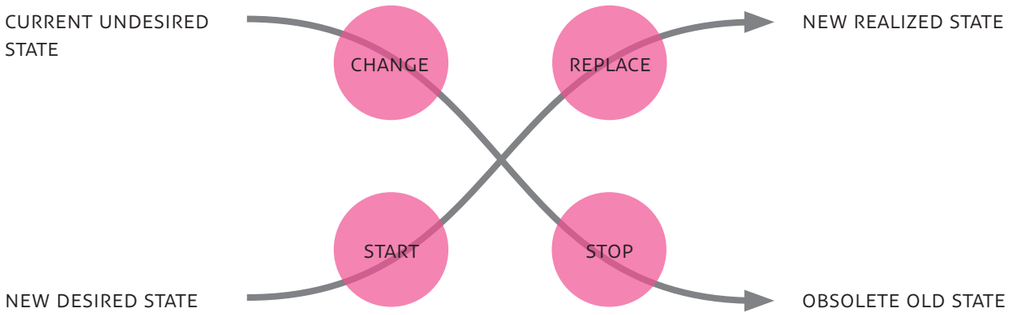
Let us consider a system to be in state A. We want the system to go to state B. In order to transition the system from A to B, we need to apply an action. If we do not take an action, or not the right action, the system continues to move on its own, and it will end up in state A'. So, if we figure out the action, we can apply it, and end up with the system in state B (See the diagram on the left page, figure 1.). At least, that's how it would work with linear systems.

Since we're talking about complex systems, and not linear systems, the system may not actually go to B (or not quickly enough), as a result of various system dynamics such as historic momentum or the rebound effect. In other words, if we apply the action on A, but do not take these system dynamics into account, we will not arrive at B, but at B', or perhaps somewhere in between A' and B'. And this may not yield the desired outcome. In order to arrive at B, we may have to apply action to try to make the system go to B*, in order to make it reach the area of B (see figure 2). Since B* is 'beyond' B, we're essentially over-aiming at our goal.

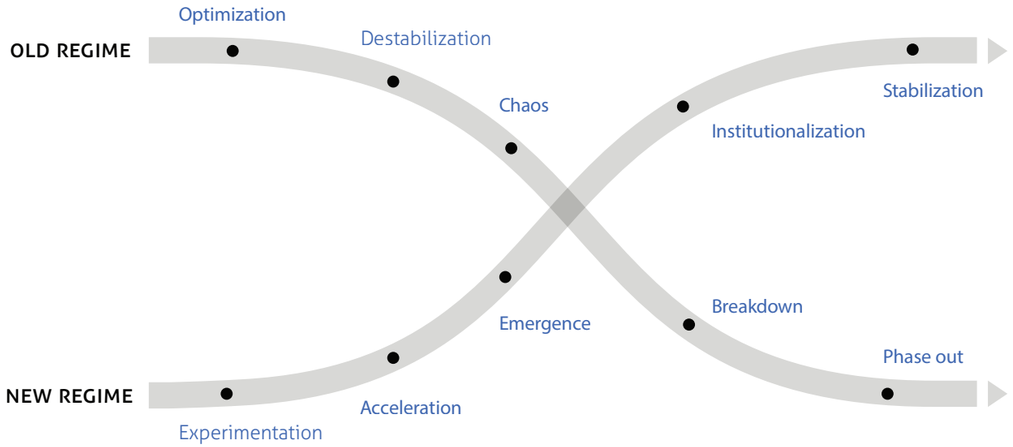
As a simple example to illustrate this, consider a sharp-shooter that aims to hit targets over great distances. When the bullet travels a long distance, it is affected by various dynamics, such as wind, gravity, and the curvature of the earth. This is why the shooter needs to aim a distance away from the target to counteract these dynamics, in order to actually hit the target. With systems, the difference is that the time delay between cause and effect can be large. We cannot apply the usual trial and error to get a feeling for how much further away we need to aim, like we would when shooting. However, we do know we need to make adjustments for the presence of system dynamics. This adjustment is usually to aim higher in ambition than where you hope to end up.

This is equally so when setting goals for the performance of a company, city, or production system. When we set goals for the transition of these systems, we need to overstate the goals to arrive near our intended goal. The usual practice, unfortunately, is to aim lower, so as not to disappoint anyone, or to prevent making empty promises. Therefore, we recommend anyone working on these challenges to push and argue for ambitious goals each and every time. It helps to overstate the needed goals. Be mindful that going too much over the top with goals may also backfire. In that case, the agents in the system may not believe in an absurdly overstated goal, and will not even try.

EXAMPLE TRANSITION PATH



DRIFT TRANSITION MODEL



source: Dutch research Institute for Transitions (DRIFT)

THE ACTIONS TO GO FROM A TO B

When we act on an existing system, and we want it to change states, the actions we need to apply to change it include the following types:

1 **Change** doing some things
2 **Start** doing certain things
3 **Stop** doing certain things
4 **Replace** doing certain things with other things

As straightforward as that may seem, the nature of each of these four acts are profoundly different. Especially when we talk about these in the context of large systems such as multinational companies, cities, or national policies. For example, to stop doing certain things on a national level may require the deconstruction of organizations, alteration of supply chains, and the search for alternatives to replace them. The process this entails is fundamentally different from the ones required when changing something, or to start doing something new. Each action type requires a different management approach, investment outlook, organizational structure, etc.

Each of these types of actions has a few phases that can usually be identified and managed. When mapped, these phases help to narrow down which aspect of the action requires the most attention. Example phases for each action are:

Change actions
› Identification
› Optimization

Start actions
› Experimentation
› Acceleration

Stop actions
› Reduction
› Phase out

Replace actions
› Implementation
› Institutionalization
› Stabilization

We recommend clearly identifying the various actions of change in the roadmaps and action plans. You can implement this as a separate mapping phase in the roadmap creation process. Understand that this process brings along a different set of skills, knowledge and process. For example, when discussing the process to start doing certain new things, having an experienced entrepreneur present is of value.

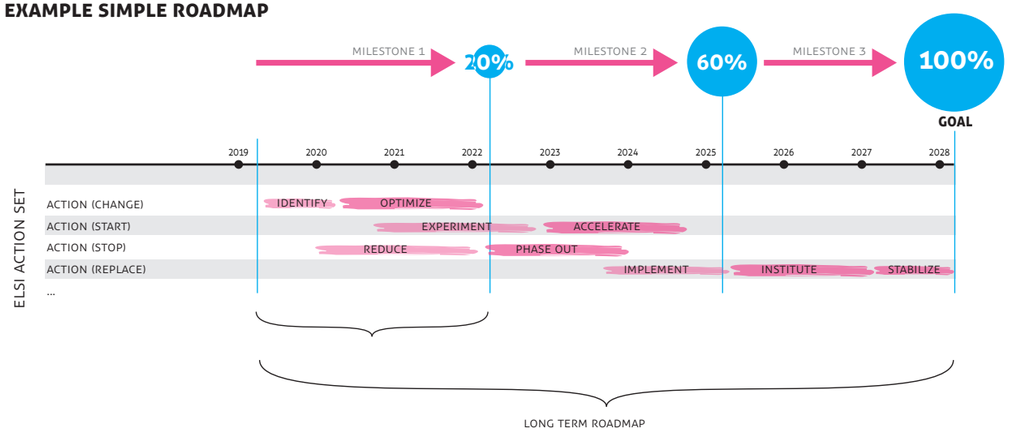
TRANSITION MAPPING

In cases where transition itself is the main challenge, it is useful to map the transition state and process. Doing so allows you to identify ways to accelerate and improve the transition, by then mapping the ideal transition path, and implementing changes. Let's have a look at a great tool to do exactly this.

DRIFT TRANSITION MODEL

The Dutch Research Institute for Transitions (DRIFT) has developed a great model to identify the different phases of a transition. The DRIFT model is useful to help map, analyze, and optimize a transition pathway. A simple diagram of the model is shown on the left. After this chapter, we show an example of a DRIFT analysis on the transition of the fashion industry, using this model. In this approach, actions can be developed in the SiD Method cycle that focus on the desired transitional phases.

EXAMPLE SIMPLE ROADMAP

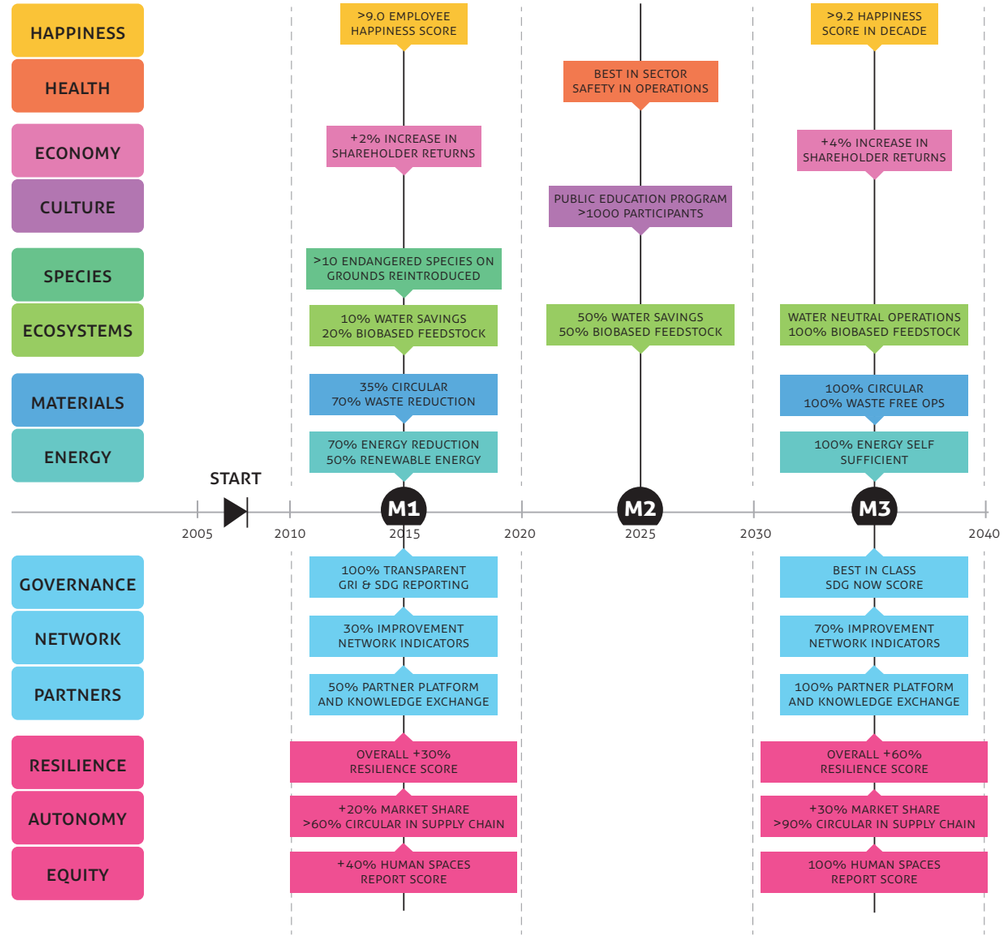


MAP THE ACTIONS IN A ROADMAP

In the method section we discuss a detailed step by step approach to making a roadmap. We put all these actions along a timeline, which shows our long term goal, the intended impacts in our ELSI indicators. For example, see the simple example above. When you're making the roadmap, in the light of understanding transitions, identify those actions as being part of one of the transition actions. This helps to determine how to execute them, and set up proper phasing for each.

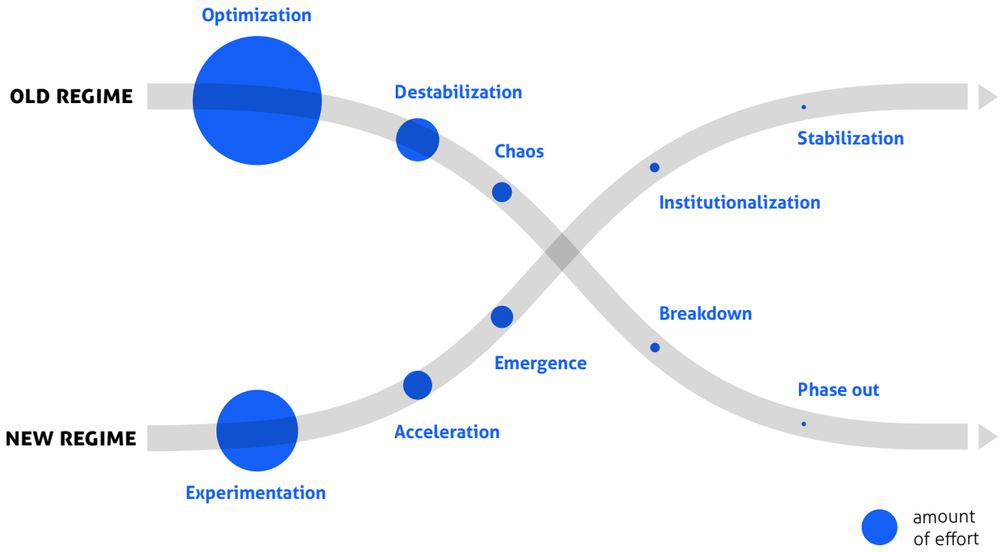
ROADMAPS PREVENT SYSTEMIC LOCK-IN

Working without a roadmap leads to high risk of systemic lock-in. Systemic lock-in is a situation in which a decision is made that locks the system's development pathway in a fixed direction for the future. For example, choosing to invest in a certain machine only accepting input resources of a certain type, locks in the need for that resource for the direction of economic write-off of that machine. For a machine, the example is simple. However, systemic-lock in can occur in more obscure, hidden areas. Working with a roadmap towards 100% systemic sustainability performance helps prevent these lock-ins. With each solution step on the roadmap, we take into account the final goal of our pathway. If a solution leads to lock-in further down the road, that becomes obvious in the pathway to follow. For example, if our goal is to achieve a truly sustainable society, we may invest in a nuclear fission power plant to achieve a CO_2 emission milestone. However, because nuclear fission plants are a form of non-renewable energy, nor actually CO_2-neutral, they may prevent us from reaching a longer term goal to provide 100% renewable energy. When planning steps and milestones, ensure that each step supports both the milestone's goal, and the greater, long term goal. We will discuss roadmapping in more detail in the Method section.



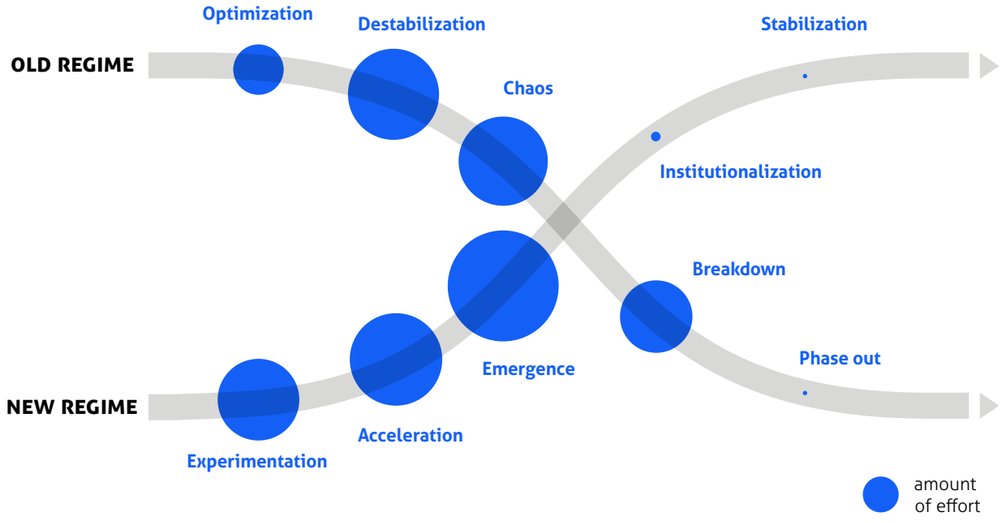
This diagram shows a roadmap that is used to show progression of goals in time for a company transition program (anonymized). This example of a roadmap does not show interventions. Instead, it tracks different levels of goals over time, communicates ambition and responsibility, as well as the intermediate milestones.

EXAMPLE: TRANSITION MAP FASHION INDUSTRY



The examples on these two pages show a 'current' and a 'desired' transition path. The examples were made by the Dutch Institute for Transitions (DRIFT) in 2018 to support the acceleration of the transition of the fashion industry, supported by the C&A Foundation's program Fashion for Good. These maps are also a great example of a before & after mapping.

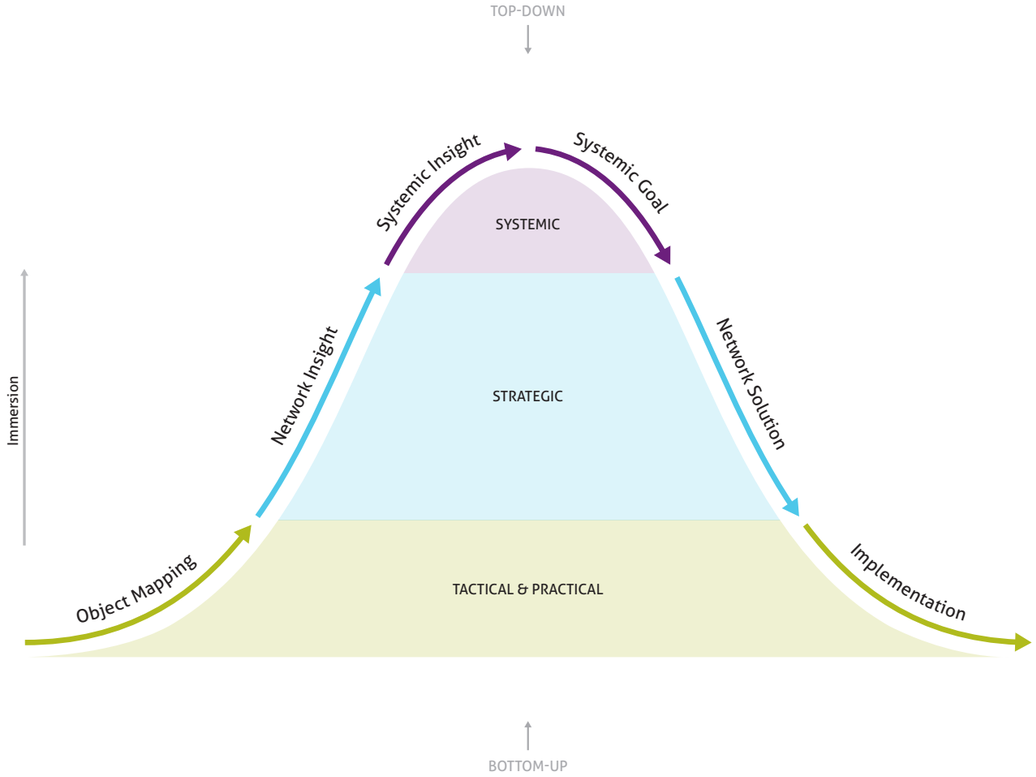
The diagram on this page shows an analysis of the current transition of the fashion industry. This process can use optimization and acceleration.



This map shows a suggested improved transition. Using the insight from this map, new actions, focus and programs are derived to boost the transition of circularity in the fashion industry.

Read the full case study by DRIFT on the transition of a circular fashion industry here:
https://drift.eur.nl/cases/mapping-the-transition-to-circular-fashion/

drift for transition



1.5.3 SID PLANNING

How do you plan for the future? An analogous situation to the systemic vs the object-oriented perspectives exists in the area of planning: do you plan top-down, or do you allow planning to surface bottom-up? This question has been the subject of much debate over the centuries. This includes various topics such as city planning, national and regional decision-making, and corporate structure and governance. These issues are related, and both perspectives have merit. The most effective approach can often be found in the (complex) middle. Understanding the benefits of both perspectives allows for a new planning approach used in SiD's route-mapping and planning phase.

Let's look at the merits and drawbacks of the two approaches at the end of the spectrum: top-down and bottom-up planning.

TOP-DOWN PLANNING

A top-down planning approach allows for long term grand plans to be executed that exemplify a singular, strong vision. For example, the city of Brasilia, was planned and executed in one fell swoop. The city plan resembles a bird from an aerial view, and at time of planning it was the pinnacle of modernist urban design.

But, top-down planning comes mostly at the cost of the human scale, adaptability over time, and entrepreneurship. It can result in woefully outdated realities once completed. Brasilia, for example, is entirely built around the concept of the car, and while other cities are adapting to more public transportation, walkable neighborhoods, and decentralized transport options, Brasilia is stuck with its grand automobile era structure, with strict planning zones that devoid the city from life.

Another example is in corporate governance. A company that's organized in a top-down fashion is characterized by a strong hierarchy and centralized responsibility. This means that the major decisions are made at the top, while at the bottom people simply execute orders. This allows for long-term plans with a strong vision about the direction of the company, allowing a singular powerful idea to be executed with precision and force. If the organization has a clear goal, and doesn't demand a significant change to successfully continue pursuing that goal, this can be an efficient machine-like organizational style.

On the other hand, because the execution workforce only follows orders, there's little space for flexibility when things don't go as planned, reducing resilience. Ideas from the bottom don't make it up to the top, stifling innovation and reducing the capacity to optimize efficiency. In addition, this style of governance doesn't tend to keep the interest of motivated, driven employees for long, who desire a degree of autonomy and influence. Surely, most organizations have implemented some feedback-loops where employees may suggest ideas and help to give some guidance to the governance of the organization. However, this doesn't change the structural nature of the organization.

BOTTOM-UP PLANNING

A bottom-up approach is structured in a way that the people that make up the users, workforce, or otherwise 'bottom of the pyramid' are given the autonomy to define the direction and structure of the whole.



Bottom-up planning stimulates entrepreneurship, private initiatives, small-scale quality, community engagement and allows for healthy local economies.

Bottom-up planning is a less common organizational structure, because historically we've evolved with predominantly hierarchical top-down planning. In a sense, democracy is an attempt to give 'power to the people', and an example of bottom-up planning. However, as any well-informed reader knows, very few democratic systems can be called efficient, or succeed in establishing a fair distribution of power. This is, to a degree, because most democratic systems have evolved from top-down governance structures such as kingdoms, and have retained much of their structural, centralized form.

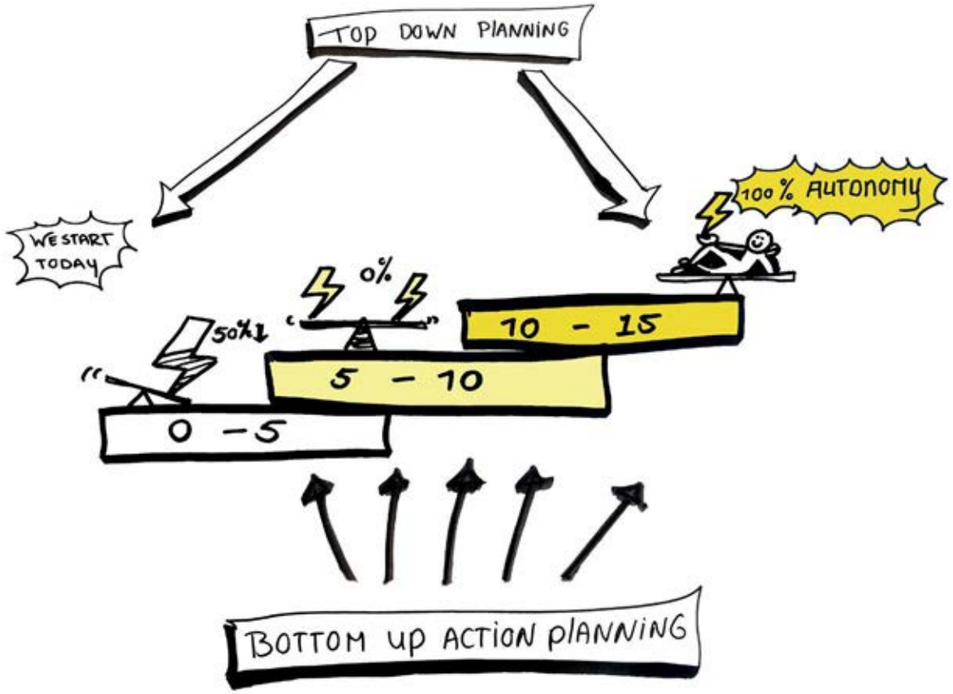
True bottom-up governance requires a high degree of engagement of the population (more than just a poll every few years or so), in combination with self-actualization. This means that members of such a structure can not only suggest changes, but can actually join in their execution. Governance, in essence, then becomes the result of the collective actions and decisions of the whole. This extreme bottom-up governance doesn't have a singular direction and purpose, so it may seem chaotic. However, it's more flexible and capable of dealing with sudden shocks and crises than top-down planning's rigid nature. That's also one of the reasons why, when a great catastrophe takes place, people fall back into a more anarchistic bottom-up mode of operation. They take matters in their own hands until some form of equilibrium has been established.

Areas where bottom-up planning has been entirely implemented with some degree of success are usually executed in 'free-zones'. These are areas of land that have been exempted from normal regulatory frameworks and with an 'at-your-own-risk' policy. These areas enable a high degree of local initiative to flourish, enabling thriving local communities and urban environments resembling the old European medieval city centers in scale and diversity (which is often the point). This approach seems feasible and even highly effective to initiate and also rejuvenate urban areas that are limited in size.

For corporate structures, bottom-up approaches have become more prevalent in the last 20 years. Many thriving companies have started out as flat-hierarchy organically planned organizations. The development of self-regulating planning for software development such as SCRUM and AGILE has also had its effect on the ideas about how these organizations are run, giving rise to many successful (and unsuccessful) organically planned IT companies and creative agencies. These organizations have a few traits in common. They empower their people, allowing them to attract and retain high valued individuals. They make room for personal initiative, driving innovation and creativity. They often have a profit-sharing system in place, rewarding all members of the organization to benefit from a job well done. They are fast to respond to market opportunities and can make sudden large changes in strategy.

Downsides to bottom-up organization structures are that a strong organizational vision is hard to maintain. Also, efficiency in executing large, singular projects governed by bottom-up planning tend to be quite low. Quality can also be a concern, and for projects where the success of the whole can be critically endangered by a single person, the risk is very high. This is the reason why for highly technical developments a hierarchical command structure is almost always implemented. Also, when organizations grow beyond 30 people or so, some form of hierarchy is often implemented, or sometimes even self-developed. People concerned with daily tasks simply don't want to be bothered with corporate decision making on a daily basis, and vice versa. A smart solution to this conundrum is to cell-divide the organization once it gets to a certain size. This retains the qualities of bottom-up governance in an organization, while allowing autonomy to all the cells with the power of limited-domain hierarchies.

As we can see, bottom-up planning tends to self-construct hierarchy, and top-down planning tends to break down and require into bottom-up initiatives to survive and flourish. This process is a natural tendency for organizations to find an equilibrium between these. That's why SiD uses a planning approach that doesn't start with one or the other. It consciously combines them, gaining benefits of both, while reducing their pitfalls. In the next section we look at how.



SYMBIOTIC PLANNING

SiD's planning approach applies the strength of top-down planning by using long-term goals and development boundaries in a roadmap. It then fills in that roadmap with bottom-up short-term initiatives in short cycle action plans. This results in a planning approach that resembles game-theory planning. In game-theory, you set rules and boundaries (top-down), and then let the system run and develop itself (bottom-up), while providing incentives to steer the process (running management). Both bottom-up and top-down perspectives are present. This approach does require initiation of both a top-down systemic strategy process, and a bottom-up stakeholder engagement process, at the same time.

THE PROCESS IN A NUTSHELL

We start the planning by setting long-term systemic goals. These long-term goals are expressed in terms of performance only, because we can't predict the future. We set the goals on a timeline, and they may ramp up over time (e.g. 50% energy reduction in 5 years, energy neutral 10 years, energy autonomous 15 years). Performance boundaries (rule-sets) are added to this. They prevent development going into areas we don't want, and stimulate the direction we do want to go in. Then, we find a mechanism to create the bottom-up development within those performance boundaries. Where necessary we initiate a 'feeding mechanism' of incentives, which attracts bottom-up development and kick-starts the process. Lastly, a monitoring system is implemented, to ensure that the performance set as a goal is the performance that's achieved.

It is imperative that the goals and boundaries are set on a performance basis, and not have any unnecessary physical constraints. We want the bottom-up execution process to be able to maximize its movement space to find ideal solutions. We go into detail about how set goals and boundaries in the 'goal setting' section of the Method chapter.

The SiD Method is an effective means to execute a SiD planning approach. We perform a systemic analysis to find the performance goals and boundaries in the goal setting stage (top-down), plan these goals on a roadmap, and engage the community to discover the initial execution steps (bottom-up). We develop these first steps as well as a set of incentives to stimulate the process.

The entire process can be executed with an organization or community, to arrive at a truly democratic process. The subsequent execution can respond to changes in context, newly available technologies or innovation, and can continuously make space for new initiatives, ideas, and development pathways. In this way, the SiD planning trajectory combines the best of both worlds: a development and governance plan that has a long term vision, is resilient and flexible, and that has space for personal initiative. In the method section on road-mapping we discuss how to practically set up such a SiD planning trajectory.

CASE STUDY: SYSTEMICALLY FIGHTING GLOBAL DISEASE

By Claudia Nieto
Healthy Living Initiative Coordinator , Tropical Disease Institute, Ohio University



SYSTEMICALLY FIGHTING CHAGAS DISEASE

The Ebola crisis of 2014 illustrated that a disease epidemic is an ever-lurking danger to society. It showed us that collaboration between a wide variety of layers of society is necessary to prevent them, from aid workers on the ground to local leaders, governmental entities, and transport authorities. This signifies a growing demand for systemic approaches to disease prevention that address the emerging levels of communication in a globalized world. The demand for non-medical disease prevention programs is not exclusive for Ebola. Other persistent diseases require similar approaches, and a systemic analysis benefits the efficiency of any epidemiological inquiry. To combat an infectious tropical disease known as Chagas disease, the Tropical Disease Institute uses systems analysis to find more effective prevention programs.

All people are connected through infinite interactions in our personal behaviors, community life, and social existence. Infectious diseases can use any or a number of these connections to be transmitted. The category of Neglected Tropical Diseases (NTD) is a concrete example of these dynamics. NTD refers to a group of seventeen diseases that have particularly impacted disenfranchised populations. Outside of medical factors, they show that geographical, economic, and cultural factors add up to the spread of these epidemics. These include populations' limited access to health services, absence from political participation, and lack of economic power. These factors create a particular and complex net of risks that place socio-economic dynamics at its core.

NTD control programs are different to single objective treatments traditionally proposed by biomedical approaches to disease prevention. The programs are required to understand disease dynamics in the context of the social, economic, and political factors in which the disease lives. This means to look at individuals and communities beyond biomedical risks, to analyze their life conditions, and propose prevention programs that respond to the actual living conditions of the population at risk. NTD compels us to avoid reductionist perspectives focused only on directly fighting diseases, and forces us to look at the root cause of the spread of the disease, including a societal factors that are causally related to disease infection. Systemic research shows that these typically include social justice issues such as poverty and 'neglect'. This expresses the need for recognition of human suffering and potential even in the context of disease prevention. In this context, reducing the distance between neglecters and neglected is not only a strategic priority but also an ethical imperative for scientists, program designers, and researchers.

Chagas disease is an infection disease affecting around 8 million people worldwide that often leads to death. It is caused by a parasite called T. Cruzi transmitted by the feces of infected triatomines bugs that infest the walls, roofs, and floors of poorly constructed houses. These bugs infect people while they are sleeping. There are no vaccines to prevent the disease, and current treatment drugs have serious side effects. Because Chagas is a disease mainly caused by the living conditions of impoverished populations, it is crucial to understand how these living conditions are determined by the structural causes of poverty.

We have used systems analysis to approach social dynamics in the design of a Chagas disease prevention model for rural communities in southern Ecuador. First, standard socio-economic indicators such as income levels were used to map potential populations at risk. To these we applied asset and network mapping to create insight into their daily lives. This analysis identified existing knowledge embedded within daily behavior, among certain populations that combat the occurrence of the disease. This approach allowed us to identify local definitions of health and wellbeing that do not necessarily match academic and technical concepts, but that more drastically determine people's actual behavior and practices. However, these traditional methods have varying degrees of effectiveness. By combining the knowledge of the scientific community with these traditional methods, more effective treatment approaches have been proposed. These treatments not only directly attack the disease, but combat its preconditions, such as poverty.

Our first efforts to apply systems analysis to disease prevention were done in an intuitive fashion. As the next step in the process of adding methodological rigor to our analyzes, SiD's framework can be particularly useful. It can be used to more systemically organize and restructure the dynamics identified in particular living environments. By connecting the pieces under the logic of systems' autonomy, resilience, and equity, a universal framework is created that can be used to collaborate among practitioners both on the ground and in research. Subsequently, SiD can be used to provide program designers and communities with approaches that can be sustained by local populations once external interventions have finished. Consistent with this idea of sustainability, SiD's approach can also help us to make visible the structural causes of poverty and its impact in the actual wellbeing of individuals and communities beyond disease control. This will allow us to connect disease prevention programs to other programs present to create synergetic results in both the reduction of poverty and disease.



1.5.4 EMBRACING SYSTEMS THINKING

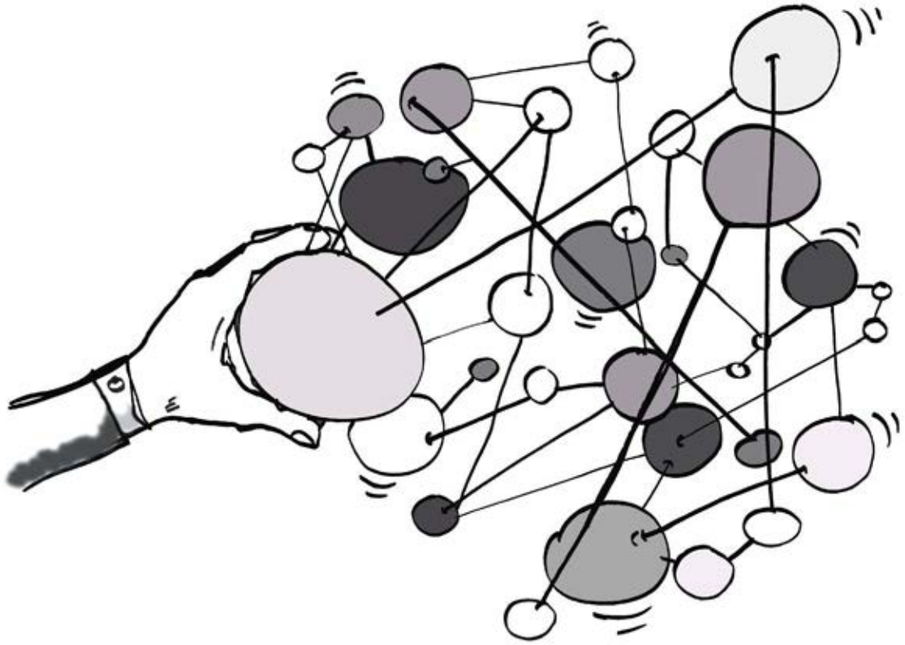
This section is about how thinking in interconnected systems helps you unravel the mysteries and opportunities of sustainable development. If you look at any object in our world, and trace its history and connections, you'll see that it is an interconnected part of everything. This is obvious for natural organisms that emerged from evolution over eons of time, but it's equally true for all elements in our society. Everything is a part of a larger, interconnected system. Our economic system affects everything in our daily lives. At the same time, our world is fed through natural systems, with oxygen, fresh water, and sunlight through the resources that have supported humanity since the dawn of time. In other words, everything is a part of a more extensive, interconnected system. Learning to think in these systems, and seeing where they intersect, enables new avenues of discovery that help to resolve the issues of our day.

The past has told us that ignoring the systemic effects of our actions leads to unforeseen effects that cause more harm than their original intent was. DDT, leaded gasoline, CFK's, sub-prime mortgages, and countless other examples, were all introduced as a great solution for a specific object-oriented problem. Not much later, each one of these threatened the very fabric of our society. These were all due to inconsiderate object-oriented development that did not take into account the complexity of our world. A shocking realization is that some of them could simply have been avoided, even with the knowledge available when they were conceived.

Investigating and understanding the complexity of our world is not only necessary to prevent bad things from happening. If we harness it in our development and genuinely engage it, then we can develop more viable, exciting, and beneficial solutions than most developments to date. The complex network that is our world offers a majestic amount of opportunity that only needs to be tapped into to benefit from.

Nature, for instance, is a complex system that predates our society for millions of years. Throughout its evolution, it created solutions for a vast array of problems. It's been only recently that we've made a significant move to learn and integrate the knowledge natural systems embody to develop solutions for humanity (using biomimicry, for instance, see the tools section). From the communication and organization systems ants use, to the functioning of cells within our own body, and the way nature recycles its energy and resources, this natural knowledge base is one of our most valuable resources. Nature has achieved this by facing complexity, and using every nook and cranny of its 'solutions space' to its advantage. Similarly, we can follow its example.

Likewise, we see new developments that make use of the power of networks and exponential growth to reap great benefits. Take a look at Google. Using a set of very simple services it taps into and utilizes the complexity of human knowledge, with only a fraction of the resources it would cost to do this using books, libraries, and magazines. Or look at the Open Source software movement, with products such as Linux, which is the most prolific and advanced computer operating system on the planet, available to anyone for free. The Open Source movement has harnessed the increasing creativity and knowledge of millions of people around the world, to create countless powerful tools for human



development in merely a few decades. Embracing complexity has a lot to offer, but is, as we'll see in the next paragraph, not yet embedded in our default way of thinking.

REFRAMING OUR THINKING

When we are young, the people around us teach us the languages and cultures we end up speaking and living. We know that language is an important aspect of our mental model of the world. The way we think is also a 'language', taught to us when we are young, just like how we speak and how we act.

Typically, especially in the modern western world, we are taught to think in an object-oriented way. We first give names to things, like tree, cup, person, and sky. By doing so, we distinguish objects, and separate one thing from another. This way of thinking is vital for our survival as biological creatures (for example, water behind a hill, tiger left of the tree, etc.). However, it is just one way of deconstructing the world. This object-division reality is not necessarily the only way, or the right way, to mentally reflect reality.

Some other mental models see the world in a way that everything is connected as one. That there is no difference between people, nature, and other things, Such models include the ancient Greek philosophical school of Eleatics, some parts of Buddhism, or even some astrophysical theories. Nevertheless, most language in those cultures and ideologies are still based on object-divisions. Again, logically, because this is how learning has evolved.

While considering that 'everything is one' is perhaps true on a fundamental level, it does not necessarily help us to move forward. If everything is one, where do you start doing anything to improve the situation you find yourself in? What even is 'you' in that way of thinking? That's quite the conundrum and can get you stuck quickly.

Out of SiD comes another way of thinking, which is useful in the time we live in right now. SiD's system-thinking model allows you to think in relationships rather than objects, and form an impression of a whole system with objects and relations combined in systems. Objects are still there, and give familiar footing, but SiD places more importance on the connections between objects than on objects themselves. It does this because it is relationships that create change and movement, and are the core of what matters in our age. Objects, one can say, are just a result of the dynamics of systems; they are symptoms, and rarely causes. Objects are inert, rarely of significance themselves. A focus on relations makes a mental shift possible that opens up the doors to a new form of perception. To do this, SiD looks at things both from a holistic 'everything is connected' top-down perspective and a reductionist 'piece by piece' bottom-up perspective, and brings these two together for increased understanding, leverage and solution pathways.

We are, to a degree, already familiar with this mental model, as it appears in economy regularly, albeit not necessarily so consciously. After all, the economy is similar to doing a SiD analysis of resource flows between people, and flows are always relational. Extending this model to include everything around us, beyond value expressed in currencies, helps us find new pathways and solutions to some of the world's most pressing issues. Similarly, it allows finding stunning opportunities that were invisible because we had our 'object' goggles on.

"Let's face it, the universe is messy. It is nonlinear, turbulent, and chaotic. It is dynamic. It spends its time in transient behavior on its way to somewhere else, not in mathematically neat equilibria. It self-organizes and evolves. It creates diversity, not uniformity. That's what makes the world interesting, that's what makes it beautiful, and that's what makes it work."

- DONELLA H. MEADOWS, THINKING IN SYSTEMS: A PRIMER



Thinking in this model, and getting familiar with it, is also useful for day-to-day things. For example, if the roads in your city are clogged with cars, it is not necessarily the consequence of the level of car ownership and their use. It is more fundamentally a result of imbalances in how people and their workplaces are connected, and distributed. This includes the planned separation of living and working areas, most apparent in cities built in the last century. But it also includes relational aspects such as a such as lack of diversity and flexibility in working hours, which is forcing most people to go to work at the same time. Realizing this leads to other solutions than banning cars (a band-aid solution), such as efforts to support working from home, making more flexible work hours possible, or, on a planning level, diversifying urban planning policies to have more mixed living and working neighborhoods. This is far more effective than investing in infrastructure 'objects', or, even more object oriented: replacing the petrol cars with electric ones. Yes, these solutions may help a little, but they won't affect the core reason the problems are there in the first place.

SYSTEMIC GOALS

When applying the SiD method, the systemic way of thinking immediately surfaces in the first step: goal setting. SiD requires the main goal of any project to be set at system level at all times. This forces the team to consider the root intent of a project. This has significant impact on the perspective of a project, or the purpose of an organization, often leading to renewed insight from the start.

For example, a city government approached us to help them "make the public transport system sustainable". They had already worked out many detailed interventions. These included things such as how to make the trams more energy efficient, how to collect energy from solar panels on bus shelters, and how to use non-toxic materials in their canteens. These though, are all object-related aspects, and besides these object oriented interventions, they were stuck. But they knew more could bed one. At the start of the SiD sessions, during the goal setting, we reframed the goal on a systemic level. The goal of the project shifted from 'to make a sustainable transport system', to 'make the city more sustainable using the public transport system'. This reframing shifted the focus away from the object, the public transport system, which is merely a means, to the actual end, which is a sustainable city. This shift caused the team to start thinking differently entirely. The focus moved to what positive aspects the public transport system could achieve for the sustainability of the city, rather than just looking at the public transport equipment itself. This lead to groundbreaking insights, and several interventions that greatly improved the resilience of the city. An example was to improve resilience by increasing the operational timeframe of the trams during the calamity of flooding. When there's flooding, you want to move people as fast as possible out of the area. Every hour of extra operational time of the public transport system helps to get people out of the affected areas faster. Looking into this, we found this could be achieved for little cost by raising the transformers and some other critical points of infrastructure by a few centimeters. This then also led to lower maintenance cost for things like the occasional local drainage overflow, which happens frequently. They could also receive support from the city to do this, resulting in a real win-win.

EXAMPLE: BUZZ WOMEN

Population growth is the most significant systemic driver of virtually all negative sustainability impacts, including the climate crisis, resource depletion, land shortages, biodiversity loss, and more. How do we curb population growth? That is a hairy subject, convoluted in discussions about personal freedom and ethics. It is notoriously difficult, just observe China's one child policy and its effects. Within this complexity, is there anything we can do to curb population growth? Yes we can. Buzz Women is a project that on the surface provides a crash course in financial management for women in rural parts of India. Meanwhile, systemically, it has powerful long term effects in limiting population growth, while providing better quality of life for hundred of thousands of women in developing areas.

Buzz Women started in 2012 when Dave Jongeneelen, a Dutch social entrepreneur, wondered how he could share his leadership knowledge with those that had no recourse to them. At the same time, Suresh Krishna, a pioneer in the field of Micro-finance industry, wondered how he could positively affect women in a developing society. They decided to work together and were joined by Uthara Narayanan, a social worker wondering how they could lift people out of poverty. The solution they came up with, called Buzz Women, has gone way beyond those first ambitions. It impacts generations of people directly and is rippling through the system for centuries to come, on a global scale.

HOW DOES IT WORK?

Like most systemic interventions, Buzz Women's approach is deceptively simple. The program, for now, runs mainly in India. A trainer goes into a small bus, drives through the countryside, and finds groups of women interested in improving their future during two half-day sessions. A week apart, they share knowledge, experience, and tools on financial management, entrepreneurship, and personal development. After the training, each group of women chooses a leader from among themselves. This woman becomes their 'anchor'. This Buzz anchor then guides the rest of the group during a three-year-long handholding programme for behavioral change, and sustainability for the future.

The Buzz anchors are supported during this journey by the organization with various forms of counselling, knowledge tools, regular updates, communication, and a fellowship. The program offers a lot, but one of the things they do not provide are solutions. They share knowledge, experience and tools, but solutions are things that the women have to develop themselves. The result is independent, resilient, and equitable change, in one of the areas where it has the most effect. Over 150.000 women have been reached in this way already.

During a chat with Dave about the program, he told me: "The other day, one of the first women we reached with the program came up to me. She handed me 500 rupees [~ €6/7$]. She said: 'Here you have the initial investment back it cost to train me. Take it and use it to train someone else.' This significant moment signalled the beginning of the system, starting to fund itself. It was amazing to experience."



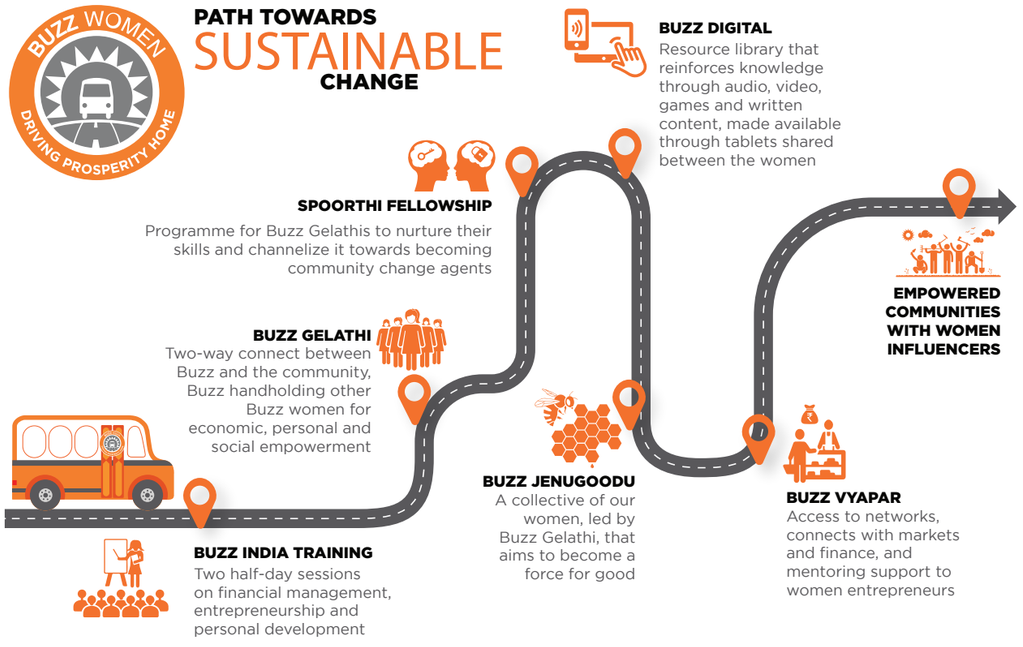


Diagram by Ranjini Sivaswamy

PROGRAM DIRECT IMPACT

The program has a direct, measurable, and significant positive impact of the lives of the women, and their families. The Buzz Women impact report lists an average 115% increase in savings with all women. 20% of them started new businesses, 9% expanded an existing enterprise, and 95% stopped borrowing from moneylenders. 81% of the women said they reached their set goal. Those are impressive results from a comparatively lightweight program. However, these are not yet systemic effects, which are a magnitude higher.

PROGRAM SYSTEMIC IMPACT

To understand what's happening, we have to understand a bit about population growth. In 2014 a United Nations analysis concluded that we're heading to a global population of between 9.6bn and 12.3bn people by 2100. A majority of scientists agree that this is a tremendous strain on all our resources. It is the largest direct driver of resource consumption, land use, pollution, and even aspects such as immigration, crime, biodiversity loss, and societal stress levels. In subsequent systemic research, a main systemic driver of population growth has turned out to be female education.

The exact reasons as to why female education drives down birth rates are not known (as is usually the case with systems effects). Jongho Kim, a researcher at Ajou University and IZA, lists three main contributing factors: "(1) the relatively higher incomes and thus higher income forgone due to [women] to want fewer children. The better care these women give increases their children's human capital and reduce the economic need for more children; (2) the positive health impacts of education, on both women and their children, mean women are better able to give birth and children's higher survival rate reduces the desire for more; and (3) the knowledge impact of education means women are better at using contraceptives. "

Research suggests that educated women have half the amount of children that uneducated women have. If the program reaches 50% of females in a population, it can reduce population growth by a staggering 25%. Also, by educating women, it increases community resilience, drives up autonomy, and has vast harmony effects; which are sustainability in its purest, long term form. It does this primarily through the network parameters of connectivity and awareness. As a result of this systemic effect, the Buzz Women project is one of the most effective drivers of reducing environmental impact and biggest boosts in actual systemic sustainability that can be achieved. While initially not directly intended as such, this mechanism of global systems change has become a motivating drive of the founders. This has boosted their desire to ramp up the program's reach, and also spread it into other developing countries.

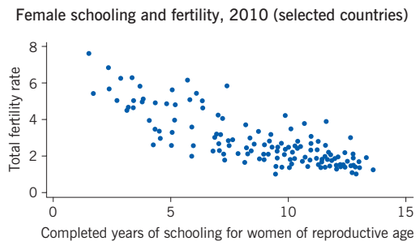


Diagram by Jungho Kim, / IZA, Germany, "Female education and its impact on fertility", February 2016

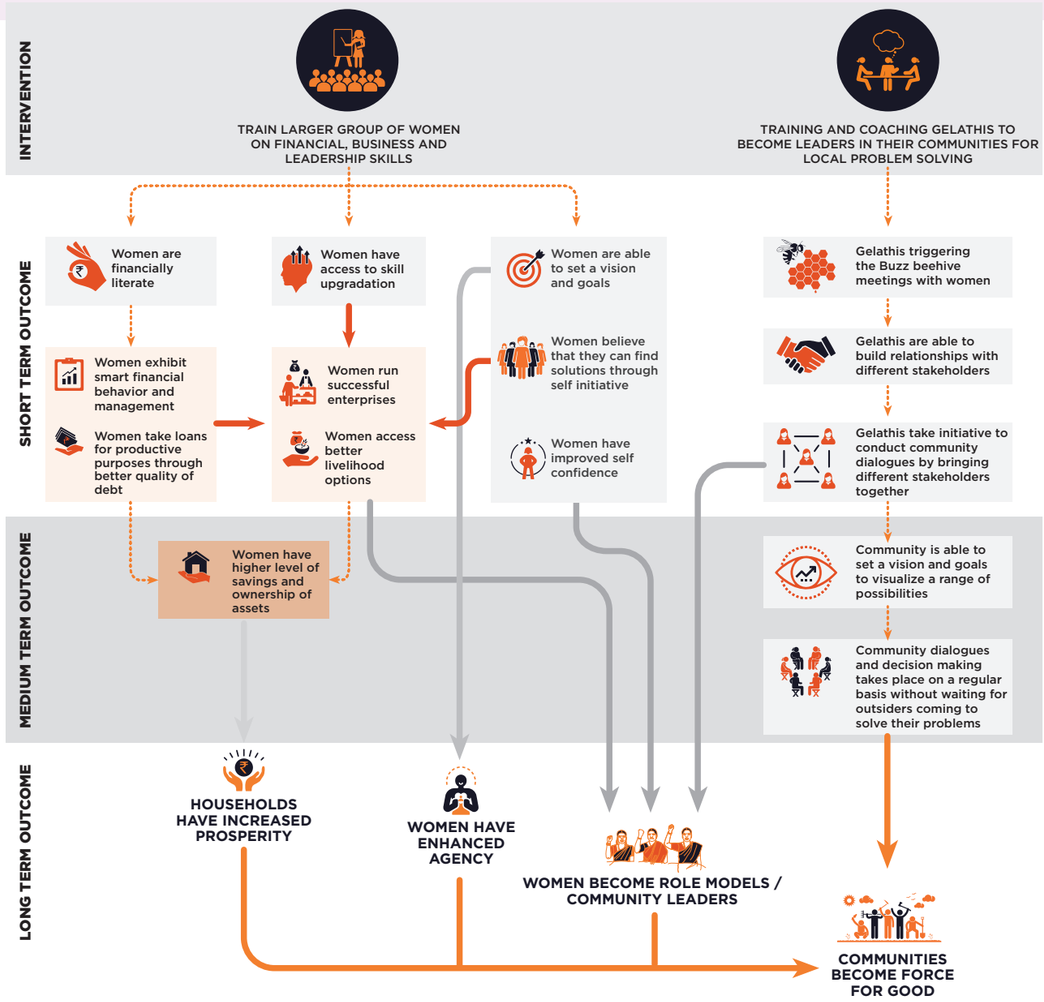


Diagram by Ranjini Sivaswamy

A few guidelines for sustainable systems exist, which help look for optimization strategies. Some of these are more developed than others, and they vary in their applicability. All are a great source of inspiration and insight. Below a few are listed, with more info about them in the tools section.

TWELVE LEVERAGE POINTS TO INTERVENE IN A SYSTEM
Proposed in 1997 by Donatella Meadows, regarded as one of the great contributors of classic systems thinking (bottom-up). These guidelines help to navigate complex reductionistic systemic challenges. While somewhat dated, they still provide a great resource on classic systemic thinking and intervention. Ordered from most to least powerful, you can use this list when hunting for ways to improve your system challenge. *See Section 4.18 in the tools section, page 445.*

FRAMEWORK FOR STRATEGIC SUSTAINABLE DEVELOPMENT (FSSD) / THE NATURAL STEP
Dr Karl-Henrik Robèrt developed the FSSD framework, now supported by the Natural Step organization. FSSD is useful to help with setting goals, using its four-element success conditions for a sustainable system. Other FSSD tools may be helpful in SiD processes, and they can be used in conjunction. *More info on page 425.*

12 PRINCIPLES OF GREEN ENGINEERING
Developed by Paul Anastas and Julie Zimmerman from the principles of green Chemistry, the 12 principles of green engineering are an inspired set of guidelines that will help anyone polish their thinking on systems optimization. While not connected to or based on a larger framework, the guidelines are practically applicable in many different contexts. *See page 415.*

THE BLUE ECONOMY PRINCIPLES
Developed by Gunther Pauli, the blue economy aims to be a practical framework for design and engineering, and as several other movements rest on a series of principles as its working method. They are useful for anyone working on physical design challenges, mostly concerning questions of autonomy, including closed-loop material and energy cycles. *See page 431.*

THE BIOMIMICRY PRINCIPLES
Initiated by biologist Janine Benyus, the Biomimicry framework is an approach that seeks to learn from nature's intelligence as guidelines for design practices. The ten principles are abstract and on a high level, useful for anyone working on practical design challenges. *See page 429 in the tools section.*

THE CIRCULAR ECONOMY
Principally supported by the Ellen MacArthur Foundation, the Circular Economy brings together various communities for practice around the recycling of materials and closing of material and energy cycles. The Circular Economy principles are widely adopted and can help to support various challenges concerning autonomy, including closed-loop systems. *See page 435 in the Tools section.*

1.5.5 SYSTEM OPTIMIZATION GUIDELINES

Now that we have a model for analyzing complex systems, both top-down and bottom-up, we can discuss interventions to improve the performance of systems. Finding these interventions is a skill, requiring insight into the system in question, and consideration of the possible effects of an action, and the associated system dynamics. The SiD method is specifically designed as a practical approach to do this, explained in the next chapter. Improving and optimizing systems is, therefore, mostly the focus on the entire next chapter. However, several rules of thumb are essential to consider in the process of applying SiD on a theoretical level. We take a moment to reflect on these here.

KNOW YOUR FRAMEWORKS

There are several systems design and optimization guidelines available from experiences sources (see left). We've included a few in the tools section. The instructions below are from our own experience and can be combined with others.

SYSTEM LEVEL OPTIMIZATION TIPS

GENERAL

1. A sustainable system is a system that is highly resilient, sufficiently autonomous, and entirely harmonious.

2. All systems, like all organisms, will eventually go into decline and perish. Plan knowing that all things come to an end, make the path healthy and long, and the ending a graceful one. Planning for eternity will lead to fragile, corrupted systems.

RESILIENCE

3. Plan for Resilience instead of growth. It lasts longer and returns more value in the long term for all stakeholders. Growth-oriented systems are fragile.

4. Rely on natural systems over technical systems. Natural systems bring numerous positive side effects, self-heal and adapt. Thus, they are inherently more Resilient than technical systems which always have adverse side effects.

AUTONOMY

5. Plan for autonomous systems as much as possible, without harming the Resilience and the Harmony of the system.

6. Plan for full Autonomy of all short term, critical resources (water, power, food, etc), and scale up Autonomy scale from there. Don't focus on full Autonomy for non-critical resources.

7. When systems are not made entirely autonomous, the feed-systems of the non-autonomous resources become a critical liability and a shared responsibility between the systems that share it. Maximize Transparency, Validity, and Flexibility in the connections with these feed-systems. Also, on a practical level, it makes little sense to privatize these networks. Privatization by itself does not provide advantages in the case of highly critical life support infrastructure (power, water, healthcare). Instead, focus here on aspects such as Redundancy, Flexibility, Efficiency, and Circularity. On a Harmony level, you want this to be a shared resource (Power balance).

8. Plan systems that fail elegantly, and still have use-value when failed. Look at failing elegantly as a possible form of Redundancy. For example, compare an escalator and an elevator. When an elevator fails, you have a dead object that serves no purpose. When an escalator fails, you still have functional stairs you can use.

HARMONY

9. Plan for harmonious and equitable operations among all entities in the system. Any endangered or oppressed entity may become a rogue agent and suddenly topple the system.

10. Investments in Harmony improvements often can rally and unite groups that can work as systemic change agents for other improvement areas at the same time.

ON NETWORK PARAMETERS

11. Network parameters are not goals in and of themselves. For example, Efficiency is never a goal in itself. If a system is fully sustainable, it doesn't have to be maximizing efficiency. What we seek with the network parameters is the right mix that maximizes RAH indicators given a specific contextual situation.

ON SOLUTION DIRECTIONS

12. Not only try to reduce the negative impact of systems, but also find and maximize the size, impact, and longevity of positive impacts.

13. Double up as many positive effects as possible in a single intervention. Choose interventions that have multiple positive effects above single-area interventions, even if not all positive effects can be quantified.

14. The higher parts of the ELSI stack are more powerful to use to help motivate people for systemic change than the lower parts. However, the lower parts have a larger systemic and societal impact.

15. Combine long term goals with direct short term benefits to motivate actors, because long term goals alone do not effectively mobilize social systems.

16. Latch positive effects onto existing systemic effects to speed up implementation (piggybacking).

RESILIENCE OPTIMIZATION TIPS

Each system is different, and it's not possible to make a universal list of tips to increase the resilience of a system. However, the following tips may help in finding improvement pathways for everyday occurring situations.

Decentralize

After decades of centralization by governments and organizations around the world, we can see that in many cases, this has gone too far. Large hierarchical governance structures, logistic systems, and complex networks are often holding back the performance of the system. Decentralization is a common optimization strategy in most societal systems today. New developments in robotics and IT can often support such a transition. For example, decentralized healthcare, with more, smaller general practices, and a few specialized centres are often more efficient than several large all-round hospitals. The same goes for most companies. Decentralize units and departments to serve local demand better. For urban development decentralizing basic services such as water, waste, energy, and food production can often enhance the performance of a city. Decentralization, in terms of ownership, can enlarge the support base of an organization if those owners are engaged and involved. Public trading of stocks doesn't help, but local ownership and involvement do.

17. **Increase flexibility**
Ironclad rules are a sure-fire way to kill resilience. Replace rigid legislation and rule systems with more performance-oriented systems and allow local adaptation for particular purposes. Make rule systems that target the performance of the end result rather than prescribing solution.

18. **Prevent solidity**
Resilience is not sturdiness or solidity. Something sturdy runs the risk of being so at the cost of agility and speed. Something that is designed to be rigid and solid is made to deal with unexpected situations by withstanding blows. This will only last for so long under pressure. Something that is resilient jumps out of the way before it gets hit. For this, it needs speed, awareness, agility, and flexibility.

19. **Diversify**
The industrial revolution has implemented the monoculture firmly into our collective thinking patterns. Do one thing well, and stick to what you're good at, the saying goes. Those times are past. Diversity is getting more important than ever. Generalists are more sought after than specialists, and rapid changes in culture and demographics make many products obsolete as soon as they leave the planning table.

Diversify the way you do things, the people you work with, the situations you can respond to, the markets you operate in, the tools you use, the perspectives you can make your own, and the areas you engage with. This automatically improves your capacity to do more with less.

AUTONOMY OPTIMIZATION TIPS

In order to improve the autonomy of a system in current society, you'll see there's much attention to closing material and energy cycles. While this is not the only factor relevant to autonomy, it does capture many of the current challenges. In order to do this, it helps to draw up energy and material loop maps. In the Method section, we'll address how to make these maps further. For the time being, consider the following pointers to help map and design more optimal energy and material circularity systems:

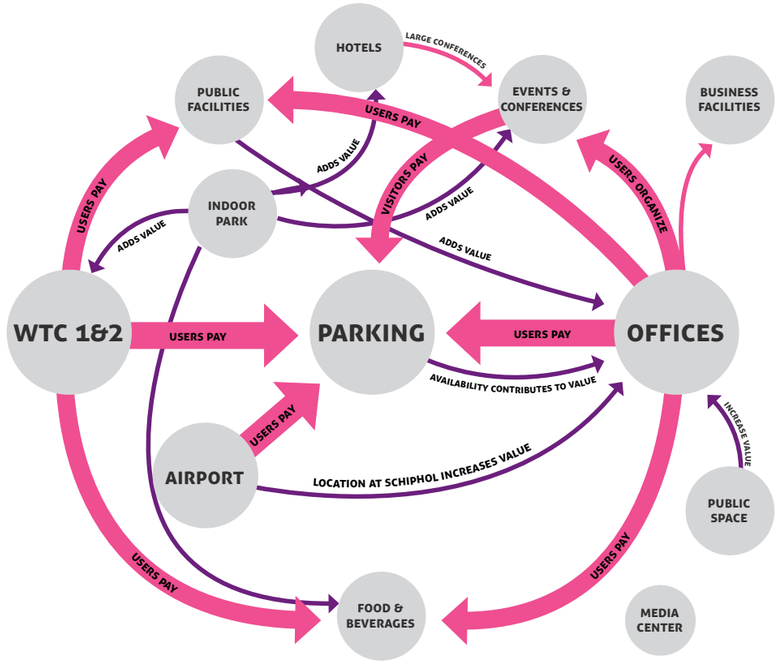
1. Create short cycles; the shorter the better.
2. At end-of-life, try to bring elements back into a value chain as quickly as possible. This means super-use over re-use, re-use over refurbishing, refurbishing over recycling, and so on.
3. Prevent unnecessary mixing or degrading of elements within the cycle.
4. Involve the entire life cycle, from conceptual-ization to design, marketing, resource extraction, production, transport, use, and end-of-life.
5. Try to use resources for various purposes at the same time, including all waste streams, e.g. if electricity is used to drive a motor, use the resulting waste heat to heat the building.
6. Involve all stakeholders along the value chain in the process from the start.
7. Create economic incentives for all stakeholders in the chain to keep waste streams separated and to close cycles, don't just rely on goodwill.
8. Embed awareness about closing cycles in education, training, and corporate strategy.

RISKS OF CIRCULARITY

It's important to note here that a circular system is not yet a sustainable system, as the SiD hierarchy should give clarity on. A system that has high autonomy through circularity is not necessarily resilient or harmonious. It's worth considering that the negative impacts of elements in a circular system increase, as their impacts multiply over time each time they go through their loop. For example, toxic materials that are looped in cycles through human systems keep doing their damage over and over. Therefore, a necessary component of circularity is to ensure the negative impact of these circular resources is as low as possible, for example, as measured on their impact on each of the ELSI categories. Some frameworks for circularity, such as Cradle to Cradle, may have their users believe that recycling hazardous materials in a system is fine as long as their use is controlled and protected (in what they call the 'techno-cycle'). This is fundamentally unsound practice, as the laws of entropy dictate that everything eventually bleeds into everything else, and the continued reliance of systems in which toxins are used should be avoided.

BUSINESS MODELS OF CIRCULARITY

It's good to understand that many elements that make circularity work (or not) are non-material. While the majority of our resources could be established in a circular system, our society has grown not to be that way. Because of value-extraction based on the tragedy of the commons, our industrial systems are geared mostly towards linear systems. The transition from these linear systems to circular ones may seem a technological or innovation challenge, but the reality shows that they are more often a challenge in governance, business modelling, and the changing of mindsets. Resources that address this challenge in a circularity that are valuable can help here, such as the book 'Circular and Business: Collaborate and Circulate' by Cécile van Oppen, Christiaan Kraaijenhagen and Nancy Bocken.



While it's most common to see the energy and material flow diagrams in relation to Circularity (as you'll find elsewhere in this book as well), making value flow maps are a useful way to find and develop integrated business models for circular projects. This example shows a value map for a circular airport parking project.

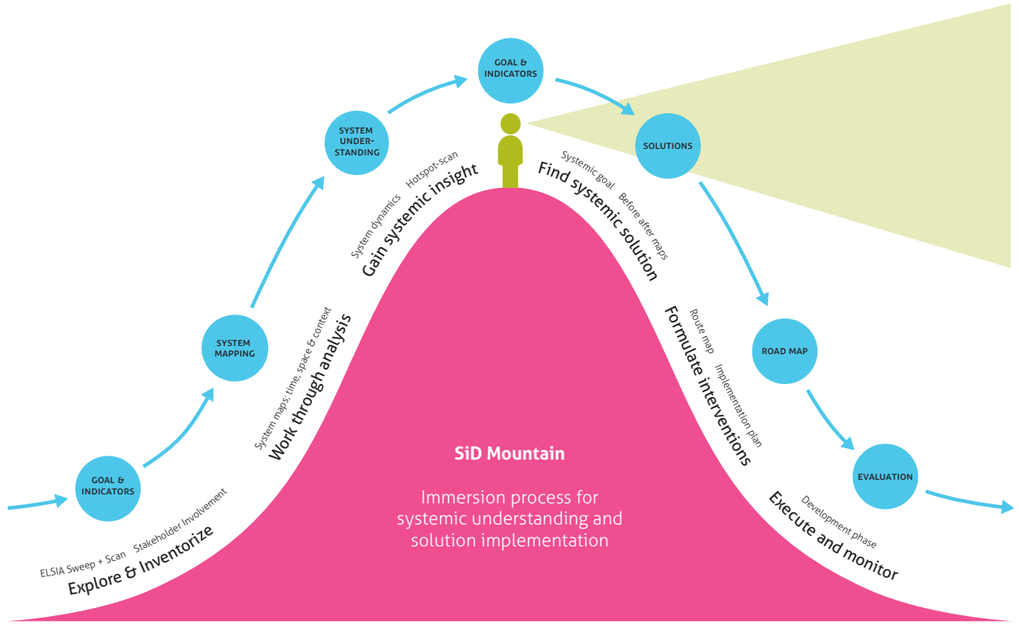
SID THEORY RECAP CHEATSHEET

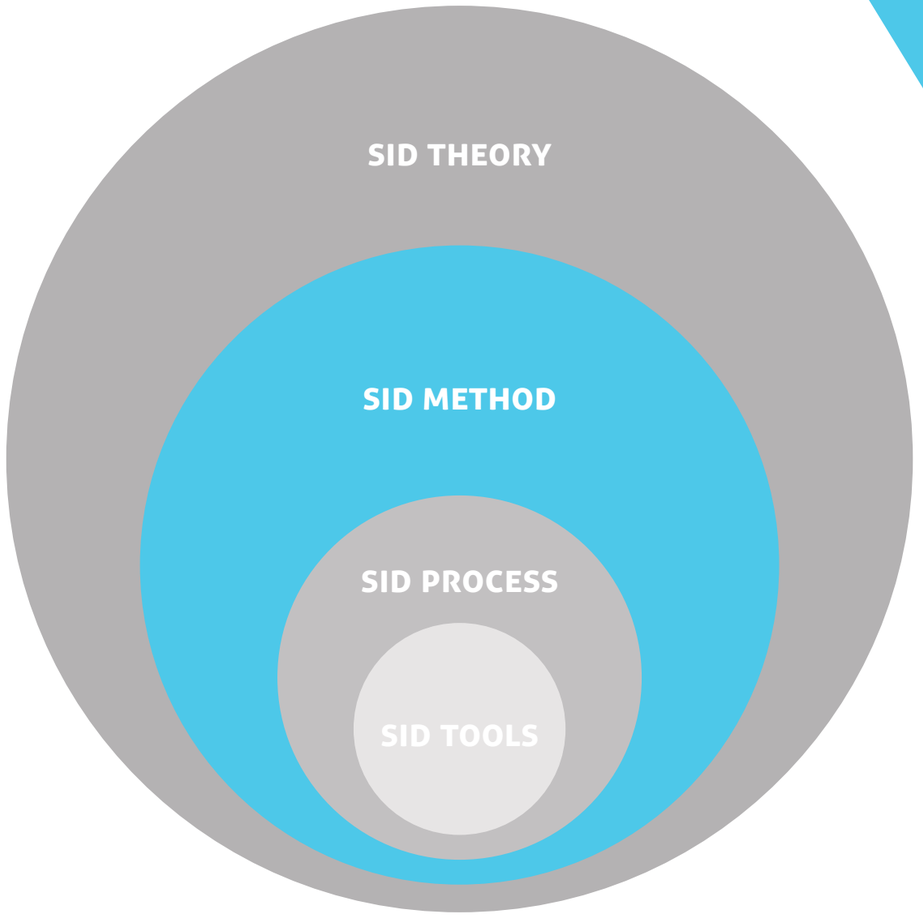
BASE PRINCIPLES

1. SiD Sustainability definition:
   "Sustainability is a state of a complex, dynamic system. In this state, a system can continue to flourish resiliently, in harmony, without requiring inputs from outside its system boundaries.
   Applied to our civilization, this state is consistent with societies powered by renewable energy and closed-loop material systems, living in thriving ecosystems on a biodiverse planet, with healthy and happy individuals living in just, tolerant, and diverse cultures, supported by open and transparent economies."
2. Systems consist of Objects and the Network. Sustainability is a system property, that is evaluated by evaluating the RAH System indicators Resilience, Autonomy, and Harmony.
3. The RAH System Indicators are informed by the Network parameters and the ELSI object indicators.
4. Always investigate in time, space, and context
5. Always investigate across scales (S, M, L)
6. Always investigate across the full spectrum (Object, Network, System)
7. Set goals on the system level, use top-down strategic planning to reach those goals, and develop a roadmap with a short term action plan using bottom-up stakeholder driven processes.
8. Map actions in a transition map, and treat them as the actions they are (Start/Stop/Change/Implement)
9. Understand and realize the difference between reductionistic and holistic system thinking, and use both strategies to your advantage.

APPLICATION PRINCIPLES

10. System level interventions are orders of magnitudes more powerful than object-level interventions. Using systemic measures gains the speed needed to overcome growing global issues, and allows flourishing in the long term.
11. Treat complex systems like organisms instead of machines; they can't be predicted, but their behavior can be understood and used to our advantage.
12. Understand complex systems in society better and faster by working with a multi-disciplinary team.
13. Climb the SiD Mountain to gain a deep, intrinsic understanding of a system, and to formulate catalytic actions.
14. Understand the properties of complex systems, and practice recognizing system dynamics in daily life.
15. Take advantage and 'ride' positive system dynamics, and be on the lookout for negative feedback loops.
16. When understanding a complex system, use both bottom-up (reductionist) approaches and top-down (holistic) approaches at the same time, and extend these into the roadmap goals and interventions.
17. Simplify that which lies beyond the system boundary, but do not externalize any effects.
18. Involve stakeholders in the process from as early as possible to gain traction fast and prevent blocking later.





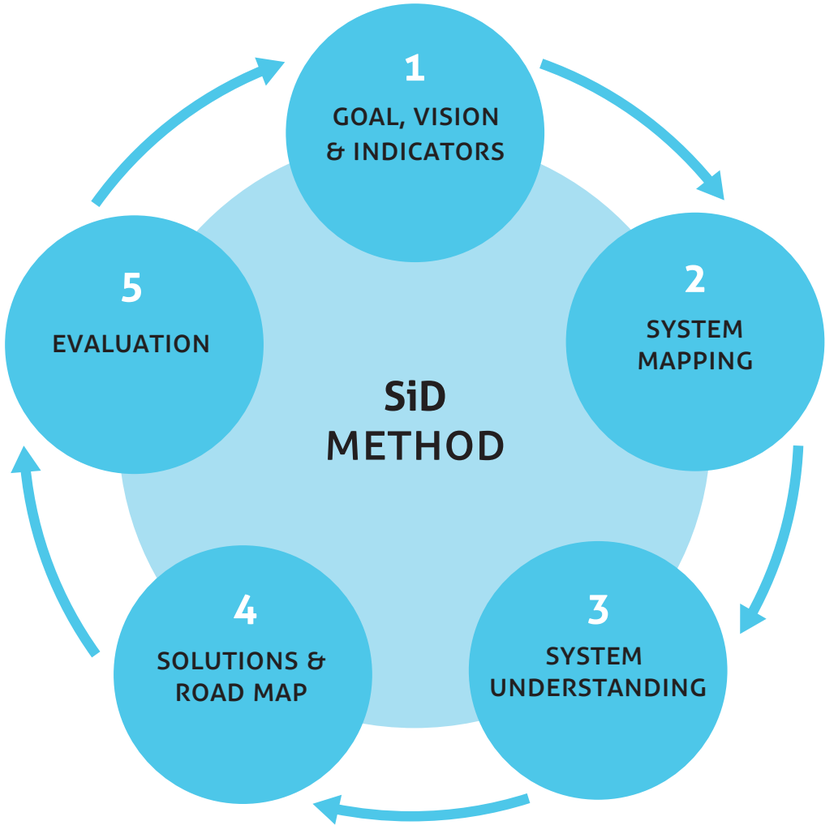
2. SID METHOD

Now that you've been introduced to the SiD theory, it's time to become more practical. The SiD method details how to take the principles of the SiD theory and use a step-by-step approach to analyze, understand, and improve complex systems. The SiD process, described in the next chapter, takes the method and offers ways to execute the method depending on a variety of different project types.

The SiD method consists of five steps. We'll give you a quick overview of all five steps first, and then look at each step in more detail.

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2.0 METHOD OVERVIEW

The SiD method is a practical way of finding pathways towards sustainable systems in five steps. We discuss the method and its steps shortly below, and in the subsequent paragraphs we detail each step separately in practice. The SiD Method is usually practiced as part of a larger SiD Process, but can also be executed on its own.

SID METHOD LIKE GOING ON HOLIDAY

It's helpful to get a good understanding of the SiD method by looking at it as if we're planning and going on a holiday. Imagine you're going on a journey to an 'ideal place', given few resources and little time. In step one of our journey, called goal setting, we think about what we mean by 'ideal place', and subsequently determine what the destination of our journey will be. When we know where we want to go, we go to step two: system mapping. In this step we investigate our environment so we can make a map of our surroundings, which will help us in plotting our route. In step three we reflect on our environment, study the map, figure out where we are, and where our destination may lie. In step four we plot routes to our destination, taking care to pass the landmarks we find important and avoiding obvious trouble. In step five, evaluation, we check if we're actually going where we said we wanted to go in the time and means we have available. Now, as you would in any journey, this process is repeated several times in the process of planning as well as being revised as you travel along, which is what we mean by an iterative process.

BETTER TOGETHER

The method can be executed by a single person, but it's intended to be used with a diverse team of scientists, designers and managers; multidisciplinary collaboration is essential to have a well-rounded perspective. The method and process work best when all experts in a process are present from the start, and to set and agree on the goals and vision jointly, including the stake-holders. In the rest of the process not all experts need to work at the same time (saving time and expenses), but it's best to have them all included in the evaluation phase. More about how multiple disciplines can work together is discussed in the process chapter.

ROUND AND ROUND WE GO
The method is iterative and cyclical. This means for any given question that the method is used to find an answer, the method's five steps are cycled through several times, starting from rough analysis and solutions to more refined ones. The method also doesn't have a defined start: It's not necessary to start working in step 1, but all five steps do need to be cycled through eventually.

The method may be applied to any question, including itself. What we mean with that is that you can apply the cycle to its own steps. For example, when applied in the SiD process, it's possible that the entire method cycle (all five steps, and cycling) are applied to the process step of 'goal setting' of a project. This means you set a 'goal' of finding the right goals for the project, then map the possible goals, try to understand them, develop solutions for a good goal, and then evaluate those goals.

MAKE IT YOUR OWN
Feel free to adapt the method to your own vocabulary or approach. Steps are often repeated as our understanding of the system under investigation grows, and the focus or goal of the project shifts as a result. Certain steps may also be iterated by themselves. Use it the way it works best for you, experiment with it for your projects, but do always include each step along the way, and keep iterating the cycles.



STEP 1: GOAL & VISION - WHERE DO WE GO?
The goal setting stage dives deeply into the challenge to uncover the true motivation of the project, as seen from a variety of angles (stakeholders, society, etc). In the travel analogy, we ask the question "Where do we really want to go?". Setting proper goals is one of the most critical steps of any trajectory, and can be harder than it looks. It is often not apparent what a proper goal of a project is. There's some useful guidelines below, as well as in the theory section on goals. In this phase it is also valuable to develop a vision. This helps to ground the goals in a real world future perspective. In subsequent cycles of the method, we also set indicators.

Goal setting is usually the first step to take, but it's not uncommon for an analysis of the current position of a challenge in step 2 to precede it. We'll explain this phase in detail in paragraph 3.2, below is a small summary. The goal setting phase usually contains the following elements:

- Set the goal for the project on a system level
- Set sub-goals on network and object level
- Develop a joint vision
- Define the project and system boundaries
- Set indicators (KPI's) to measure against in the evaluation stage

PERFORMATIVE GOALS
When setting goals, we try to strictly use 'performative' goals. With 'performative' we mean to identify a goal that talks about a system's performance only, not about a physical property or static position. A performative goal ensures we remain focused on what truly matters.

SET OBJECT AND NETWORK LEVEL SUB-GOALS
Main goals are further refined with sub-goals on object or network level. These can also give more direction to the wishes of stakeholders. These are also performative goals but they can be more defined, as long as the system goal is the main destination.

VISIONING
The goal setting stage can also contain a visioning stage where dreams and ambitions are put on the table to create motivation. This can also help to set sub-goals.

SET PROJECT AND SYSTEM BOUNDARIES
In addition, this is the stage where the boundaries are stated, in terms of the time and resources available for the project.

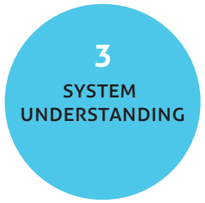
DEVELOP KPI'S
In more advanced iterations, we narrow down the scope and performance of the sub-goals by developing Key Performance Indicators (KPI's).



STEP 2: SYSTEMS ANALYSIS: WHERE ARE WE NOW?
If you go on a trip, and you are planning your route to get to your destination, you first need a map to see where you are and what's around you. While this seems a non-issue when you're planning a trip (you can just buy a map in the store or go online to look at one), regarding complex systems there's usually not a map there at all. Also, we usually don't know where we are, as we don't have insight into the system when we start. That's why in this phase we make maps using various forms of systems analysis.

Mapping is the process of collecting information and representing it so that we can learn something from it and it's useful in the rest of the process. We first make maps to explore, and later, in step 4, to make 'desired state' maps, that you can relate to 'before' and 'after' pictures of a diet program. In the mapping process, the SiD SNO hierarchy helps us to make sure we collect information integrated and relate it to different levels as we go along.

In paragraph 3.3 we discuss system maps, how you create them, and give some examples. Also, we'll show you how a good mapping cycle can yield understanding and insight in the system, thereby opening the way for system-wide solutions.



STEP 3: UNDERSTANDING: WHERE ARE WE?
Once we have the map, we need to figure out where on those maps we currently are, and what possible directions this 'ideal place' we want to go to is in relation to our position. On a roadmap this can be very straightforward (if you have a GPS, or know the name of the town you're in), but with complex systems we usually haven't got a clue. We need to decipher the maps, get a grip on what they tell us, and what we really mean by 'going to' a different state given the situation. In this step we gain a deeper, over-arching understanding of the whole scenario.

We do this by studying the system, discussing it with a variety of perspectives, investigating its various obstacles and dynamics, and try to take it all in. And last but not least: to let it sink in and give our brains time to decipher it all, and perhaps even find patterns within the complexity of the system. This is done by 'immersing' yourself in the system both solitarily and as a team. This way you'll develop a 'feeling' for the system, which will open solution space and solutions may emerge from this understanding naturally. We can then start formulating ideas on what direction to go, and what obstacles to avoid.



STEP 4: SOLUTIONING & ROADMAPPING: HOW DO WE GET THERE?
Once we know where we are, what's around us, and where we want to go , we can start plotting a route to get there. We do this by establishing the various obstacles in our way, and the pathways which seem most likely to get us to our goal in the set time frame. If solutions didn't emerge naturally in previous step, you can use several tools to identify leverage points and gaps within or between systems and increase solution space.

Just as with plotting a route for a trip, the time available to us defines not only what routes we can take, but also what transportation type we will use to get there, and if we can afford to explore or need to get going quickly. With systems, we usually plot routes in time rather than on a geographical map, but the essence is much the same: we have some alternative routes, some scenic routes we'd like to take if we can to improve the quality of our trip, a clear destination and points of interest along the way. Sometimes a route is a single solution, sometimes it's a string of different solutions executed in time.



STEP 5: EVALUATION: ARE WE GOING RIGHT?
We're well on our way into planning, we determined where we want to go, how to get there, and made a plan to do so. In this stage we evaluate if this journey, its length, the places it takes us past, is feasible, conforms to our goals, and if we feel confident enough to get moving or if we want to reconsider.

Evaluation in step 5 is a moment where we reflect on the goal we set in the beginning, and see if the routes we plotted align to them. We also determine if the routes we plotted are good enough, or that we need to go forward into another cycle to refine our maps, understanding and solutions. If everything is great then we can stop the method cycle, pack our bags and get going. We typically need a couple of refinements to our route and our solutions, so usually, we cycle through the method a few times, and usually at Evaluation we determine what was good about the last try, what we want to keep, what we need to improve, and plan for the next development cycle.

CYCLING THE METHOD

The method is designed and works best when it's repeated several times. The first cycles function as a quick and dirty survey of the entire challenge, and subsequent cycles refine the analysis, understanding, solutioning, and evaluation. There's no fixed number of cycles, and there are no rules for how long each cycle needs to take. We do generally recommend to perform at least three cycles. As an example, most of our basic projects have 3 cycles at minimum, but some projects have had dozens. For larger challenges, we suggest performing up to about 8 cycles, for example in a year long project.

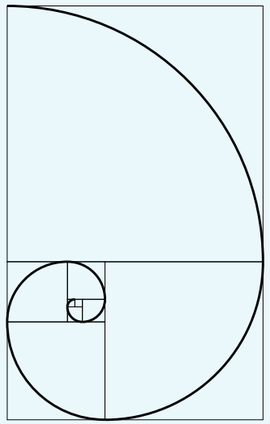
In our experience, it's best to do the first cycle quickly, almost as fast as you can, maybe even in a few hours, with the entire team. In this reconnaissance cycle, the team becomes acquainted with the method, the various steps to go through, as well as with the major outlines of the project. Each subsequent cycle goes deeper, with more time, more refined research, adjusted goals, sharpened evaluation tools and, of course, with better solutions and roadmaps. You can bounce back and forth between steps in a cycle as well, if that helps. For example, it's common to iterate between goal setting and analysis a few times at the start. In the end, a last finishing cycle rounds everything up.

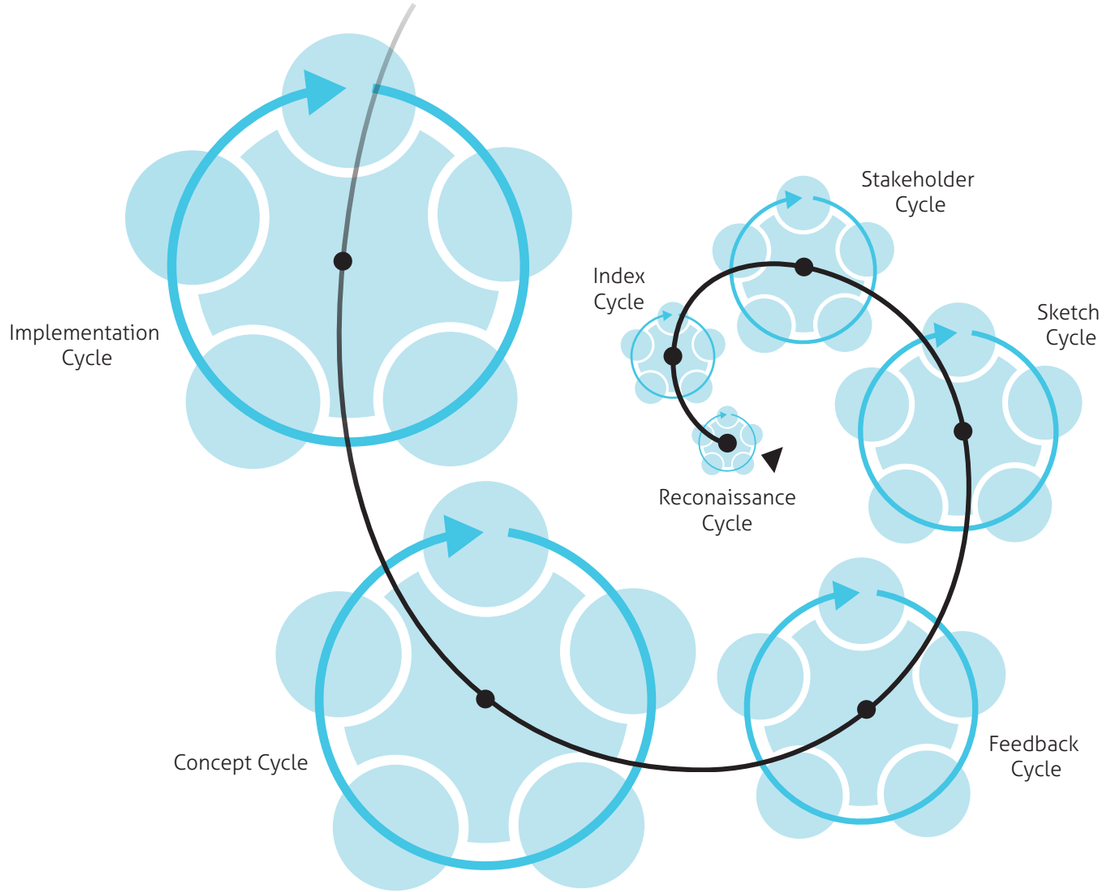
A rule of thumb to plan the cycle lengths is to use a pattern that's found in nature called the Fibonacci Sequence (see box). This is not a rule, but we've found it a useful planning and iteration pattern. This means, for a 7-cycle approach, that if the first cycle takes 1 day, the next one also takes 1 day. It basically repeats the first cycle, but gets people to be more familiar with all the steps. The third cycle takes 2 days, the fourth 3 days, the fifth 5 days, the sixth takes 8 days, the seventh 13 and the eight day takes 21 days.

FIBONACCI SEQUENCE

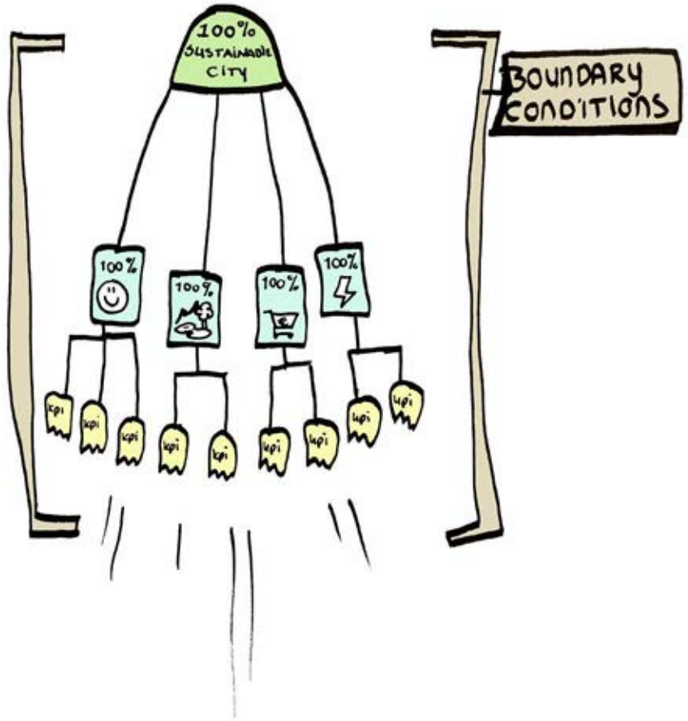
The Fibonacci sequence (F in table below) is a number series where each number is added to the one before it to produce the next. This produces a series of proportions that generates patterns found everywhere in nature. When drawn as a spiral, it is found in uncountable things around us, ranging from the arrangement of flower petals, how water spins down the drain, cloud formations, and even in many dimensions of the human body. It's great for proportioning cycles in a natural way, and can be used as a starting point to scale SiD method cycle lengths.

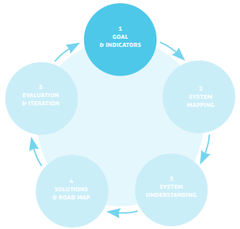
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1	1
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3	2
4	3
5	5
6	8
7	13
8	21
9	34
10	55











2.1 STEP 1: GOALS & INDICATORS

The first step of the SiD method consists of setting the goals for a project, determining its vision and, usually at a later stage, setting its indicators and system boundary. This is where the project's externally-applied edge-conditions find a home, including stake-holder demands, time and budget restrictions. This is also the stage in which a major revision of the project usually takes place in later cycles.

The different parts of this stage are:

- Goal setting on System, Object, and Network levels
- Develop a vision (optional but recommended)
- Set project and system boundary
- Set performative indicators

SETTING GOOD GOALS

The goals determine our final destination. They are usually set with your entire team including the client and later revisited with the stakeholders, if applicable. Your goal is the dot on your horizon to aim for. A bad goal distracts you from what's important, and a good goal keeps you motivated. Good goals are expressed on a system level and performatively. For example, a good goal is: "Our goal is for our company to maximally contribute to a sustainable society:". Here, 'as sustainable society' is the system your goal reflects on, the company is the object within the system to improve, and, maximally contribute to the system's sustainability is the performative aspect. Also see section 1.5.4 'Embracing Systems Thinking' for an in-depth discussion on systemic goals, and why they are so important.

Setting goals on a system level often means the system goals can get a bit broad and generic. This is okay. The sub-goals will provide further refinement. For example, we might say: "we want our neighborhood to be sustainable in 30 years, meaning resilient, autonomous, and harmonious." That's a fine goal. If this is where you start, you will eventually refine this goal throughout multiple method cycles into more detailed sub-goals. One thing to keep in mind: do not limit the ambition of the overall systemic goal. See the chapter on transitions and the section on over-stating goals in section 1.5.2.

PERFORMATIVE GOALS

Next to being expressed on a system level, goals are

best expressed performatively. This means that the goals should always be expressed so that they only describe the intended outcome, and not determine the solution through their formulation (a deterministic or prescriptive goal). This allows the largest possible solution space and prevents suboptimization by letting a latent idea of what a good (object-oriented) solution would be influence the process.

An example of a bad, prescriptive, non-system goal, would be "All the buildings of this neighborhood should use solar panels to provide the neighborhood with its own electricity". While it would be nice to have all the electricity of the area be provided by solar panels, and perhaps that is indeed one of the solutions, this goal locks in the use of a certain technology (a solution) for a certain purpose. Perhaps there are better ways to achieve the actual goal. A performative way to say this would be: "The neighborhood has to provide its own source of renewable energy." This way, solar panels may still be used, but it's also possible to use other approaches if they work better in a particular context.

Now, if we want to express this example on a system level, we'd have to think about why we would want to achieve this on a higher level of abstraction. One could say that providing one's own source of energy makes us less dependent on fossil fuels, and thus more resilient as a community. Someone else may say that it is better for the environment and our climate to do so. Other reasons may include aspects of education and setting an example, providing economic stability and so on.

Several additional reasons may be named which hint at a system level goal. These are investigated in relation to their meaning on a system level. Firstly, we want to make the system more resilient. That's a system level goal. Expressed this way, it may also lead to other solutions that lead to higher resiliency besides energy. Second, we want to keep from harming the environment so that we may continue enjoying its benefits, that's also a system level goal.

In our experience, the goal is often already set before we're involved, but not on a system level. In that case, we use internal systemic goals to pursue the solution, and try to make sure they also comply with the goals set by the client. The client goals often describe more of a boundary condition concerning costs and such.

SETTING SUB-GOALS

After the main goal is set, it can help to break down the system goals into performance-based network and/or object goals. When for instance the project is to design a specific building, the goal may be expressed on various aspects of it, such as its influence on the direct environment, the people that will live and work in it, its related businesses and its use of materials. This does assume that making a building is an absolute given, and not just assumed (boundary condition), as there's usually much more effective ways to create a sustainable system than through real estate construction. ELSI and the Network Parameters are good tools to use to formulate sub-goals, and to ensure you've covered all the bases while doing so. Despite this, the main overarching goal should still be on a systems level at all times.

Since the goal is formulated on a system level, it may sometimes be necessary to know more about the system before figuring out what the goal needs to be. Without prior understanding of the system this can be very difficult, if not ineffective. In many SiD processes we apply a preliminary mapping exercise preceding the goal setting stage.

VISIONING

For a variety of projects, a vision statement can be used instead of, or in addition to, the usual goal statement. Especially for longer-term trajectories involving large groups of people and multiple stakeholders, a strong vision may be helpful or even required to energize people and get the process moving. In addition to this, a vision may provide a qualitative point on the horizon that can help in directing the process, and a reference point to reflect on when you get stuck, or need some fresh ideas to move forward. A vision does not replace nor function as a systemic goal, but can be used to render it live or to arrive at a systems goal.

When creating a vision, the team, often in collaboration with the stakeholders, formulate their dreams and ideals of where they would like to end up in the future. This vision can be quite specific and can be expressed through movies, drawings, written stories and many other media. After the visioning process is complete it's usually straightforward to extract specific goals, indicators and to set a system boundary.

A good vision helps in jump-starting the development process. With the vision in hand, it's also possible to use back-casting (see also Tools section): to quickly run through a SiD method cycle in reverse to see if there are any clear pathways towards a desired end result, and to make an early assessment of potential pitfalls. After this quick walkthrough, a normal method cycle may yield more satisfying results.

DETERMINE THE PROJECT AND SYSTEM BOUNDARY

The project's boundaries are the external conditions placed on the investigation, such as budget, time, resources, team, level of detail, and so on. Setting these creates clarity for the team and ensures the project is completed within those boundaries. The conditions that determine the specific boundary of the project itself, are called 'edge conditions'. These include aspects such as your project's budget, deadline, and hard client or stakeholder requirements.

The system boundary is an artificial edge at which we stop investigating specifics of the system, and regard everything else as 'external' (we still account for it, but in bulk). Setting a system boundary is important to determine what level of scale and detail we operate at during the various stages, all the way to mapping the system and determining its performance. In general we consider what lies inside the system boundary to be 'the system' that is under investigation, and everything outside of it is part of another system. The system boundary lets us concentrate on particular issues while regarding everything outside of it as simplified. This allows us to deal with complex systems in an organized manner, and to keep things manageable by controlling the level of complexity we deal with.

The system boundary determines the project's depth and length. The smaller the system boundary, the simpler the system inside of it becomes. The advantage of this is that a small boundary makes it easier to map and figure out a solution for the issue at hand. This comes at a price, which is that the number of things we can do in that system also decreases because we have less 'levers' we can pull to change its operations.

We call this the 'solution space'. The larger the solution space, the more possibilities lie at your disposal to solve a particular problem, but it also increases the effort needed to analyze and understand. The system boundary therefore always needs to be set as large as is necessary for finding adequate solutions, and small enough to keep it manageable within its set conditions.

The following rules of thumb can be regarded for setting system boundaries:

- System boundaries are usually not singular, but have different values in time, space, and sometimes for sub-goals as well. The system boundary for investigation in energy flows, for example, can be different from the boundary for ecosystems.
- System boundaries do not have to be set in stone, can be irregular, can be a gradient or otherwise loosely defined. They may be adjusted as a result of an iterative process and progressive understanding.
- System boundaries are not always specifically set at the start, but can be set later in the method, when there's more understanding of the complexity of the system. Also, especially for innovative projects, in the beginning it's best to keep the systems boundary as open as possible.
- If a project requires a strongly defensible and/or reproducible research, for example for peer reviewed scientific research, the system boundary has to be set in stone clearly at some point, usually according to a set standard, and documented as such.

EXTERNALIZED FACTORS

A critical aspect of setting a system boundary is that we must recognize the elements in the system that we have 'externalized'. These are all the elements that lie outside of the system but have significant relations that still interface with the system inside of the boundary. Let's say we have drawn the boundary around a neighborhood, in that case, elements outside the neighborhood that interface with it that are of vital importance of its operations are, for instance, food production, the sun, air, and rain, but also employment areas that lie outside the system boundary, things like water purification plants and so on. When factors are externalized they still need to be represented, but for example as a simple in- or output in a system map. These externalized factors can be important measures of the performance of the system, and may be a starting point for listing performance indicators (see next subsection).

Another system boundary is the system's embedded resources. An example would be the energetic output of the sun, the amount of water underneath the land, the quantity of copper on the planet, the amount of people in an organization, and so on. These are usually fixed, and provide limits to the system's capacity, and thus to the performance we may expect. For instance, we can't get more sunlight to fall on a given area of land, so this is a given and unchangeable fact that lies outside our ability to alter. These aspects become fixed resources that we can easily calculate and work with, and can form a starting point for investigating what the carrying capacity of a system may be, for instance by calculating how much 'free' energy is at a system's disposal when relying on sunlight as a source of electricity. This may help in determining the possibilities for maximizing a system's autonomy.

DETERMINING PERFORMANCE INDICATORS

Performance indicators are used to measure how well a system is operating. We can set some in the first step of the method so we can evaluate later if the system is doing well in step 5, and whether or not the proposed interventions improve the system's performance. The idea is that when we measure them before we start doing things, and measure them after we've formulated interventions, we can see if there's actual improvement. To prevent externalizing problems, it's important to make sure the set of indicators is complete enough to be sure of your actions. For example, we might lower the energy use of an area through the use of a certain new technology, but if we don't measure the amount of toxic outputs of the system as well it's possible that we shift for energy use to increased toxicity. That's a very common example, which happens quite often in reality. That's where ELSI and Network Parameters come in.

TO CONCLUDE

At the end of this phase we have a goal, perhaps a vision, clear boundaries for our operations and a comprehensive set of indicators by which to measure our performance. When these goals and indicators are clear and shared by all stakeholders, it's time to explore the system you're working with before you can think of solutions to meet your goals. This process is done by mapping the system.

EXAMPLE GOAL SETS

GOAL OF PUBLIC TRANSPORT ROTTERDAM

We developed a Public Transportation (PT) strategic development plan for the city region of Rotterdam. The project's goal handed to us asked "to make the public transport system more sustainable". In the subsequent SiD session held with stakeholders of the major pubic transport organizations we redefined the goal as:

> *"To increase the sustainability of the city region of Rotterdam by means of the Public Transportation system".*

This 'flipping' of the goal testifies the major mental shift in the group resulting from a systemic inquiry. The group had realized that a 'sustainable public transport system' is meaningless, since the PT system is a means to an end, and not an end in itself, and that this way of looking at most might result in object-oriented interventions such as energy efficiency measures. We saw that it makes much more sense to try to contribute to a sustainable city *using* the public transport system.

This gave the group a completely different perspective on what actions to take, and the subsequent roadmap focused on the performance of the city as a whole, rather than just the performance of the bus, train and metro lines as was used before. This renewed insight subsequently inspired the entire process and yielded more far-reaching results.

GOALS OF SUSTAINABLE SCHIEBROEK-ZUID

Schiebroek-Zuid is a social housing neighborhood in the Netherlands from the post-war era. We were asked to create a redevelpment plan to make the neighborhood more sustainable. The primary goal was simple on a systems level: "To realize a sustainable Schiebroek-Zuid". To give more direction to what this entails for the specific neighborhood, we did an extensive stakeholder involvement trajectory to figure out the wishes and abilities of the local residents and companies. The sub-goals on an object level (ELSI4) then became:

ENERGY & MATERIALS

- Close all energy and primary material cycles
- Generate its own energy from renewables locally
- Celebrate abundance of renewable energy
- Export energy to surrounding areas, net positive
- Do not import water of fossil fuels
- Minimize waste and close local waste loops
- Toxic free environment
- CO_2 neutral

ECOSYSTEMS & SPECIES

- Landscape source of recreation and education
- Rich biodiversity supporting generation of food, and ecosystem services such as water filtration and energy generation
- Intense interaction between people and nature
- Self-maintaining and regenerating

CULTURE & ECONOMY

- Low costs of living
- Strong culture and social dynamic
- Flexible support for new economic initiatives
- Close cooperation with surrounding neighborhoods and organizations
- Neighborhood financially self sufficient

HEALTH & HAPPINESS

- Support residents in a healthy and fulfilling life
- Challenge residents to optimize their physical and mental state and to support others doing so
- Inspiring, healthy living environment, fed by productive ecosystems and local economic opportunities

GOAL OF A SUSTAINABLE COMPANY

A large (~50.000 employee) company working in the service sector in the United States asked us to help them improve their sustainability performance, initially focussing on energy efficiency, waste recycling and water management. During a strategic session with the board of directors, we asked what the company's officially stated goal was. The directors answered with the company mission of providing the best service level to their customers. After a joint systemic inquiry during the day, the group realized that by far the largest impact on society of the company was not the services it provided to its customers, but its ability to provide and sustain quality employment for their workforce, and that this positive impact was an order of magnitude larger than its negative resource footprint.

Where the company had previously focused on increasing its sustainability performance by reducing their negative footprint such as with energy savings and recycling, they now saw that besides these measures, it was more important to strengthen their positive societal impact. It was at this moment when the board understood that their sustainability performance encompassed the whole of their strategic planning, and wasn't a side issue as first interpreted and scheduled. From this point the entire strategic outlook of the company was put on the table, and instead of their previous efforts in exploring new markets and services from a service supplier point of view (to limited effect), we used this new insight to explore the company reoriented to provide as much quality employment as possible, while maintaining a healthy profit level. In a

systemic exploration of this perspective a number of opportunities came to light that not only strengthened and expanded the existing workforce, but provided a host of new quality services to customers. An important component of this became the ability of their service workers to positively affect the sustainability performance of their customers, instead of just their own operations, exponentially increasing the positive impact of the company. This then became part of their core service offering, and while doing so embedding societal value into the services, making them valuable as a service provider and a frontrunner in the industry. It allowed penetrating new markets, including sectors not before penetrable such as governments and NGO's.

When subsequently setting out a new strategic pathway, the directors focused on their ability to put more people to work and improving their positive impact while maintaining healthy profit levels, which became the de facto new company goal.

This result is an almost direct effect from reorienting the goal of a system, in this case the company. By understanding and using the systemic position of an organization and using its positive impact to drive a reduction of negative impact in its larger network, exponentially more positive performance can be expected as opposed to just focusing on the object level (physical footprint).

In many cases, such as this one, doing a systemic inquiry before setting the goal is necessary to gain the required insight, which means starting the method in step 2 instead of 1.







On the right page some photographs of a SiD strategic goal setting session. During this day long session, together with the board of the Vebego cleaning company in the Netherlands, the vision and future of the company was explored.

This is an example of how a SiD method cycle can be used to focus on only one of its steps. During the sessions, a full cycle of goal setting, mapping, understanding, solutioning and evaluation was performed, but it was focused on setting a good goal for the company. In sessions like this, it helps to have real time sketches made by illustrators that can map subtleties of conversation during the day. In this case it's Annabella Meijer making the illustration.

EXAMPLE GOALS FOR A SUSTAINABLE OFFICE PROJECT

The following goal set is a real world example of a full-fledged systemic/object goal set for a highly ambitious multi-tenant office building at an airport. It was created during several stakeholder cycles in co-creation. The systemic and network goals are inter-weaved under the strategic and the user goals. The object goals follow ELSI. This goal set was at time of use the most ambitious for any sustainable office project globally. Research showed this project to be feasible with these goals, and financially viable due to a smart integrated concept design.

STRATEGIC GOALS / SUPPLY DRIVEN

1 The CBD becomes the preferred location in the Netherlands for companies with a global perspective, from high potential front runners to multi-nationals.

2 The CBD becomes a future-proof development
- **a.** A place where people and companies want to be for at least 50 years on its own strength besides future developments
- **b.** A place with the flexibility to respond to new trends, social and business standards quickly, including new ways of working, tenant types, services, parking, and changes in mobility
- **c.** Have a resilient user mix, no monoculture but a varied mix of different company sizes, sectors, and characters
- **d.** Set a inspiring new national standard for future area developments, and offices

3 The CBD scores outstanding in sustainability performance
- **a.** Best in class sustainability, combining aspects such as energy, material, biodiversity, culture, social, health and wellbeing
- **b.** Sustainability measures are visible and educational

4 Outstanding experience for residents and travelers
- **a.** Get travelers reliably fast to their destinations; the connectivity between highway, terminals, and parking is optimized
- **b.** Inspiring and motivational space that makes future users proud and serves as a business card for the national business landscape
- **c.** A public, lively heart of CBD, with a quality outdoor experience and a clear orientation along and supporting the green axis

5 Catalytic effect; improve value of the CBD and beyond
- **a.** Leverage with a factor 10; boosting the value of 200.000 m^2 with 20.000 m^2

6 Be the front door of the country
- **a.** A showcase of national values, innovation, entrepreneurship, environmental qualities, and hospitality
- **b.** Establish a clear and welcoming entry for the CBD and beyond from plaza/station

USER GOALS / DEMAND DRIVEN

1 A rich natural experience, with easily accessible public spaces with green outdoor qualities
2 A range of additional functions and services that makes residents feel at home
3 Establish the ability for resident companies to express their identity in physical presence
4 Instill a sense of pride in those working and investing in the location
5 Establish a healthy, comfortable working environment
6 Flexibility for expansion and change
7 Establish transparency and fairness towards residents and companies and among each other, and for them to have a voice about issues that impact their wellbeing and operations
8 Generate a vibrant community by boosting connectivity between organizations
9 Enable a socially flourishing diversity of people and companies
10 Traveler journey becomes predictably comfortable and stress free

HEALTH & WELLBEING

- 10% increase in productivity and reduction of sick days vs. local benchmark office 1
- 90% weekday life-cycle support of services
- Inspiring location that increases productivity, attracts more visitors and stimulates interaction between people
- 75% of materializations according to Human Spaces Report
- Reduction of Volatile Organic Compounds (VOC's) by 75%

CULTURE, ECONOMY, LOGISTICS

- Future-proof parking solution, 100% convertible
- Full flexibility in office volume, floor plates, subdivisions
- Prepared for future expansion up to 6-10 stories above parking levels
- Pro-active education and public sharing of sustainability measures
- Equitable participation of users in decision making
- Provide exemplary urban quality for pedestrians
- Loyalty programme for parking customers
- Footprint pedestrian level and park mainly purposed to public use

ECOSYSTEMS & BIODIVERSITY

- Global demo project for application of functional green and polyculture ecosystem services in business environment
- Ecosystem services applied for the majority of building services
- On site food production
- 100% food sourced from sustainable sources
- 100% organic waste purposefully recycled internally or within its direct metabolic system
- Cultivation of a number of endangered local species

ENERGY & MATERIALS

- Energy positive, no medium exchange
- Water positive, 100% service water fed from rainwater
- Minimum of 20% energy production on-site using renewable sources
- Zero waste construction and operation, min. 80% waste separated
- Construction 100% design for disassembly with pre-developed recycling plan
- CO_2 neutral operation
- Full support for non-fossil fuel use transport modes
- Zero fossil materials and/or fuel use for operations
- No use of toxic materials as base construction materials

CASE STUDY BK CITY SLIM

BK City is a magnificent listed monument of more than 30.000m² functioning as the faculty of Architecture of the TU Delft in the Netherlands. Except used SiD to create a phased plan that converts the building into a didactic tool that puts sustainability at the heart of education for generations of architects, introducing a unique in-building ecosystem that provides an inspiring environment, functional qualities and cost savings. The result is a plan to maximize the historic educational building's positive impact on society, as well as have it feasibly energy and carbon neutral within ten years.

The newly-chosen building, dubbed BK City, was a historic 1920s labyrinthine brick structure whose contemporary funky furniture and colorful designs belied a much less wallet-friendly energy bill.

Except was invited by the Technical University of Delft to design a sustainable vision for their newly-relocated architecture faculty, after a 2008 fire left the original architectural faculty in ruins. We applied SiD with a team consisting of an architect, an environmental scientist, an engineer, an ecologist and a business analyst.

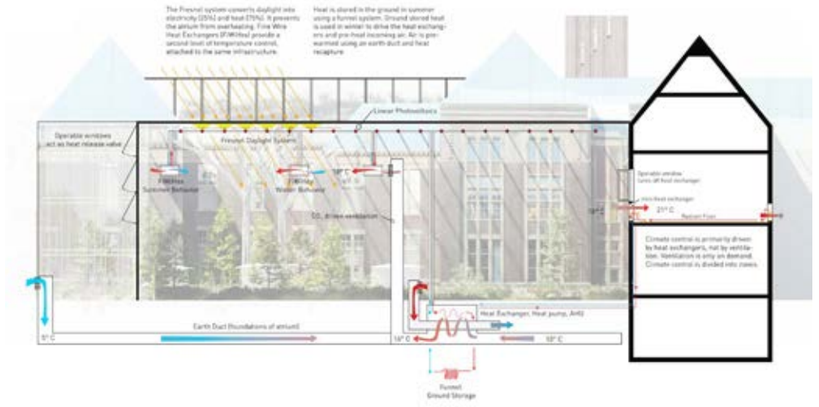
SYSTEMIC GOAL & VISION

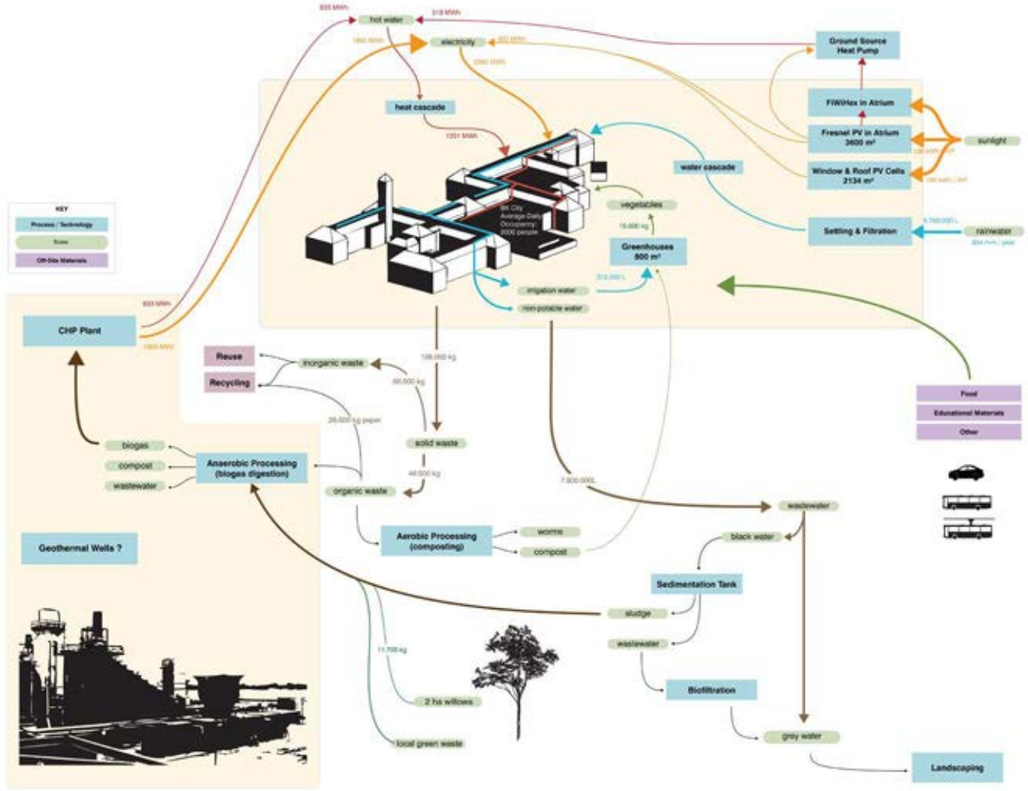
Our project began from the idea of the building not only as a structure that houses knowledge, but as one that can impart it as well. While focusing on increasing energy efficiency and decreasing operating costs, we also embraced the refurbishment of BK City as an opportunity to increase students' hands-on experience and understanding of sustainability. We designed the interventions to be participatory, didactic, and engaging, providing students with a 21st-century knowledge base they could leverage within and beyond BK City. This didactic experience goes beyond architecture and construction, to include ever more important aspects of health, biodiversity, and ecological processes within the field of architecture.

BK City is more than a building: It connects the lives of many individuals, functions as a learning platform for generations of architects and urban planners, and acts as the social and functional hub of the disciplines it serves.

This vision informed the central goal of the project: to transform the building into a didactic tool that anticipates and responds to the shifting field of architecture, with an influence that extends beyond its own walls through the actions of those it has educated.







APPROACH

We broke our analysis and approach into the components which we rely on in all our projects to ensure that sustainability is addressed in an integrated manner: Energy & Materials, Ecosystems & Species, Culture & Economy, and Health & Happiness.

In addition to these four thematic streams we also created a phased vision which interweaves easy energy gains and immediate solutions with more ambitious and systemic interventions. Each intervention has cross-cutting benefits, and each phase is designed to build on the one before it, offering an integrated vision for BK City which evolves over time.

OUTCOME

The result is a highly didactic building with exemplary environmental quality, an indoor plant ecosystem, more than 10.000 m² of extra space, energy and water usage that is operationally sustainable, and a plan that is feasible and phase-able (with a total of less than € 25 million invested over 10 years).

INTERVENTIONS ON OBJECT LEVEL

ENERGY & MATERIALS HIGHLIGHTS

- Wall, roof, window insulation, saves 67% heat
- "Easy gains", electrical equipment & lighting, glass embedded PV
- Compact volume reduces 32% surface exposure
- South atrium with Fresnel PV, Ground storage
- Connection to campus bio-gas CHP
- Space for future energy innovations

ECOSYSTEMS & SPECIES HIGHLIGHTS

- Pervasive Building Ecosystem
- Enclosed Atrium Garden, the 'Green Lung'
- Polyculture & Monoculture Greenhouse
- Plant-based climatization system
- Water self-sufficiency and bio-based filtering
- Green roofs on existing atria

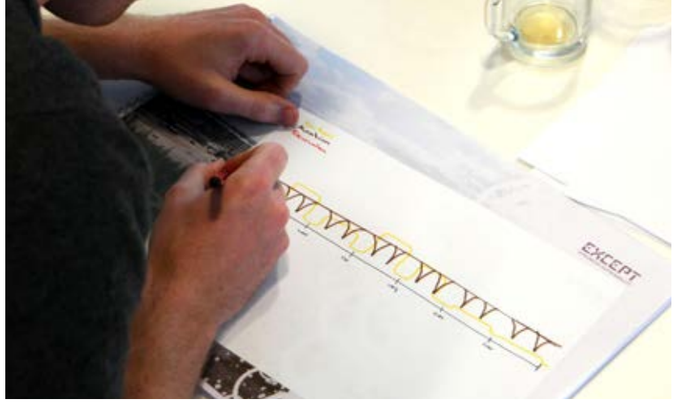
CULTURE & ECONOMY HIGHLIGHTS

- Open-Source, and participatory framework
- New main entrance, west atrium, pods
- Collaborative frameworks with Wageningen, TU Delft Botanical Gardens
- Integrated campus where the technological and ecological meet
- Long term economic stability

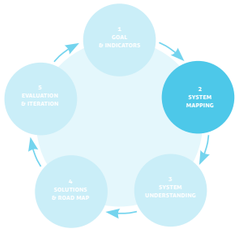
HEALTH & HAPPINESS HIGHLIGHTS

- Upgraded heat recapture ventilation system, using existing tower as driver
- Sustainable, healthy, low energy input food system
- Relaxation & natural zones
- BK City Gym
- Natural Environment: 12% performance gain









2.2 STEP 2: SYSTEM MAPPING

In the second step, we go into the analysis of the system, which we do using system mapping. We use system mapping because it allows us to manage the wealth of information that can confront us at this stage. System mapping is one of the fundamental tools of SiD. It's a key approach to understanding systems and working to improve them, as well as communicating them with others. System mapping consists of charting the system's objects and constructing a network to establish what the system looks like in space, how it behaves in time, and what it affects. From these maps we can derive insight into possible improved states and solutions.

WHAT IS MAPPING?

Mapping has been with us for as long as human history goes, in various forms. A map, after all, is nothing more than a graphical representation of information. Mapping has changed the course of history significantly (think about the first world maps). System maps are no different, except that they map other things than geographical patterns alone. System maps also map relations in time, movement, and the flow of resources. When properly executed, a good system map hands us solutions on a plate, just by the mere insight they provide. Just like when we are lost in a city, having access to a city map presents us with a solution immediately. In addition, the same map may leads to take different routes given different destinations.

Systems maps do not necessarily represent solutions, rather, they show the landscape of the system. This allows us to chart a route depending on where we are, and where we want to go. We can then map these routes to clarify the direction, purpose, and steps along the way.

WHY SYSTEM MAPS?

People are better at handling large amount of data if presented visually than in text. In visual formats, more correlations and insights can be gained as well as an oversight of more complex issues than when represented in text or tables. When done right, system maps provide deep insights that help to find both the root cause of issues and the possible pathways to solutions. These maps function as strongholds for strategy and planning for many years in the future, create unified understanding across teams, inform and allow stakeholder participation, and turn into powerful strategic

planning tools. System mapping is therefore a worthwhile investment for the team as a learning experience, and a valuable investment for organizations.

WHAT IS A SYSTEM MAP?

A system map is a way to organize data and information from the real world in a way that reveals an underlying order or pattern to determine the nature or behavior of a system. They are usually visual maps, but can also be lists or other ways of organizing information. System maps rarely come alone. To map a system, multiple perspectives and scales need to be taken into account, which means making sets of interrelated maps. Maps exist in either of three dimensions: time, space, or context.

Examples of system maps include a geographical map showing a neighborhood's available sources of energy (a space-based system map). A time-plotted graph of the times you enter and leave your house is a time-based map. Examples of context maps are a flowchart of an organization's legal structure, the causal relationships between a tax-policy intervention on the available income of a senior citizen, and the evolutionary family tree of a badger. A typical system map used in a SiD process shows multiple relevant parameters. For instance, when making a map showing energy and material flows in relation to economic gains, you;'d want to represents it in such a way that it result in new insights. This can be a result from both the resulting map, and the mapping process in itself.

Maps start out as sketches, lists and explorations with quick mock-ups to see what will yield the required results. From a large set of quick sketches, the maps that seem the most useful are explored further. For each successive method cycle, new maps are drawn or existing ones further elaborated.

WHAT MAKES FOR A GOOD SYSTEM MAP?

A good system map does the following:

- Reveals important connections or disconnections
- Is not so complex that it becomes unreadable
- Does not overly simplify reality to disqualify itself
- Can be easily augmented and adjusted
- Is appealing to the eye to make it easy to read
- Is part of a larger organizing system that allows multiple maps to form a complete overview together

START WITH A SKETCH

System mapping typically starts with sketches on paper. In the first few iterations, you'll work on a sketch level in order to figure out what you're up against. In later iterations you'll find the form and layout that works best for your purpose. In many cases, the sketches themselves are good enough and usable for insight. In some cases, they can be elaborated and redesigned in several steps, often involving new research in between. In some cases, you'll advance to a computer model or illustration to progress or refine.

Computer visualizations allow you to make dynamic system maps, and maps based on large data sets (including 'big data' maps). With this approach, you can embed the time dimension in space or context maps, and see the developing patterns emerge. For example, the Gapminder project is an excellent resource to dynamically map global statistical data in time, space, and context (www.gapminder.org). For big project or large organizations we can use specialist tools for big-data analysis or agent-based modeling. These can be powerful, but require a high level of technical expertise, and making these is beyond the scope of this guide.

MAP COMPLEXITY

The purpose of mapping is never to be complete, because complex systems have too many components to be mapped. Mapping is performed to reach an understanding of the system, and to take into account as many aspects as possible without being overwhelmed by data. We manage this by simplifying maps on a higher level of abstraction, and making them rougher and less detailed. It's not a good idea to simplify system maps by restricting our set of categories, such as only mapping energy flows or economic relations. Make sure you cover all dimensions, scales, and aspects (as covered in paragraph 2.4), not for the sake of completeness, but for the sake of range and of depth. Otherwise it's likely that important aspects of the system are missed and solutions you'll develop later in the process won't create the sustainable state of the system you had in mind. It's therefore preferable to limit system mapping in terms of resolution and depth, rather than limiting it in scope.



A system map of the city of Boston's public transport system and its ridership (Except 2009). Thickness of lines and size of circles indicate daily transfer rates. Bottlenecks are glaringly obvious. Reviewing this data in numbers and tables would not do that.

2.2.1 HOW TO MAKE A SYSTEM MAP

Mapping is usually started with a diverse team of people, large sheets of paper, a healthy dose of energy and plenty of time to explore different ways of mapping as well as doing the mapping itself. After this, the maps may be remade with software for refinement, new data researched, and graphic layout, or mathematical models made to simulate the system.

When facing a new, unmapped system, we start with deciding what maps to make first. Then, we start mapping the objects in the system, and then looking at the relations between the objects. When this is done, we can look at and perhaps even map the behavior of the system itself. The understanding of the system is the final goal and it may arise out of mapping just the objects and the network.

Either way, remember that the process of mapping itself is often what brings insight. Some system maps are completely illegible to others, but for those who made them, they were the key insight that led them to understand a particular aspect of the system that yielded a brilliant solution.

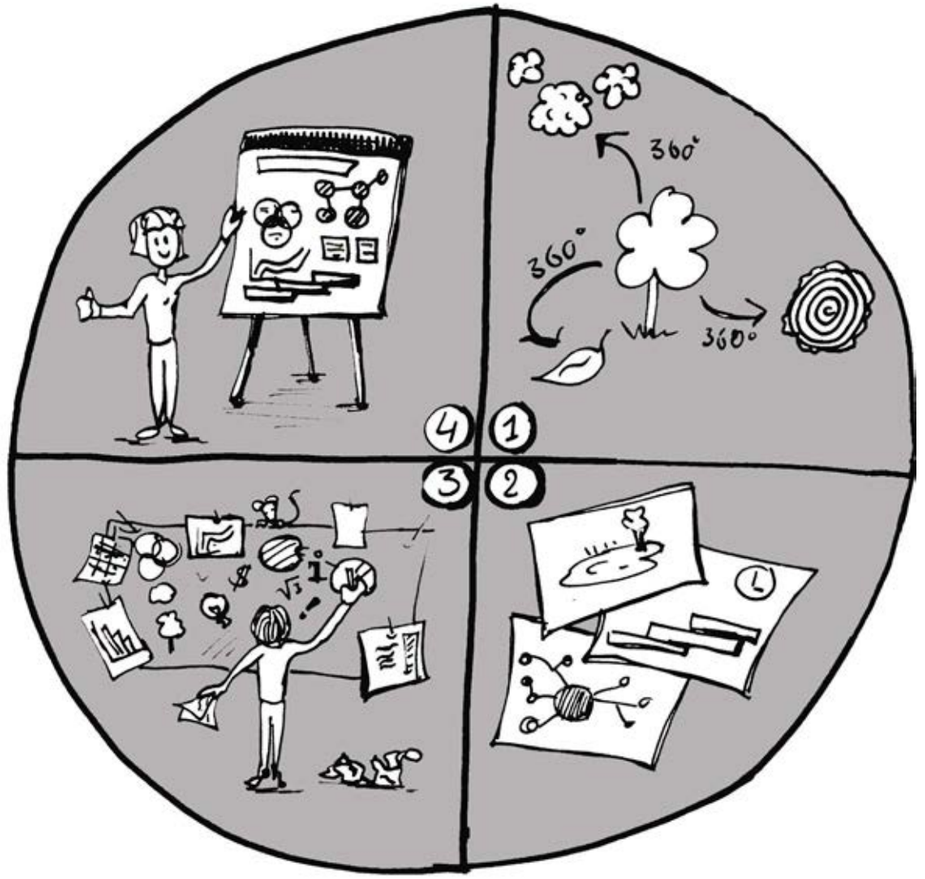
1. DETERMINE SUBJECT AND GOAL

We first need to determine the objective of our mapping. Are we making maps in order to figure out a strategy to improve the system, or are we looking for a specific relationship or quality, or perhaps just using it to create general awareness? These aspects will factor in when setting up the framework and making the content. Then, we need to know what we'll be mapping. Are we mapping a neighborhood, a person, an organization, or perhaps the influence of an action or policy decision?

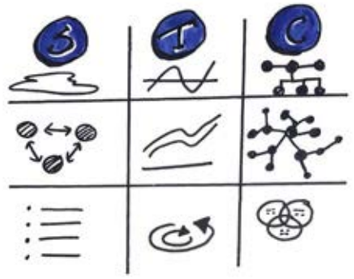
STEP 2: DETERMINE WHAT MAPS TO MAKE

You'll likely make at least 3 maps, or more. For these to correlate to one another you need to set up a framework for your maps, so they speak the same language. Determine what kind of maps, what subjects each map has, and how you'll be representing the information. You'll do this in several iteration, so just start somewhere at first.

One of the best ways to do this is to quickly make a map of maps. You need to map in at least three dimensions: space, time and context, and in three dimensions (small, medium, large). Make a quick grid with two vertical and two horizontal lines, and fill in the 9 areas with what subject and map type you think you can make for your challenge. See the next page for an example. Let's look at what time, space, and context maps can be like.



A. Decide what maps to draft (Map of Maps)



B. Make a bunch of sketches for each



C. Choose promising ones and merge into final maps



SPACE MAPS
Space maps are a common mapping format we're all used to in the form of city maps and floorplans. However, don't be tricked into using a common mapping format without reflecting on it. Space can be mapped in many ways, it doesn't have to be geographical, or even uniform in its dimensions. Also, make sure to list different scale maps, for example a map of the surroundings, the city, and the country.

TIME MAPS
We mostly know time maps from graphs and time lines. Time maps allow more freedom than these formats, but graphs and linear timelines serve as a good starting point. Typical scales for a timeline include daily, weekly, monthly, yearly, decade, and century. Usually we don't map beyond 50 years into the past and future, as we're a shortsighted species, but if you do, they're usually fascinating, so please send us your maps! See for an example the history of sustainability map on page 49.

CONTEXT MAPS
Context maps can be the most confusing map type, but at the same time the most powerful. Context maps do not have a fixed meaning for their axes, so they can show other kinds of relationships between the mapped elements. Simple examples include things like a shopping list, or a budget spreadsheet; they are not time or space maps either. More advanced and useful maps within the context of system mapping are causal loop maps, connectivity diagrams, and material and energy flow diagrams. Different scales can be seen as different levels of connectivity, for example, the order of connected stakeholders of a company through its supply chain.

For the content, use ELSI8 as a starting point. Fill the categories with areas of interest for each of the 8 ELSI categories, gather data, map these in individual maps, see if this works, and expand from there. It helps to use ELSI as an index to determine what data you'll be mapping and to ensure a wide spectrum of analysis. Then you can list options for the followings questions:

› What type of maps will be used for what dimension? For example, will you use causal loop maps (see paragraph 3.3.2) for the contextual dimension, agent-relation maps, or something else?

› In how many scale steps would you like to make the maps? For example, for the dimension time, will you make a timeline of 50 years into the past and the future, or will you look at a single day, or even an hour? Different scales often yield different insights.

› What subjects or data will you map on which map? Will you use a basic set of ELSI indicators, an extended set, or another set of relationships? It's not unusual to make specific maps for specific indicators, E.g. geographical maps with materials and energy flows, economic relations or biodiversity.

› In what way will you make the maps? For example, will you use a workshop type format or have each expert make their own map separately and then join them together?

STANDARD MAPS
While there are no official standard maps, the following map types nearly always play a role in the mapping phase of most projects:

Material and Energy Flow Map (Context map)
A map showing the major energy and material flows, like the one on the left.

Stakeholder Map (Context map)
A map showing the major stakeholders and their relation to the challenge.

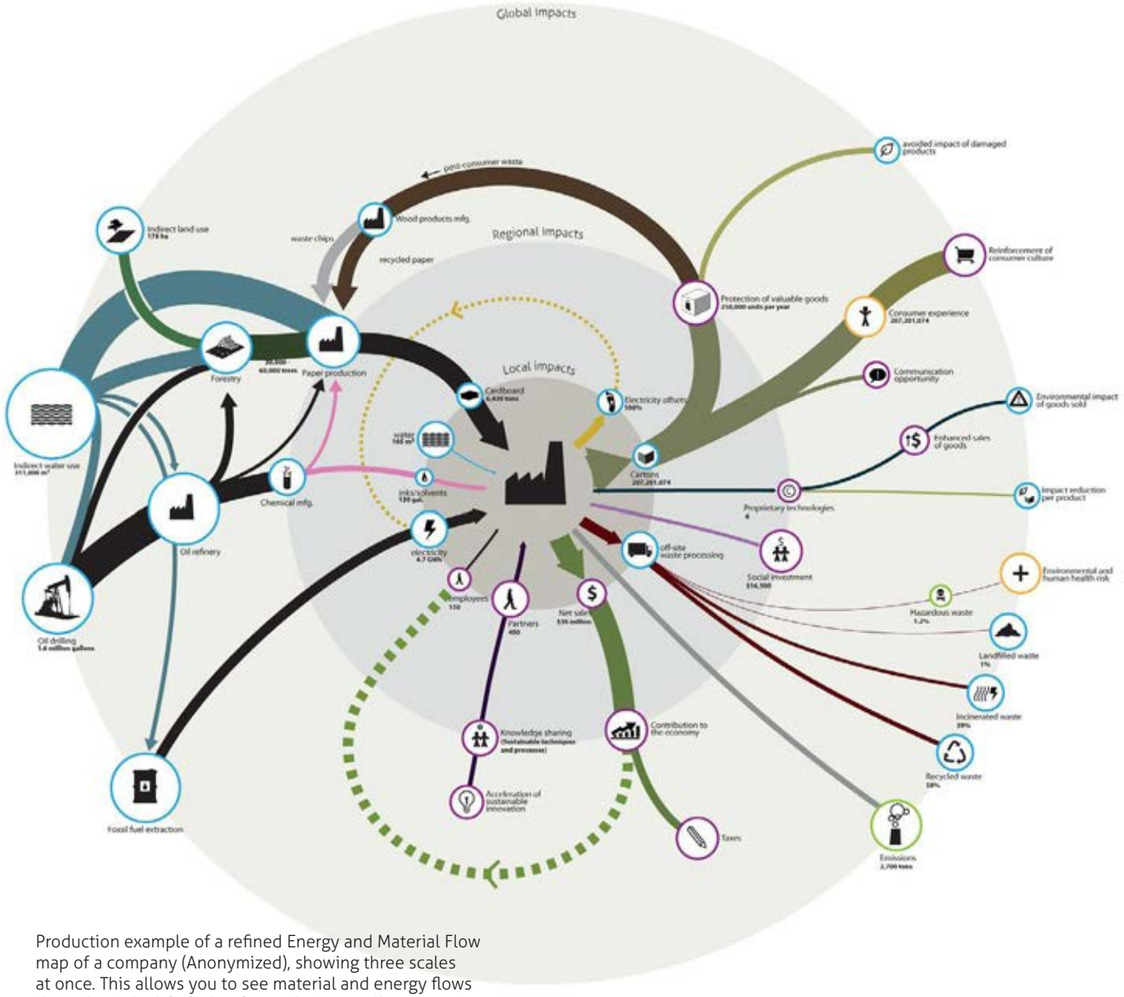
Organizational hierarchy (Context map)
A map showing who is in control of what teams, and what departments.

Trend map (Time map)
A past-oriented graph plotting critical societal parameters in time.

Project timeline / Routemap to the goal (Time map)
The overview of the intended actions towards the goal.

Programmatic plan map (Space map)
Showing relevant program elements on a space map.

On page 266 you can see some map examples.



Production example of a refined Energy and Material Flow map of a company (Anonymized), showing three scales at once. This allows you to see material and energy flows throughout the life cycle of a product, as well as impact mapping for an organization or activity. (Except, 2014)

STEP 3: SKETCH THE MAPS AND COLLECT DATA

When you made your map of maps, it's time to get going and sketch the actual maps. First iteration, just see if you can sketch what you want a map to look like. This will inform you of what kind of data you need and what insight you think the map will give. Don't dive too deeply into one map, be sure to sketch them all roughly first. In the beginning, do not try to be complete for everything, but work on all areas evenly. You'll see that you'll make more coherent and communicative maps this way.

As you progress during the mapping, you may find certain map types don't work. That's fine, great even. Adjust the framework for this to fit, and repeat the exercise until you've got the maps that do what you need them to do according to the goals and subject you set.

System maps contain data from a wide variety of sources. Data collection can be a time-consuming process. In order to narrow data collection, we recommend first making some system map sketches and exploring the system this way, and documenting data needs and desires along the way. From this, data research can be focused on the areas of interest.

STEP 4: SELECT AND REFINE

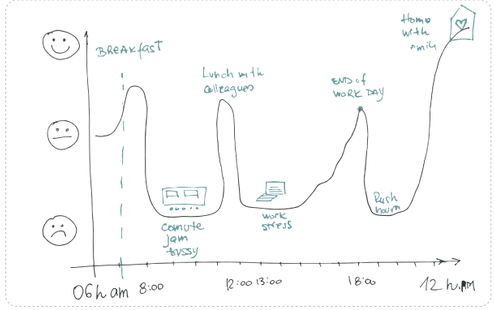
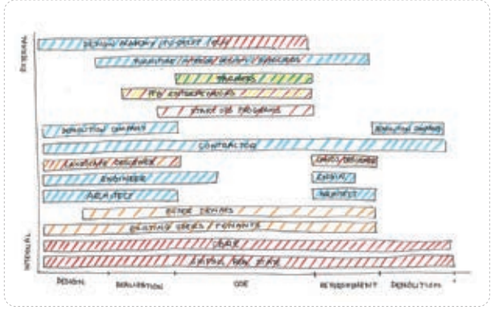
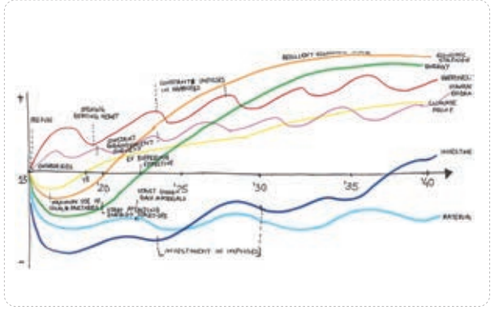
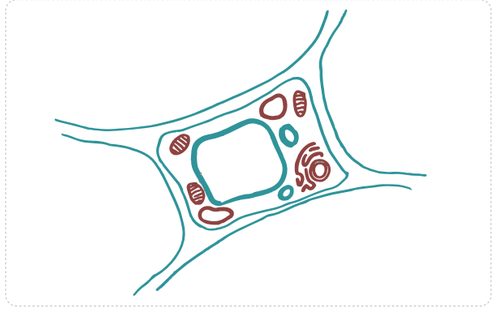
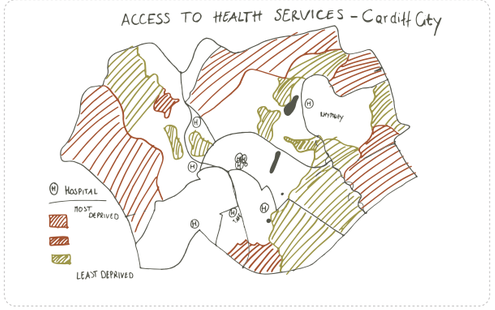
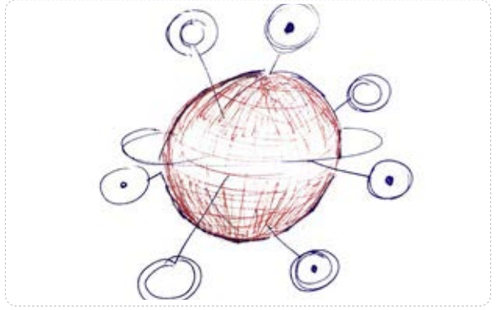
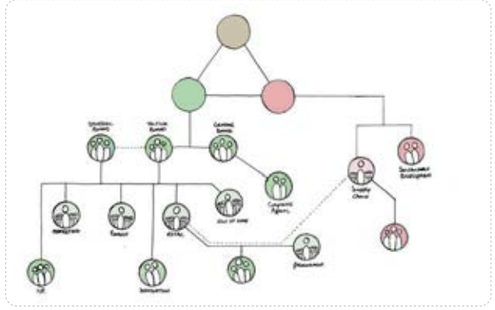
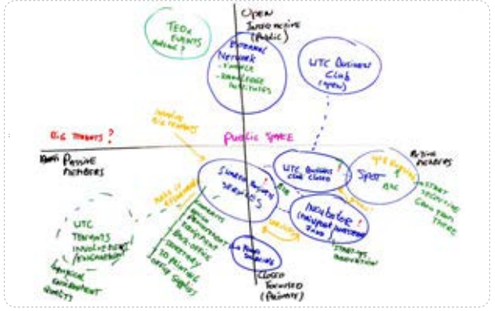
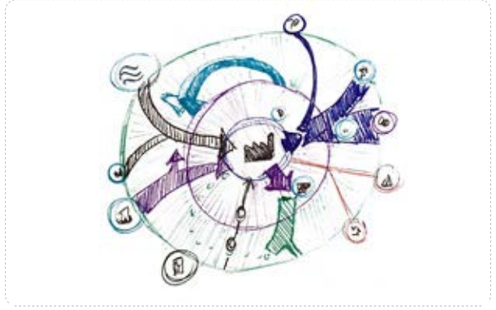
After you've made a range of map sketches, select the ones you find particularly interesting. See if you can merge maps that are on the same dimension, for example, merge geographical maps of different subjects, or combine information on a single timeline where possible. Then, research missing information and redraw the maps.

When you've gone through these cycles and are happy with the framework, map types and data, you can set to finalize all the maps to their end result. Perhaps have a scientist on the subject add details, and a designer polish the representation. Involve other stakeholders to perform some final evaluations and get some extra insights if you can.

WHAT NEXT?

The maps should be revealing opportunities and patterns for the systems you're investigating. If they're not, re-iterate the process, perhaps setting new goals in the process.

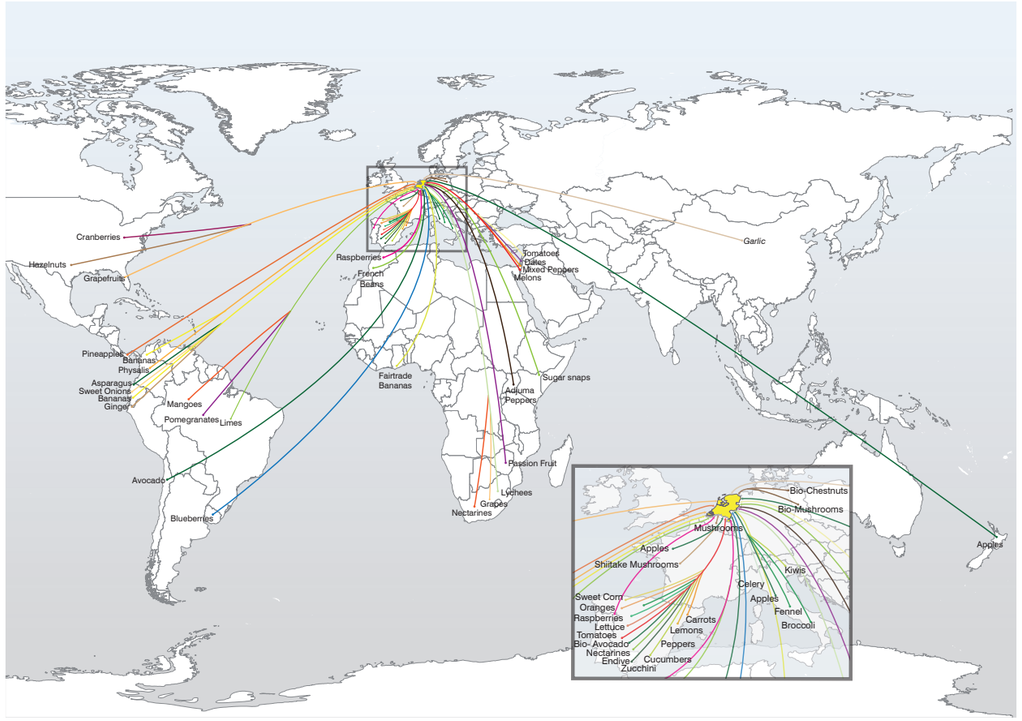
Once you're done mapping the current state, you'll be mapping the desired state later on in the solution cycle. Using the same framework, map the systems as you would like the system to be in the ideal state, in order to be resilient, harmonious, and autonomous to the degrees necessary. You can use these future projections as a point for discussion, or as a way to find pathways to improved performance of the system.

	SMALL	MEDIUM	LARGE
TIME			
SPACE			
CONTEXT			

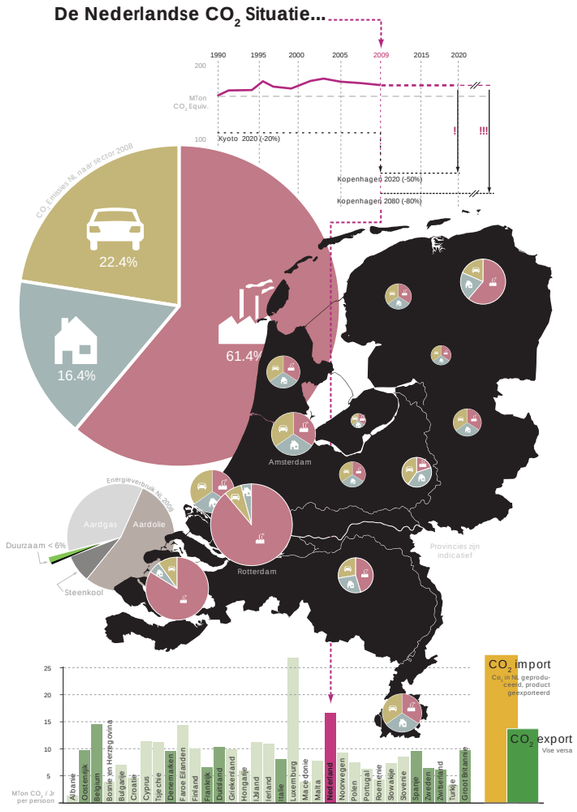
ADDITIONAL MAPPING TIPS

- Try to map using a multi-disciplinary team if you can. Different backgrounds and ways of thinking greatly enhances the quality of system maps. See team formation in the process section for details on how to form a balanced team.
- System maps are not always rendered in a beautiful form. If a sketch provides the necessary insight, they've done their job. Examples shown are often redrawn for communication purposes, which looks nice, but a sloppy sketch on a napkin does the job if it does the job.
- Likewise, system maps are not the same as infographics. Infographics are a way to display information in a graphical way, usually by simplifying information, while system maps add insights obtained by making them in an expansive process. While infographics can be used to improve maps, and maps can be used as infographics, system mapping is a separate skill that doesn't require skills with graphics programs.
- Feel free to stunt around with system maps, experiment and find new ways to create the clarity you seek. You love tables in Excel? Go for it. You enjoy organizing potted plants in your garden as a way to organize your mind? More power to you.
- As a primary tool, system maps should not be rushed. Let them sink in and allow time to redraw them.

Let's look at some example maps.



This world space map shows the origin of the fruit and vegetables from a single supermarket in the center of the city of Rotterdam in 2011. With little annotation, this system map clearly shows a remarkable geographical impact of our food system. (Except, Stephanie Bartscht, 2011)

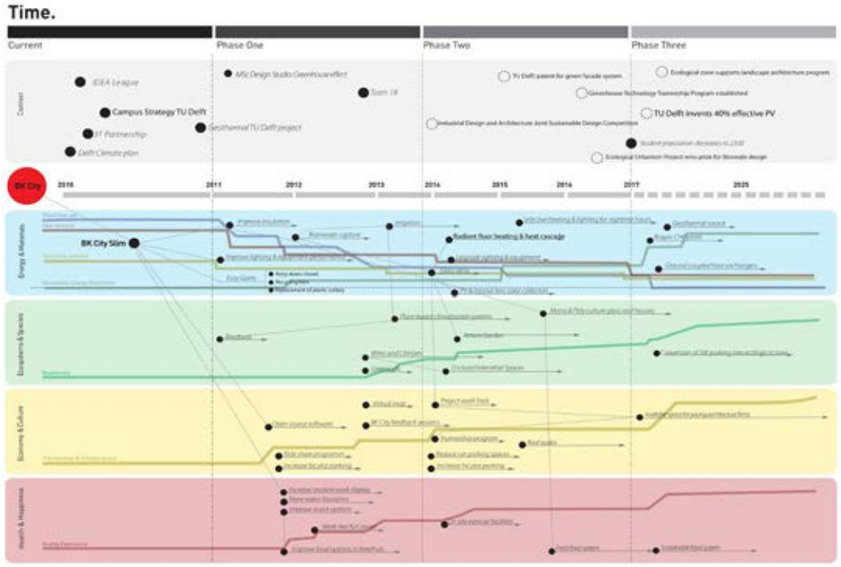


This national space map shows the CO_2 production per province in the Netherlands, and its relation to the various climate treaties. (Except, 2011)

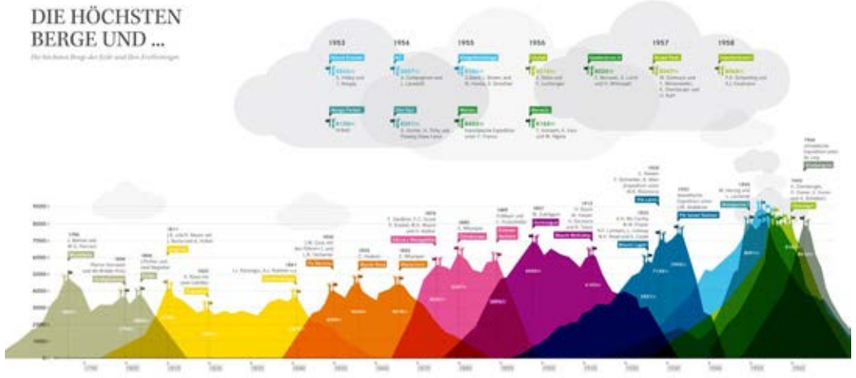
2.2.2 MAP TYPES

SPACE MAPS

Space maps plot elements of the system in space, at various scales to show spatial relationships. In the case of mapping a business, we can make a map of its facilities in space by taking the ELSI system, and mark elements on a geographical map for each of the ELSI categories (suppliers, policy authorities, audiences, etc). For instance, draw where energy is consumed and generated, and what types of energy are being used. Then draw where in the surrounding areas energy could be taken from, and see if you can link these up. You can also map the ecological system around the facilities to examine the company's direct relations to the ecosystem, and see how it can benefit and improve its performance this way. Continue to map all the ELSI categories until you have a decent overview. Next, review the maps, and think about how the company might be affecting areas on neighborhood, regional, and national levels. If these are significant, make maps of those, for instance of its logistical operations, the sourcing of its materials or its business relations.

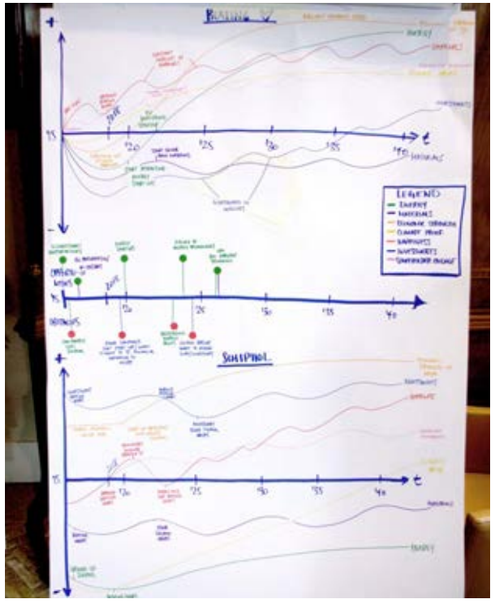


On the left, a roadmap for the sustainable redevelopment of a university complex. It shows the ELSI stack and its individual actions, and the contextual (policy) actions on a timeline. (Except, 2014)



On the left, an example of an attractive communication-level time/data map showing the highest mountains and when they have been climbed.

(Brockhaus encyclopedia infographics by Martin Oberhaeuser)





Above, SiD workshop time-maps with interventions in time and space planned. The lower image explores the network parameter Connectivity in an area development process.

TIME MAPS

Time maps show the chosen categories in time, both their historical development and perhaps its future predictions. If future predictions are not available, we just map in history, and worry about predictions later. Just like space maps, time maps usually come in sets, sets of different time scales.

For a company there's a great many cycles to map which influence its operations. There are daily cycles, with people coming to work, perhaps different production teams in various shifts, supply times and transport schedules. The same goes for the weekly, monthly and yearly cycles. Important events are marked on timelines to get a general overview of how the company works through time. To get an understanding of how the company has functioned in relation to world events, it makes sense to make a time map which spans many years, beyond the starting of the company. We'll receive some insight in how the company has handled changing conditions in the past. The time maps can prove to be very useful when mapping a route, so we're careful to use as much empirical data as we can, so that we can map our route accurately later.



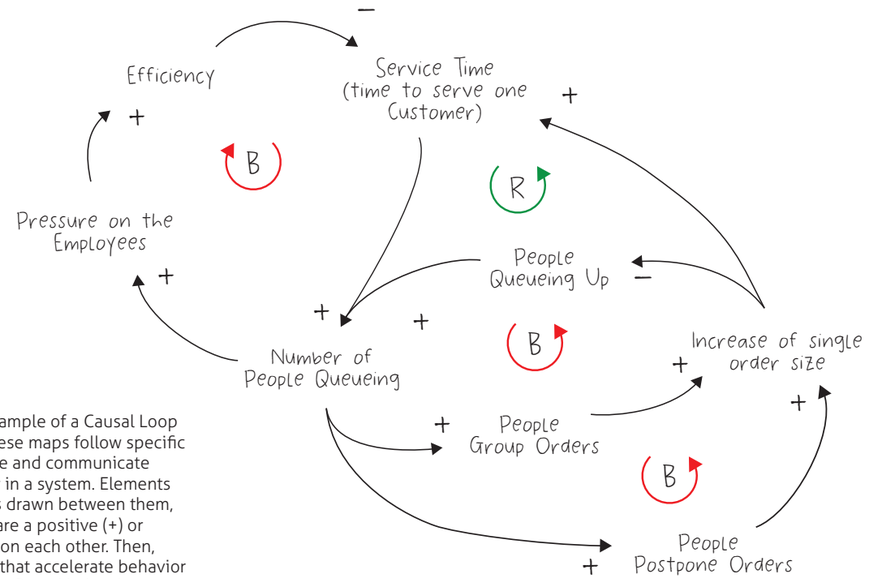
CONTEXT MAPS

Context maps show relations between elements free from spatial or temporal dimensions. They show the invisible relations between things, and give us an overview of how cause and effect are related in a system. For instance, a context map can show how the electricity that feeds into a company powers its production machinery, computers and the building's lighting systems (a material flow map or MFA). A context map can show the relations between suppliers, how decisions are made in a system, or what its dependencies are. We can look at how ecosystems affect the company, which is usually in many ways, from providing the foundation for its feedstock, providing fresh water to its employees, air to breathe, and so on.

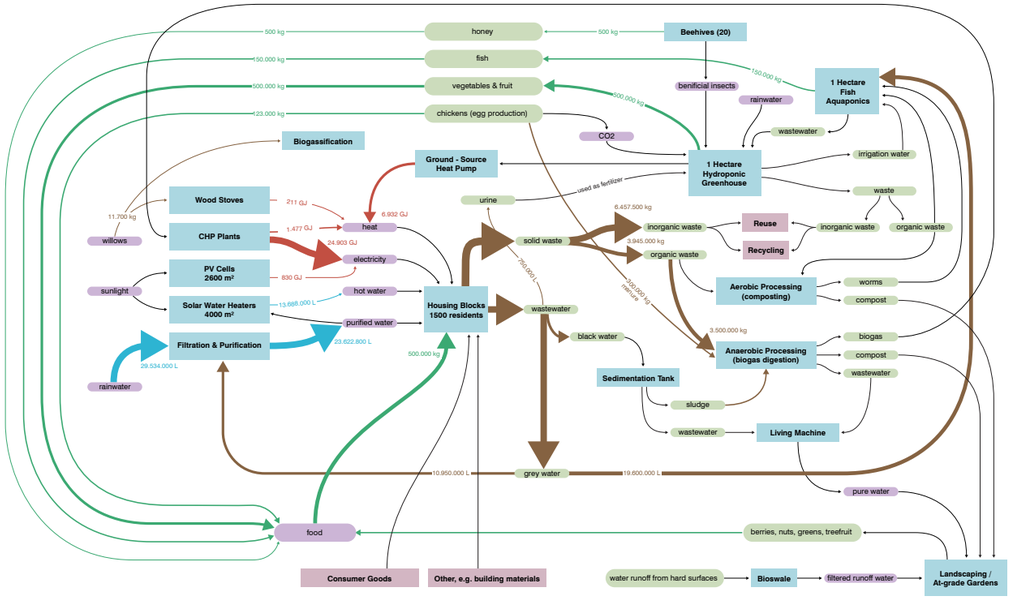
Causal loop maps are a useful type of context map. Causal loop maps (see example below) are maps showing the objects and causal relations between them in the form of arrows. These maps allow us to see the working of any system in context.

You can increase insight in context maps by scaling items in relation to their impact. For instance, when mapping energy you can make large energy flows drawn with fat lines and small energy flows with thin lines. Sankey maps are a specific standard type of resource flow map that show the volume of flows between subjects (see example on the next page). The below map is an expanded version of a sankey, combining it with a context map showing volume of flows by thickness of lines. You can do the same with aspects such as decision weight per stakeholder, impact levels, or dependencies.

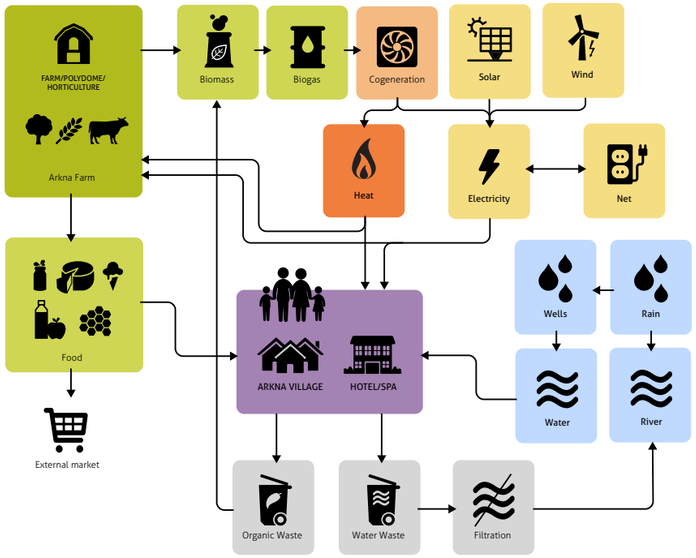
Sometimes it's useful to track elements in a spreadsheet as a context map. These spreadsheets can prove to be handy when dividing work among members of a team as well and to keep track of progress. Agent relation maps are another useful mapping type. They display the relationships between the stakeholders and the system. Such a context map is valuable when analyzing which stakeholders are involved and how their interests could influence the outcomes of your endeavor to transforming the state of the system. This can also be extended with agent-based modeling tools (also called individual-based models).



On the right an example of a Causal Loop Diagram (CLD). These maps follow specific rules to investigate and communicate systemic behavior in a system. Elements have relationships drawn between them, indicating if they are a positive (+) or negative (-) effect on each other. Then, Reinforcing loops that accelerate behavior is indicated with an R, and balancing behavior, that counteracts the acceleration, is indicated with a B.

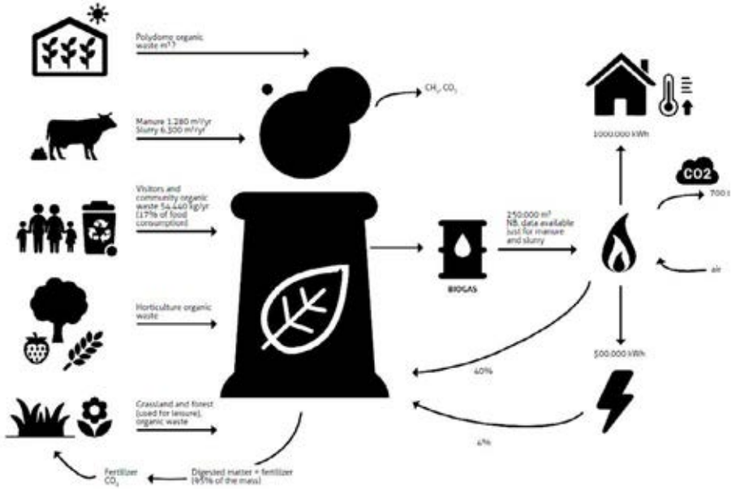


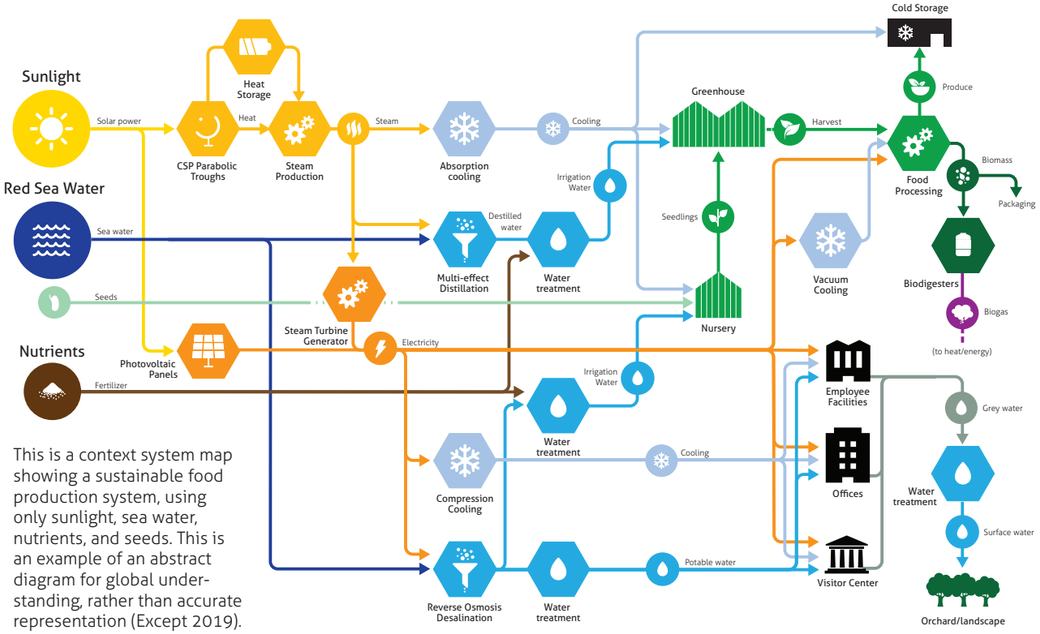
Above, an energy and material flow map for the Schiebroek-Zuid neighborhood in the city of Rotterdam. It was part of one of the first conversions of an existing social housing neighborhood to a sustainable one. Flow sizes are shown with weighted arrows (Except, 2011)



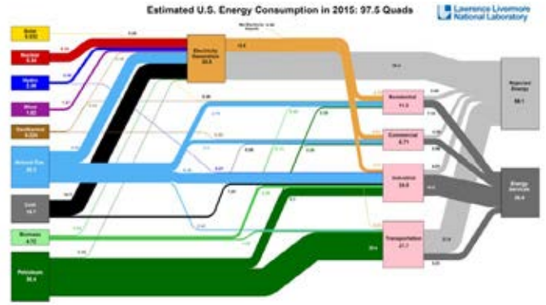
On the left, a general overview context map showing the overall metabolism for the Arkna self-sufficient eco-tourism park in Estonia.

Below, a detailed map for one of its segments; the biomass strategy. It shows volumes in numbers, not graphically expressed. These are very fast to make.





This is a context system map showing a sustainable food production system, using only sunlight, sea water, nutrients, and seeds. This is an example of an abstract diagram for global understanding, rather than accurate representation (Except 2019).



On the right, an example of a proper sankey diagram, showing the estimated US energy use distribution (Lawrence Livermore National Laboratory).

RESILIENCE LEVEL - NETWORK ANALYSIS

Parameter	Score	Note
Connectivity	**Low**	Schiphol-Oost is well connected with road infrastructure, energy and water. It is minimally connected for public transport and bicycle access. From a community point of view, it is hardly connected. Connectivity inside Schiphol-Oost between parties is low. Relative to other business parks, the connectivity of Schiphol Oost is low. Increasing connectivity is a required point of improvement to increase resilience, both externally and internally.
Redundancy	**Very High**	Schiphol-Oost's program is a monoculture, which leads to a high redundancy: there's much of the same. While this is good when demand for this program is high, it is beyond necessary to service the market. Redundancy has room to go down.
Awareness	**Low**	Schiphol-Oost is not very visible to people outside the area. It does not have a strong identity. Internally, it does not have high awareness either. There's no central information point, except for word-of-mouth at Wings. Awareness should be improved to increase the resilience and autonomy of the area.
Flexibility	**High**	One of the major benefits of the area is that there's plenty of open space that can become anything. This is the most important area of flexibility gain for Schiphol-Oost. Other than that, it's quite a standard office park, except for the airport restricting certain uses. Yes, because of the large open space, its flexibility remains high. The challenge is to find solutions that increase other parameters while maintaining this flexibility.
Transparency	**Very Low**	Decisions, plans, activities and programs of the different parties at Schiphol-Oost are almost entirely invisible. In this case, Awareness and Transparency are closely linked. Raise one, the other shall follow.
Complexity	**Low**	The area has a low complexity level. This can be raised sufficiently without leading to over-complication. This is a positive attribute.
Centrality	**Low**	There are few centralized aspects about Schiphol-Oost, which allow its flexibility and postential diversity to be high. The only shared functions are parking and Wings, which can both be expanded, are close to each facility, and parking has the ability to shrink, especially when connectivity is improved. Therefore there is room for more centrality, which is a positive aspect of the area.
Diversity	**Very Low**	Diversity is a major driver of resilience, and this parameter is the strongest low in the area. The program and physical structure of the environment, with its closed, unconnected buildings, low variety of buildings and urban space, and low variety in functions and use demands a higher diversity for increased resilience.

Example of a real-world resilience network analysis for a neighborhood around Amsterdam. This kind of analysis can be performed for all three network areas, and be used to qualitatively scan for optimization areas on the network.

NETWORK MAPS

So far, we've mostly discussed how to map objects and their relations using a bottom-up approach. Once this is complete, a network analysis may be valuable. A network analysis doesn't concern itself with the objects in the system, but analyzes the network emerging from the interrelations of the objects. For example, you can create network maps to analyze specific network parameters. This sounds complex, but a quick network analysis doesn't take long to make. After trying a few times, you may quickly get the hang of dealing with its abstraction. An example of a network map is on the left.

Network maps give us insight in a higher level of a system's operation. For instance, you can make a map of the transparency of information in an organization, connectivity between certain areas of a city, or an index of the diversity of the elements in a system.

Other types of typical network maps are those showing the various suppliers in a product supply chain, or the relations between stakeholders of a project. An additional network-level check may be useful for these projects, using the CRAFTDCCV, PEAIE, and SSCNE network parameters.

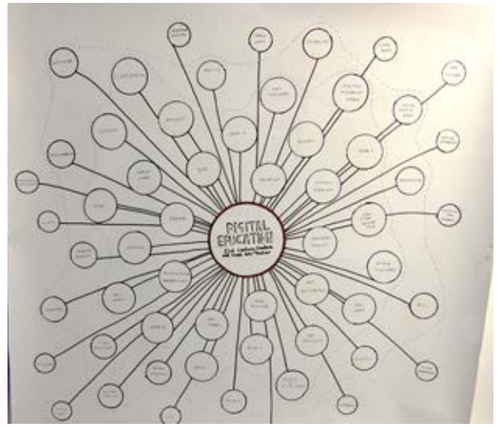
ACCOUNT FOR EXTERNALITIES

Don't forget that we're always excluding things from our maps that may have an influence. We may not be able to quantify them, but it's important to acknowledge their existence to inform our thinking processes. Mark them clearly on each map.

SYSTEM IMMERSION

System maps create an understanding of the system you're working with, and to allow you to work step-by-step to develop an integral view on the system. As said before, it's not about mapping the system completely, as this is an impossible task. Instead, it's about creating a global overview of the system so we can start to evaluate its behavior, and to start searching for system-wide solutions. After you've familiarized yourself with all different dimensions, scales, and aspects of the system, it's time to immerse yourself in the dynamics of the system and develop a 'feeling' for its behavior.

In this way you can find solutions that shift the existing state of the system to another, sustainable, state. In the next section, we'll describe how you, both individually and as a team, can immerse yourself into the system's dynamics. Before that, we have a few exercises in mapping you can use to practice or to run as a workshop.



A relational context map made by a workshop of students in the Design Futures program at the University of Brighton (2016)

ONE HOUR ELSI/STAKEHOLDER MAP EXERCISE

Here's a guide to making a stakeholder system map using ELSI. Involving stakeholders is a primary process step of SiD. To find out which stakeholder to involve in what way, making a stakeholder map helps. The first step, the ELSI indexing, can also be used for any subject. See for this also the ELSI Sweep in the tools section.

A stakeholder map is a type of system map that shows a visual representation of the relationships between parties encircling a particular issue. Its purpose is to create an at-a-glance insight into the network of relationships, allowing multi-disciplinary teams to create precise and effective intervention strategies in a limited time frame. The map also helps to communicate relationships surrounding a project to an uninitiated audience. Depending on its level of detail and structure, making a stakeholder map takes anywhere from one to several hours.

A stakeholder map can have many forms and sizes. During co-creation sessions maps are usually presented in a A0 or A1 poster format. We recommend drawing the map by hand from sketch to finish. Using Post-It notes you can re-use your inventory of stakeholders. This saves time, is more flexible and allows all team members to participate in the creation process. After finalization, the map can be formalized.





Above shows a sketch context/ relationship map in its first (post-it) iteration. It is mapped on three basic concentric rings representing inside of the organization, its direct suppliers, and third parties beyond this.



Above we see the process from its first post-it iteration to a more refined version, starting to 'lock' certain items on the paper with a market.



Above you see the same map in a later sketch phase, all post-its replaced by permanent markings. This was the final registration that provided the insight required.

On the next page you can see this same map in its finalized form after design processing for communication purposes outside the group. It looks very different, but the informational value is the same.

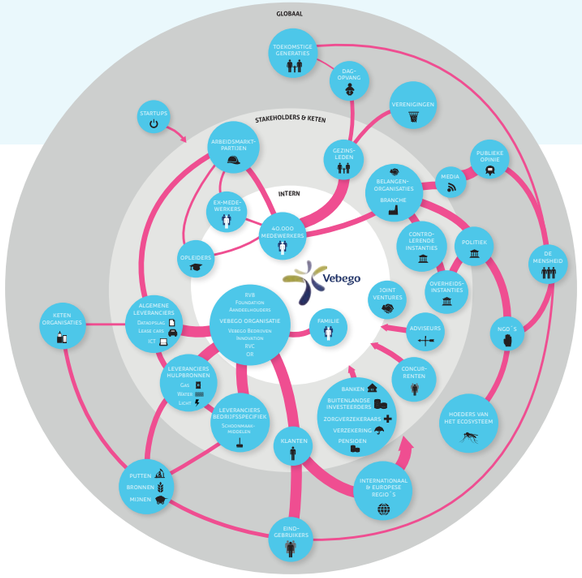
1 Ask main problem-owner who the main stakeholders are (5 minutes)
There's no easier way to figure out who's what by asking the main source. Of course, the source may be biased, but it's a good head start to just list the parties and their relationship to the project in the eyes of the problem owner. Adjustments can be made later.

2 Short stakeholder brainstorm (10 minutes)
Take a flip-over and write down all stakeholders that come to mind (brainstorm rules apply).

3 Short stakeholder ELSI brainstorm (10 minutes)
This is a repetition of the previous step, except now try to think of stakeholders that are in each SiD ELSI8 category. This helps 'fill out' the stakeholder pool. Take a flip-over board, write the ELSI8 categories on it as large squares, and place post-its with stakeholder names in them. (ELSI8 categories are, from top to bottom, Happiness, Health, Economy, Culture, Species, Ecosystems, Materials, Energy)

4 Prioritize the stakeholders (10 minutes)
Underline all stakeholders which are either the largest benefactor, problem owner, or influencer of the project's topic.

5 Sketch and choose main map structure (10 minutes)
There's many map structures that can be used, an the structure depends on the problem at hand. Sometimes a timeline is useful, where stakeholders are mapped along the timeline of a process,



Above the final communication-level system map. While the final map may look better on first sight, maps are best kept in the earlier stages until there's a formal communication requirement. This keeps them fluid. A carefully hand-drawn map can also be more compelling than a digitized one, if its status is to invite people to participate.

history or development trajectory. Sometimes a geographical map is useful, where stakeholders near and far are mapped. In others, and most cases, a spiderweb context-relationship map is most useful. Sketch ideas about what maps are useful, discuss these and choose the ones to start with.

6 Build map structure (15 minutes)
Execute the map structure, also with (new) post-its on a central empty sheet. Often, it's best to start out with a context-relationship map. This type of map shows the relationship and priority between stakeholders. To start with this, take a new flipover sheet and write the name of the project's focus in the center. Write the primary stakeholders on a post-it and place them close to the center. Grouping these primary stakeholders where they are 'close' in relationship (E,g. government entities, private entities, businesses, invidivuals, benefactors vs sufferers, etc).

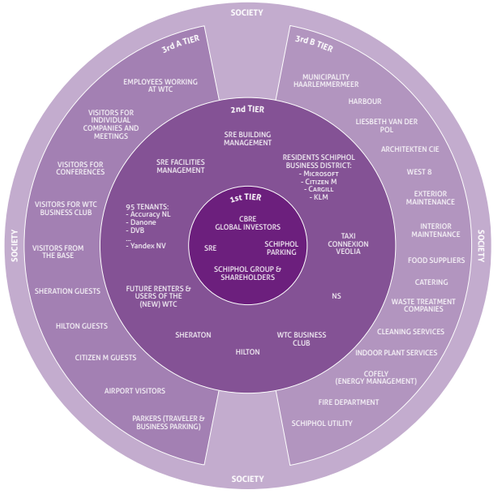
When starting with a timeline, write a long line on a ladscape-oriented flip-over sheet. Identify what the scale of the map is (proces lenght, years, decades, 24 hours?), and fill the map from left to right.

A geographical map starts with a sketch of the actual geography that's relevant. Also here think about scales. Is it just local, regional or even the world? Perhaps make several maps at several scales?

7 Refine map (30 minutes)
Add stakeholders that are related to each of these central stakeholders outward. For example, when investigating a supermarket, a primary stakeholder is a supermarket's supplier. A secondary stakeholder is the supplier of this supplier. Or their investors. Draw connections between primary and secondary stakeholders with lines.

8 Iterate
Look at the resulting map. Is this a clear map? Is its structure revealing or creating clarity? If not, consider using a different map type. Or reclustering the primary stakeholders. Each iteration consists of the above steps. Some can be done very quickly (do we need more or a reevaluation of who the stakeholders are?), some may require a redrawing of the map.

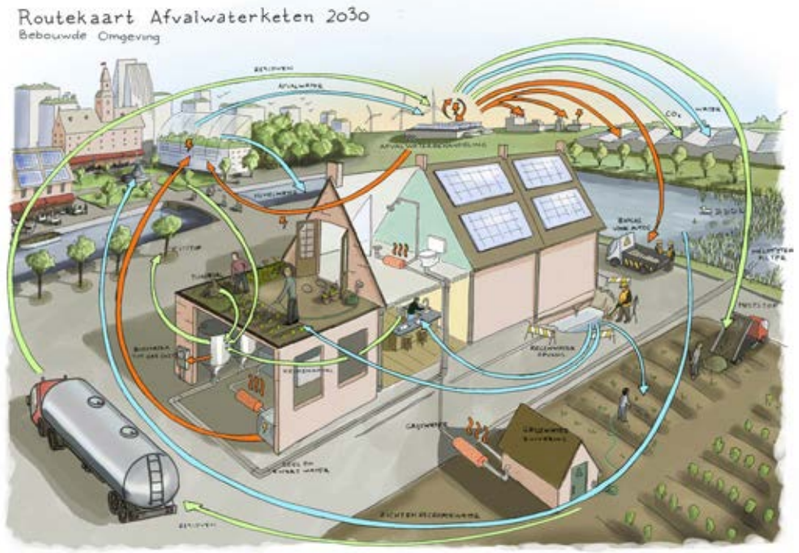
9 Try to let your creativity loose and experiment. It's okay to make a rubbish map first. This means you've learned what doesn't work. In the end, a good systems map is revealing on its own. But, remember that the most important part of system mapping is the process itself, in which you and your team become the master of the subject.



Another example of a 'formalized' stakeholder map. While it looks presentable and clear, the lack of relations between the stakeholders does not necessarily increase insight.



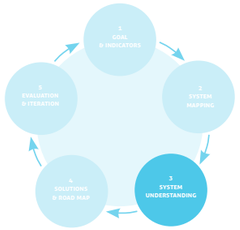




To help make the waste water system in the Netherlands more sustainable, we developed the SWIG serious card game (Sustainable Waste Water Innovation Game).

The card game allows stakeholders to explore and learn about a wide variety of methods, technologies and relationships.

Developed for DNV, game design by Tijn Schmits.



2.3 STEP 3: SYSTEM UNDERSTANDING

Now that we've mapped the system, it's time to take a step back and try to understand what's going on. How does the system behave? If you pull this lever over here, what will happen over there? This phase involves experimentation, discussion, and contemplation to get acquainted with the system, in order to define steps we can take to improve it.

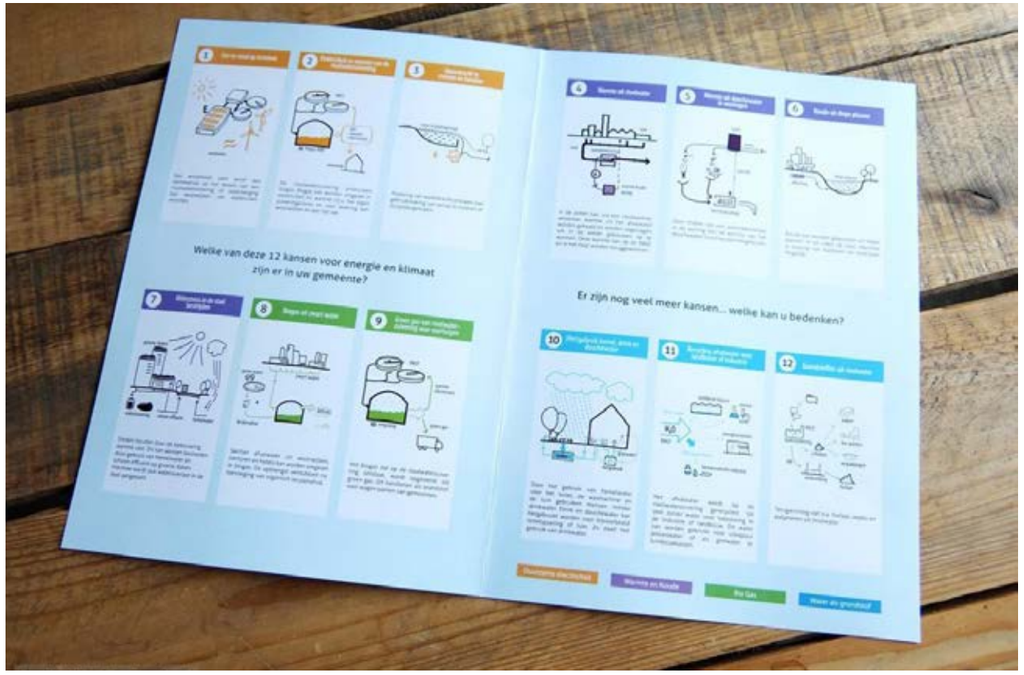
The central focus of this step is intuitive understanding of the system through immersion, using the knowledge of the maps you've created. Through this immersion, the system starts to become a living mental thing for you. Through this, you'll develop a feeling for the dynamics of the system and get a sense of how it's all connected. In this way, the bottom-up created system maps and top-down system understanding are able to meet, generating deeper understanding of the system.

In our experience, this mental process is powerful and leads to the required insight from which steps to improve the system emerge naturally. Yet this process can be hard to describe, just as describing how to get an 'a-ha' moment is difficult. What we know is that opening the mind after mapping the system generates a natural feeling for its dynamics. You reflect about it, you talk about it, you play with it. Our brains have evolved surrounded by complex systems, and we are in tune with their behaviors and patterns. To be able to recognize patterns and obtain an intuitive understanding of the system, time and mental space are crucial and change of scenery and context might help. 'Immersing' yourself in the system can be done by:

- Relax & reflect (take a walk, let it rest)
- Play & learn (make a game out of it)
- Talk & reconsider (focused open discussion rounds)

The process entails both solitary introspection and group discussion. Mental rest is required, and is not optional. If the project is small and you personally have mapped the system, there's a chance that you've already developed a deeper understanding of the system while mapping it. In most cases, that luxury is not available, and a group of people needs to understand what's going on, or the system is too complex to figure out entirely by yourself. Especially when working in groups, the following methods are valuable to create a general and shared understanding among the team members.





RELAX & REFLECT

The story goes that Archimedes had been plotting on a complex math problem for days, and finally his wife drew him a bath and forced him to relax a little. In the bath, he finally figured out the solution. He had uploaded all the required data into his brain, couldn't figure it out by 'thinking', and just needed some down time to let his subconscious work with it. When he figured it out, he famously yelled 'Eureka!', the term forever associated with this "a-ha" moment. Do as Archimedes did: Have some down time. When you're with a group, take a day or half a day off and process all this complex data by not thinking about it. Walk in a forest, go knitting, work in the garden. Whatever it is, make sure it's mentally light, physically relaxing, and distracting. Nature is a great place to do this.

PLAY & LEARN

Playing with a system is one of the most intuitive ways to figure out its character. If you have access or find a way to play with the system, using a card game, a creative process or otherwise.

SERIOUS GAMING

For complex social, policy, and economic issues serious gaming is a powerful tool to explore a system. For example it can investigate how international stakeholders can influence a carbon tax credit system. These games may allow a large group of people to explore a highly-complicated issue over the course of several hours, or even days, and have everyone walk away with an intricate understanding of its details, workings, and possible solutions pathways. These games may be aided by specialist serious game organizers that can help unravel the system and turn it into a dynamic, playable simulation of the topic. If the project is of the type where this may be relevant, and the resources are available to do this, it's a highly recommended way to explore a system.

CLIMBING THE MOUNTAIN OF UNDERSTANDING

This mental exercise helps to gain an holistic understanding of the system. The essence of the exercise is to walk from an object perspective to a systems perspective and back again. This exercise makes you raise your thinking from the material level of our reality via the interrelations of the network towards the systems level where everything is connected. From the systems level you have a wide view over the entire system where you can explore and scan the horizon. You then descend down to the object level again with new insights and learn how these manifest themselves on a material plane.

ROLE REVERSAL

In projects where stakeholder interaction has a strong presence, it is useful to play games where one takes the position of a particular stakeholder and tries to maximize this party's interest in interaction with others. This can be done for example through conversation, games, and written exchange.

SIMULATION

For projects that deal with vast amount of resource flows, processing and technical operations, it may be possible to develop functioning simulations of parts of the system using computer simulations. For instance, when designing a building, using thermal analysis software may lend us insight into the functioning of the heating systems. This should also be seen as 'play', because you can't truly model complex system, but you may well experiment with computer models and see if they help gain insight.



Going outside, and exploring the system and the challenge physically is a great way to help process them. A group walk already works wonders, but there are also specific group exercises that can be done to explore different aspects, such as network relations.

In SiD training weekends, these exercises are also used to help increase understanding of systems thinking in general. On the left, a group explores the importance of Connectivity, Transparency, and Awareness parameters on the dynamics of a group.



Large scale system mapping in a group is also a way to help understanding. On the left, a group at Brighton University in the UK map the persistence of homelessness in the city, and ways to counteract the dynamic systemically.

The team made initial system maps. Then, the working components were combined, expanded, improved, and deepened in sketch form. Finally, a story is created in large scale presentation format to communicate the solution.

WALK DOWN SID ROAD

To gain a better overall understanding of a system, walk down SiD's object, network and system indicators one by one, and probe them with 'what if' questions. What if you want to increase transparency in the system, what does that mean in the system's context, and what would it result in? What are the strongest drivers for resilience? How do the ecosystems of the topic at hand influence the diversity of the system's network? Ask many questions, probe the system, poke it and see how it responds in your mind. When you're with a team, you can do this in a structured fashion, by going down each parameter one by one, and discussing what each means in the context of the system.

TALK & RECONSIDER

Discuss the system with others; perhaps try to explain it to someone that's not initiated into the process to try to find the words to express it. Many realizations will happen when talking to someone you respect and appreciate for their insight. Depending on the system's complexity and size, you might want to call in some external colleagues and experts in the various aspects of your challenge to discuss what's going on in its subsections, so that you can put one and one together and reflect on the insights you found. For larger projects, the system mapping is often performed by experienced mapping experts, and not the whole team is up to snuff with the details. In that case the whole team needs to come together to discuss the maps made, and explore the system.

Once you've 'immersed' yourself the system, you'll have developed a thorough understanding and comprehensive system-perspective of the issue at hand. You can measure the acquired experience with the behavior of the system against object or network parameters, and ultimately, the goal of the trajectory on a systems level. By doing this, you'll develop a feel of what will happen to the state of the system if you change an object or network property. Once a decent understanding of the system has been established and solution space has been opened, it's time to move on and map a route from where the system is to where we feel it should go.

VSM BOTTOM UP NETWORK MODELING & ANALYSIS

A great tool to help understand network relations from a bottom-up reductionist perspective, and worthy of mentioning here, is a tool called the Viable Systems Model (VSM). VSM has been developed by cybernetician Stafford Beer, and published in 1972. It is especially useful for rapid analysis of organizational structures, internal logistics, supply chain complexity, and other finite network structures. Because VSM has been in development for a long time, there are many resources available to learn and apply it. VSM can be combined with SiD's qualitative network and systems analysis approaches, and can be used to set up and perform a quantitative analysis on selected network parameters.









2.4 STEP 4: SOLUTIONING & ROADMAPPING

In this step, we find opportunities that reach our goals, and boost the performance of the system. We scan for actions we can take that help to achieve this, like ingredients for a meal. We then make the recipe for the meal by mapping and combining selected ingredients in the roadmap. Developing the solutions and making the roadmap are usually done in different method cycles.

We'll provide you with some tools to help you find and optimize solutions towards sustainable systems. This is not an exhaustive set, there are many other tools available, from design and engineering fields for example. If you know any yourself, be sure to try them out. In this chapter, we cover:

- 2.4.1 System solutioning approaches
- 2.4.2 Network solutioning approaches
- 2.4.3 Object solutioning approaches
- 2.4.4 Roadmapping

2.4.1 SYSTEM SOLUTIONING APPROACHES

There is a number of approaches to take when finding system-level solutions. Some build from object level upwards to a systemic understanding, others use network theory to try to reach a top-down systemic effect. In practice, you often find yourself using some bits and pieces of one approach with some of another to meet up with the specific requirements of your project.

Below we discuss the following approaches:

- Block Transition Strategy
- Before/After Solution Maps
- Largest Factor Approach
- Internalizing External Resources
- Re-visioning
- Training the system

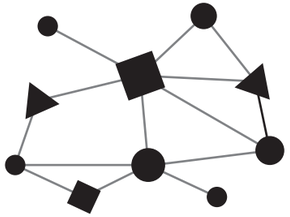
BLOCK TRANSITION STRATEGY

When we see that a socio-economic system is not in a sustainable state, and we want to 'move' it towards sustainability, we can harvest useful actions to take by making use of the block strategy. It's a strategy that can work very fast, and requires little knowledge or experience to successfully apply. The block strategy uses a metaphor of blocks on a table, connected by rubber bands, that we want to move towards a certain goal. For example, we can move the blocks one by one, and have them pull each other towards the goal, or we can tilt the table to move all of them at once. This approach helps to scan the system for transition actions, and forces us to consider that transition usually requires a variety of approaches by different actors, rather than a singular one.

GET STARTED

Imagine a group of blocks on a table, connected by rubber bands to each other. The blocks represent agents in our system, and the rubber bands are the network connections that tie society together. The blocks are of different sizes and weight. We want the group of blocks to move towards a more sustainable state, which is somewhere else on the table. To scan for actions to help do this, go through the following steps:

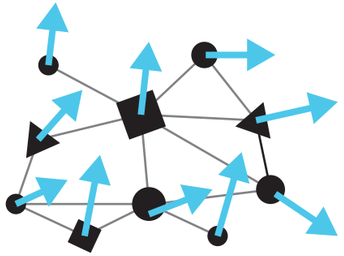
1. Determine the agents; understand what the blocks are (system mapping, stakeholder map).
2. Create awareness: the majority of the blocks need to be aware that they should move to a sustainable state (prevent unnecessary friction).
3. Align Goals: among the agents in the system, there should be a general agreement on where on the table the system's sustainable state is, so they all try to move in the same direction (goal setting).
4. Enabling actions: helping the system to move with a variety of actions (roadmap activation).



1. DETERMINE THE AGENTS

If you didn't already map the stakeholders in the system mapping method step, do this now. Map a rough understanding of the major actors and players in the system. Also, in the case of industry, it is useful to make a supply chain map, with the relevant actors along the chain.

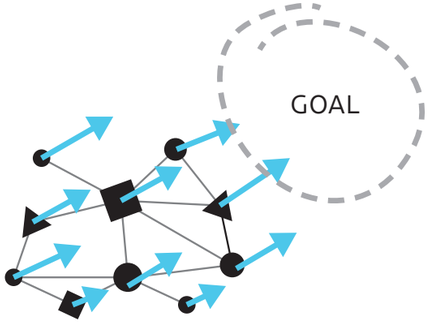
Figure out what the goals are for each major player, and sketch the major relations between the actors.



2. CREATE AWARENESS

Awareness creates the desire and knowledge for actors to move their positions. It develops internal 'change energy' in each agent. Some agents may already be aware, but others may not. Giving those that are not yet aware this change energy helps to create willingness for action. Prioritize the development of awareness for those key actors that can influence the system in some way. Awareness also activates innate tension and the self-propelling power of many agents. This means that creating awareness in agents that were not aware before may make some of these agents move on their own accord. Not all agents will become aware, nor do they need to be. Once the system moves, they will move with it.

As more key agents become aware in the system, a focus on awareness becomes less important. It becomes more important to make sure they all move in the same direction (in step 3).

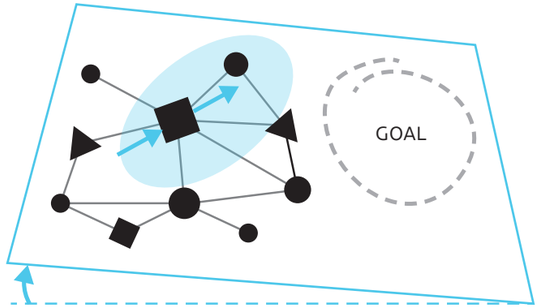


3. ALIGN GOALS

Aligning goals between the actors is important to ensure they all pull in the same direction. Otherwise, they may nullify each other's energies by pulling in opposite directions. As you can imagine with the blocks on the table, if a few of them are pulling in the wrong direction, it's hard to get the system to a specific point on the table.

Doing this is also a good opportunity to build a community of agents following the goal. The actions that typically help align goals are stakeholder sessions, or the creation of standards, such as the UN SDG's.

If the system has a fair number of actors pulling on the system, but it still isn't moving on its own accord in the right direction after this, or isn't moving fast enough, we need to increase our efforts. Perhaps there's too much friction for the blocks to move, or a number of blocks holding the others back. This is what we'll address in step 4.



4. ENABLING ACTIONS

When sufficient blocks are aware, goals are aligned, and some agents are pulling into the right direction, the system could be moving in the right direction. This could be one heavy block dragging everyone along behind it, or a lot of small ones doing the same, or, ideally of course, every block moving in concert. But, as is the reality in many cases, the system may be held back by a large group of heavy agents that are simply not all that interested to move. Basically, the movement of these blocks is too slow, and their mass holds everything back. So then, there are a variety of actions to enable us to move them; push, pull, lubricate, and tilt the table.

Pull action: Let the aware actors pull on the rubber bands to make another block come along. This may be a financial incentive, trade deal, some marketing benefit, or the creation of some other 'attractive' carrot.

Push action: Find a way to push the actors; the stick. Regulation, fines, confrontation, etc.

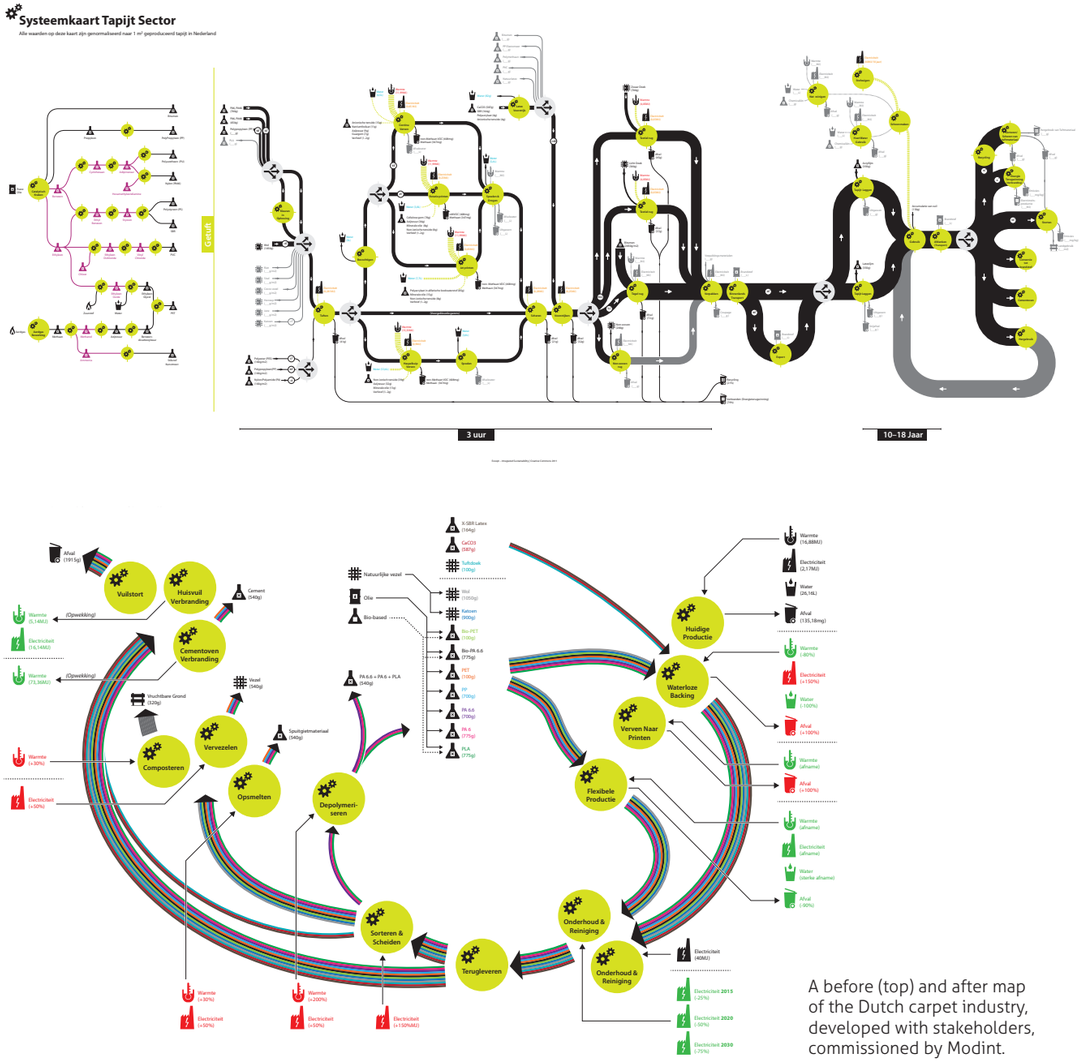
Lubrication action: Smooth and lubricate the table, so that there's less friction for each block, and less force is necessary to move the blocks. This can be achieved, for example, by providing best-practice examples that show that moving is possible and attractive. Or, to make tools to help the agents calculate how it's in their best interest to move. Also, it helps to set up guidelines and other practical tools that help save people time and effort.

Tilt the table (Systemic action): angle the table, and the blocks will all slide in the direction of the goal. Finding a systemic action is the most effective way to achieve fast transition. Care needs to be taken that the blocks don't overshoot, hit one another, etc, since systemic action can be disruptive. Systemic actions can be anything that changes the whole playing field, for example by changing (international) laws, or with breakthrough innovation.

PUTTING IT ALL TOGETHER

When looking at a transition challenge, clearly identify the actors that are able to exert influence on the system. List which actor can do what, and align these actors to enable a combination of push/pull/lubricate. Find systemic actions where you can, but this approach also works without them. More approaches to find systemic actions are listed further along this section.

When you have your set of actions, you have your 'ingredients'. To use a different metaphor here, when you have the ingredients, you need to make the recipe to cook the dish, which is the roadmap. The recipe tells you how much to add of each ingredient, at what time, in what way. Typically, you map the awareness actions first, the goal setting actions second, and the enabling actions after, in a step by step process.



A before (top) and after map of the Dutch carpet industry, developed with stakeholders, commissioned by Modint.

BEFORE/AFTER SOLUTION MAPS

Solution maps are a great tool to help resolve complex issues and consider the full complexity of the issues at hand. They especially works well in complex stakeholders trajectories. These maps are akin to the 'before' and 'after' pictures of a weight loss program. We take a map of the existing situation, and then make a map of the desired state of the system. With these two in hand, we can see (and clearly communicate) what are the benefits, what is needed to get from the current to the future state, and then trace each step to put in the roadmap. We can plot the stakeholders on these maps to see which parties contribute to what transition process, and start to weave a coherent story where the whole system is activated to realize a positive movement.

For example, when working on an area development, we may want to make the areas energy self-sufficient. When we map the current energy system it may not be apparent as to how we can achieve this, since all we'll see on them is the existing energy infrastructure. However, when we draw a map of the neighborhood's 'ideal' energy system as self-sufficient, we are presented with clear new questions. Which component of the exiting system can transition into what components of the new system? In what order do we execute these changes to maintain safely operating energy supply? Which party is responsible for what part of this transition? This process leads to core solutions and a roadmap in the process of answering these questions. Making multiple maps to test a variety of scenarios is recommended, as it increases the likelihood of finding an efficient solution.

See also the before/after transition maps made by DRIFT on page 206 and 207 for a great example.

LARGEST-FACTOR APPROACH

Sometimes it helps to first reduce the numbers of ingredients you work with to get oversight and prioritization in the process. To determine what levers in the system are most influential, we can perform a largest-factor exercise. In this exercise, we ask two questions:
1) Which factor or element in the system contributes most to the overall negative and/or positive performance of the system?
2) Which actors and/or aspects have the most potential in changing the state of the system?

These 'largest factors' can be both objects and relationships. You can use an ELSI Sweep to help inventorize the actors and relationships (see the tools section for details). You can use a network scan to find network level levers, and see what contributes more or less to the RAH indicators. There's many way to do this, try to experiment to see what works best for you for your challenge before committing to a thorough process.

INTERNALIZING EXTERNAL RESOURCES

Resources that flow into our system from outside of the system, may improve the autonomy of the system if internalized and made renewable. If energy, materials and/or water is sourced outside of the system from other areas, try to internalize them.

RE-VISIONING

This is a thought-exercise that examines the validity of the goal in a systemic context. Is the goal that was set for the project really the best thing imaginable given the resources and abilities of the topic at hand? If a factory is making trinkets, and it's really great at making detailed objects, can it have a greater system level effect if instead they made medical equipment that's necessary in the local area (for example)? Is it possible

to, when the goal of a certain policy is poorly thought-out, remove an already-existing law thereby actually making way for the desired development rather than making a new one? If the goal of the project includes making a physical object, such as a building or product, can you achieve greater effect by doing something non-physical? Answering these questions may lead you to re-evaluate the goal of the project and have a much larger overall positive impact, with less investment.

TRAINING THE SYSTEM

This approach is for advanced system thinkers that are well-versed in system dynamics. The challenge in this approach is to find system behaviors that can 'boost' the transition of a system towards its intended goal. For this purpose, there needs to be a clear picture of the 'before' and 'after' state of the system for the team. Then, incentives motivating the system to move from one state to the other need to be found, as well as the thresholds holding the system back. Questions to explore are:

- What levers are there to engage systemic behavior?
- What beneficial system dynamics can be found with these levers?
- How can this process be accelerated?
- What parties are involved in making this a success?
- What are the motivations for these parties to participate?
- What secondary system behaviors may we expect?

2.4.2 NETWORK SOLUTIONING APPROACHES

For network-related questions, such as in transportation or energy networks, conducting a network resilience analysis can show how to make the network more efficient while strengthening it at the same time. This network analysis may show bottlenecks in the flow of information or other resources that can be improved through a new way of understanding the network. You can use network analysis software or system modeling tools to help you find specific issues, or use the Network Parameters to do a quick scan, explained below.

OPTIMIZING NETWORK PARAMETERS

Given a set of network parameters (such as the CRAFTDCCV set), solutions are often easily found by contemplating each parameter and attempting to optimize it. You can use the network parameters and review these one by one, asking specific questions for each, such as "Where are the main nodes of a system; can it be made more decentralized?" or "What does transparency mean in this network, and where are its improvement points?". These can then be related to the system indicators to see if any possible actions on the network can make an improvement. For instance, given a company, its autonomy can be assessed by doing a material flow analysis on its operations. We can see what happens if one of its supply chains is cut, be it in primary resources such as electricity or materials, or in cultural resources such as staff, employment motivation or the presence of certain laws concerning its operation. We can then find which lines may affect autonomy or resilience the most, and use these to prioritize our actions.

This process of attempting to optimize parameters can be used for all system and network parameters. In case of the organization, this often leads to re-evaluating the structure of the organization as a whole. This may lead to massive gains in efficiency and productivity, while lowering resource use, increasing employee happiness and improving work conditions.

2.4.3 OBJECT SOLUTIONING APPROACHES

GAP FINDING & CLOSING LOOPS

This approach is about finding gaps in the system (missing connections between different objects), and connecting them to create closed loops. This will increase the autonomy of a system while saving resources. Examples include connecting heat wasted in one place to where it is needed somewhere else in the system, or making the waste from one factory useful in another factory. It's not just about creating new connections, sometimes it makes sense to reroute an existing connection to increase efficiency.

Sometimes the largest benefits can be achieved by changing the layout of a system. For example, by re-organizing departments of an organization, transportation may be reduced, connectivity increased and resource usage minimized. Doing this requires good system maps that show the flows in the system, and possibly an additional refinement of the system maps.

OBJECT CULLING

Closely-aligned with gap finding and the largest factor approach is a process of object culling. Which elements in the system are superfluous or can be combined with others to simplify the processes involved? Which objects are detrimental to the system, and which ones are highly appreciated? Remove the ones that are detrimental, replace them with beneficial ones if necessary, and make more space for the ones that are valued.

SYSTEMIC EMBEDDED DESIGN, BIOMIMICRY & OTHER OBJECT STRATEGIES

If a new object has to come into existence in the system, for example with product design, you can work from a system perspective to develop a solution that

is strongly embedded within society. To do this, you can take the SiD tools and system dynamics guidelines as departure points for your design, and see where in the system you can have the most positive effect with your object. A common way of doing this is by developing a vision for backcasting. This means to project the idea systemic situation, for example by making your system analysis maps in a 'before' and 'after' state, and then figure out step by step on how to get to that future ideal state over time. The backcasting approach is explained in the tool section in more detail. Other useful tools to look at embedding solutions into a systemic context are to follow the biomimicry rules, which are a set of guidelines that help to learn from and connect with natural systems. Also, the twelve rules for green engineering may be helpful. Both of these guidelines are covered in the tools section.

ALWAYS DEMATERIALIZE

Remember when developing solutions, that we don't need to introduce more objects to reach a sustainable state of our society. In most cases, it is possible to find a non-material solution to your challenge. If you are working on an object, as a given, consider what objects your object replaces. Are you achieving a strong systemic effect with your new object, or object intervention? Or are you only marginally improving on the object level? If so, is there a danger of the rebound effect or other system behaviors making your efforts futile? If these considerations are present, perhaps reconsider your strategy to find a solution that works on the network or system level instead.

Once you have some solutions, you can evaluate them in the next step to see if they actually do what you hope they do. Or, you can go ahead and start making a roadmap to making the solution happen,

2.4.4 ROADMAPPING

When you have developed one or a number of solutions, or a central solution strategy, it is time to start making a roadmap to achieve that solution. A roadmap is the plan that will lead to implementation and success of the solution, and without it, you may not succeed. In many cases, the solution is the roadmap itself, for example, when performing a sustainability improvement trajectory with a company. For others, where stakeholders determine the success of a project, the roadmap is the central glue to the co-creation process that helps stakeholders align, agree with, and support the trajectory over time.

Making a roadmap happens after several rounds of the method, and is a phase of convergence. This means the roadmap is not used to develop new ideas so much as to select and eliminate, map, and plan them in time. A roadmap consists of a long term trajectory (e.g. 5-50 years), and a short term action plan (3 months - 3 years). This helps to focus, concretely divide tasks, set responsibilities among parties, and meaningful milestones.

PLANNING FLEXIBILITY

Roadmapping is an exercise in planning a systemic change in time. Because we can't predict what will happen over larger time spans, roadmaps need to be flexible. We adapt the roadmap over time to the system's responses to earlier interventions, as well as external influences such as new developments in technology, trends, and shifting of perspective. The way we do this is to map the measures to be taken in the near future (the action plan) with firmness, while those further in the future more flexibly and globally. Then, program in a review and roadmap update cycle in the action plan.

S, M, L, XL?

A roadmap differs greatly depending on the size, scope, and ambition of a project. For a small community project, it may consist of only a few steps, for a short amount of time, and may not be more than a few bullet points with some time frames and role divisions. On the other end of the spectrum, a multinational company improvement program may span decades, involve hundreds of stakeholders, and require a full time team to help manage along the way. Despite their diversity, the basic essentials are the same. Therefore, we hope the following tips are helpful in all cases.

USE PENS AND COLLABORATE

Start a roadmap on paper or on a whiteboard. There are great time planning tools available, such as Gantt charts, and Kanban boards, but these restrict roadmapping in ways you may not notice. Paper is unbeatable in setting up an initial roadmap. Once a main structure is set, and the main items planned, it may be useful to digitize the map. In our practice, we usually maintain both a digital and a paper map throughout the project. Paper invites collaboration in ways a digital map does not.

THE ROADMAP AS A STAKEHOLDER TOOL

In projects where stakeholders play a deciding role, the roadmap may be the main subject of the entire SiD trajectory. In those cases, the roadmap is best made with the stakeholders in co-creation. A core team prepares the project, researches data and stakeholders, invites them, informs, and guide the stakeholders along the way. This process is covered in the process chapter. We focus here on the actual document that a roadmap can be, its basic framework and ingredients, and some useful tips at arriving at a good one.

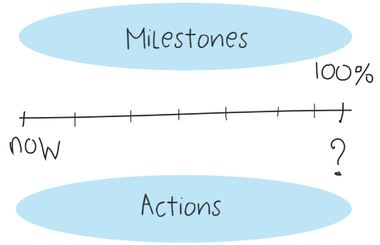
TEN STEPS TOWARDS A ROADMAP

The following ten steps are a good way to quickly work towards a roadmap. Even for a complex challenge, making a first pass at a roadmap can be done in a few hours to figure out its main structure. Team members can all work at the same time to plan items in time, and then step back together to review, and repeat this process a few times. Making a roadmap in the first pass is usually best done on a flipover, a whiteboard or, for big projects, a large paper covering a wall.

The ten steps, in short, are as follows, expanded on after:

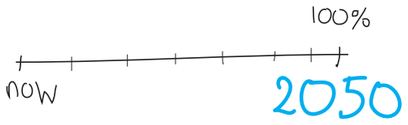
1. Draw the global timeline
2. Place the end-goal (set ambition level)
3. Review ambition of the goal in time
4. Map main solutions on the timeline
5. Cluster/arrange solutions in channels, e.g ELSI
6. Identify and solve missing steps
7. Identify transition phase for solution/channel
8. Identify responsible parties for solution/channel
9. Set milestones/reporting at intervals
10. Set an action plan, and evaluate

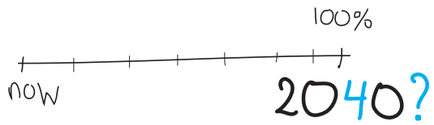
After this, the roadmap can be formalized, documented, shared, or whatever is appropriate in the process.



1. DRAW THE GLOBAL TIMELINE

The timeline always starts at today, and ends at the project's 100% success. When that is, determines the project's ambition. Draw a line on the paper from now until the timeframe you estimate the end of the project to lie in (e.g. 1 year, or 10, 20 years). This may coincide with the time frames explored in the system mapping exercises. Mark its years/months in between. If you draw the timeline in the middle of the paper, you have two sections to separate items on the timeline. For example, you can use the top section for performance goals and milestones along the way, and the bottom for the actions required to achieve them.





2. PLACE THE END-GOAL (SET AMBITION LEVEL)

Setting the 100% success point of the project is the single most important performance factor of the project. If the project goal was set in step 1 to include a time frame, then this is it. If not, next time when visiting the goal, make this is a main point of discussion. When making the timeline, it's possible that insights arise that require this goal to shift, to make it more or less ambitious. Therefore, discuss in step 3:

3. REVIEW END-GOAL AMBITION

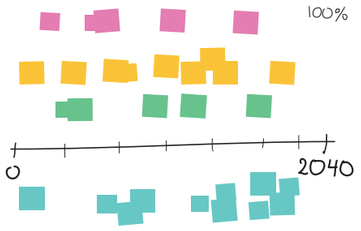
Take a moment to reflect with the group on the project's goal in its time frame. Think about everything that needs to happen, whether or not you think it's realistic enough, and if not, move it further back. Alternatively, think about the ambition. Do you want to be a world leader? Or just follow the pack? If you want to lead, set the ambition high, and make the timeline shorter. Also consider 'overstating the goal', as explained in the theory section on page 201.

Determining in what time frame to set the project's goal is the single most impactful decision the project will have. For example, making the entire world run on renewable energy sources sounds ambitious. But when you set that goal in the year 2150, nobody's going to be very impressed. 2050? That will ruffle a few feathers. Taking this as an extreme example, it shows that simply moving the time frame of the project's success is the determinant of the project's ambition level. As the famous saying goes: "A goal without a deadline is a dream.". You want to change the world? Set a deadline.



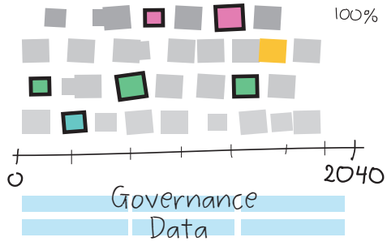
4. MAP SOLUTIONS ON THE TIMELINE

Gather the solutions made in previous iterations, write them on post-its, and place them on the timeline. If there is just one 'solution', then that is the 100% goal, and you can skip to the next step. Usually though, there's a whole range of solutions that together make up the ambition. For example, when creating a sustainable city, we need solutions in transport, energy, water, biodiversity, education... you get it, the ELSI stuff, the network stuff, all of it. Write these on post-its and stick them on the timeline where you think it's appropriate. This is a great group exercise as well. Be sure to review this with the group too, as there will be madness going on.



5. CLUSTER/ARRANGE SOLUTIONS IN CHANNELS

If the solutions have not yet been filtered, e.g. the result of a raw brainstorm dump, cluster the solutions by finding similarities, for example along ELSI lines. When you've done that, eliminate duplicates, review the clusters with everyone, and eliminate the crazy or unwanted outliers. For projects with many small items, it may be useful to replace or container whole clusters with single over-arching 'cluster' solutions within channels. This way, a single roadmap can have many projects nested under it.

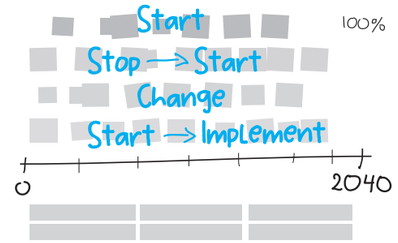


6. ADJUST, IDENTIFY AND SOLVE MISSING STEPS

Your clustered solutions are now on the roadmap. Order them neatly in time, to make sense for each cluster or channel. Reviewing them, you might see that there's important steps to take for each solution to happen that should be in the roadmap. No need to go into crazy detail, but critical steps that take effort and management should be placed here. For example, a solution could be for a circular product to replace a non-circular product in a company's lineup. A new product doesn't fall out of the air, needs to be designed, and perhaps an investor needs to be found before that. Or, a certain step will require a stakeholder session, which needs to be planned and prepared.

At this stage, it may be helpful to add roadmap governance channels that cluster certain universal overarching tasks. For large sustainability projects, typical roadmap management channels can include:

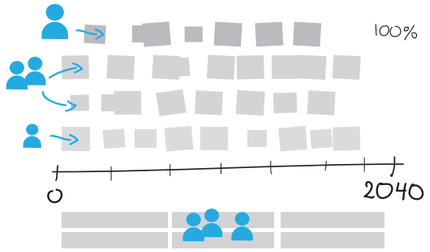
- Governance (Mgmt, Funding) & Stakeholders
- Data management, collection & tooling
- Reporting and Communications
- Guidelines and Training



7. IDENTIFY TRANSITION PHASE

For advanced roadmaps for transition projects, set transition phases for each channel. For each solution channel's items, identify what transition type they are from the ones described in the transition chapter. For example, to start doing something, stop doing something, change, or replace (or your own). Perhaps, make a transition map, if that helps. Make sure that these types are clustered, and that the right management actions are in the governance channels to support each cluster of actions.

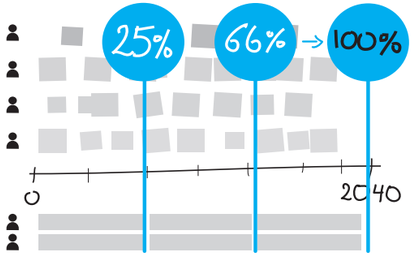
For large projects, it may help to set different teams for each transition type. Transition types can benefit from expertise within its transition type in the team. For example, managing a 'change' process is fundamentally different from managing a 'start' or a 'stop' process. Having a team member on board familiar with change processes helps if that is the predominant transition action.



8. IDENTIFY RESPONSIBLE PARTIES

The roadmap is now done in terms of content. Now, parties should be identified to take responsibility for each channel or solution. If you do not do this, chances are, nothing will come of it. At this point, responsibility needs to be set and agreed. For large stakeholder sessions, this process alone can take several sessions, meetings, and bilateral in-depth sessions to figure out party lines, responsibilities legal issues, etc.

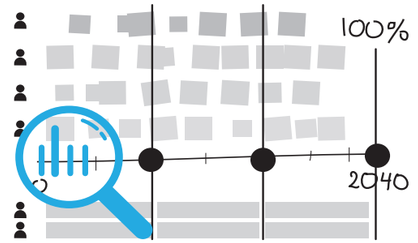
With this, set a governance structure as to who reports to whom, in what fashion, and on what intervals.



9. SET MILESTONES AND REPORTING INTERVALS

With responsibilities and governance set, it's time to determine how often a project evaluates along the timeline, and commits to milestones. For large projects, such as city of company transitions, the roadmap may span decades. In that case, set a reasonable milestone cycle that hooks into the existing management cycles of the involved organizations. For example, starting and ending with the company's fiscal year, reporting coinciding with yearly management meetings, and so on. Milestones may then be every so many years.

Performance milestones may help. For example, towards the 100% goal, divided in 3 periods of 5 years, at the first milestone you'd like to achieve 33%, and 66% at the second. You can use this to curve the difficulty of a project as well, by making the beginning milestones easier, and later harder, this allows for an ease-in of a project.

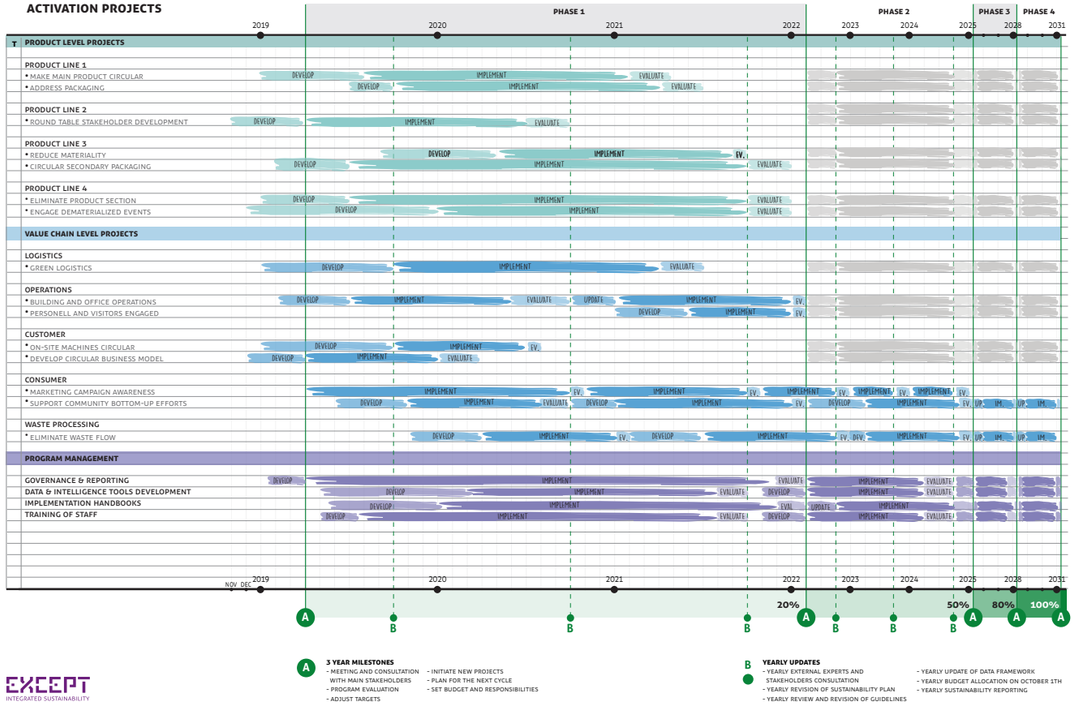


10. MAKE ACTION PLAN AND EVALUATE

The roadmap is now finished. In order for the roadmap to start rolling along the timeline, a short term action plan is made to kick it off. This may include processing and documenting the roadmap, final approval of stakeholders, PR and communications, starting management actions, and so on. The end of the action plan is best set as a gathering of all relevant stakeholders, in a meeting that evaluates the process until then, and set a new action plan. Depending on the complexity of the project this point may be at the first milestone, or sooner.

The action plan should focus on unambiguous, concrete and transparent actions that each player can execute independently. Usually an action plan spans a few months to a few years maximum. Set any required meetings that can be foreseen, such as management approvals, and important stakeholder gatherings as part of the action plan. Then organize a kickoff event, and... well, kick it off.

EXAMPLE: MULTINATIONAL ROADMAP



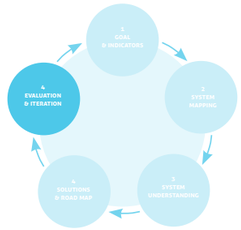
EXCEPT
INTEGRATED SUSTAINABILITY

The roadmap on the left is an anonymized real-world example of a roadmap developed by Except for a large multinational organization that produces consumer goods.

This is a top-level roadmap, where each item line has its own sub-processes. It uses 4 milestone periods of 3 years to cycle its way towards 100% goal performance. This results in a 12 year ambition plan. Each 3 year cycle the roadmap is revised with stakeholders (indicated by A's). This roadmap version splits the actions into four product levels (green), five life cycle stages (blue), and governance actions (purple). Each of these items is budgeted, its impact assessed, teams assigned, and tracked individually over time. The timeline is made non-linear to focus on the next actions to come, while still showing the entire trajectory.

This map is supported by a company life cycle map (a context material-flow type map) indicating where each roadmap action intervenes. An action plan is drawn up as a separate text document, covering all short term actions before the start line. Roadmaps such as these are vital to maintain oversight, coordination, and a long term perspective on transition processes.





2.5 STEP 5: EVALUATE AND ITERATE

The evaluation step reflects on the activities of that cycle, compares the solutions to the goals, and determines if they were successful and whether another method cycle is necessary. This evaluation step can be different for each cycle, and is just as much a combination of creativity and analysis as the other steps. For larger projects it can be valuable to set up an evaluation system that tracks progress and provides running feedback on the performance of the project.

The evaluation stage may reveal that the goals or boundaries were set incorrectly, and result in their adjustment before executing another cycle. This is also the point when research questions may be formulated for a separate trajectory or future use.

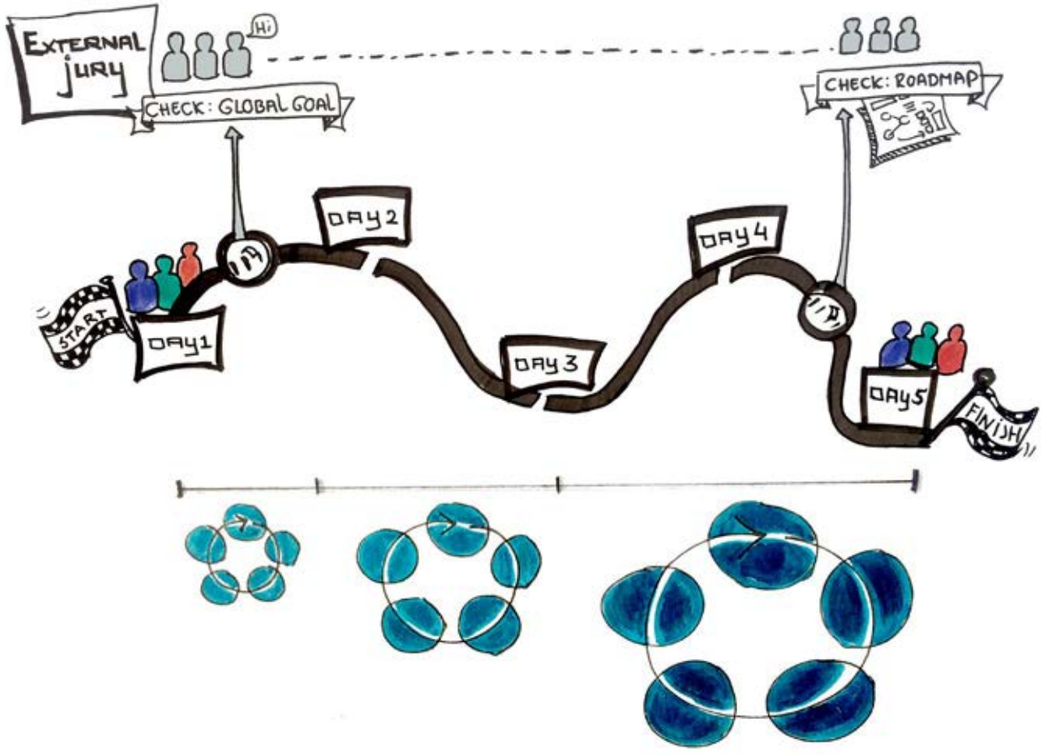
Evaluation has a different nature at each different stage of a development cycle. In the beginning, evaluation may only estimate whether the process is going 'in the right direction', whereas in later stages it may be an extensive process of checking details against the predetermined edge conditions, indicators and goals. Setting up a good evaluation framework in advance will help you manage the quality of the process. A shortcut to doing so is to involve an additional person who is critical and experienced in the matters at hand, and have them be an outside critic of the solutions and decisions made.

METHODS OF EVALUATION

There are many ways you can evaluate, and most disciplines have their own preferred tools for doing so. Explaining all of them goes beyond the scope of this book. We list some common evaluation methods we've found helpful in most circumstances. For all of them the main question is, "Did we achieve our goals with the chosen solutions, within the chosen boundaries?". A second, but no less important question to ask at all times is: "What are potential unintended consequences of the solutions on the system and all stakeholders, and what is their impact?"

EVALUATION MATRIX

Make a list of all the goals and edge conditions, and score the found solutions from low to high for each aspect. This is especially helpful to compare competing solutions and figure out the strengths and weaknesses of each one. This may result in creating another solution



by combining (parts of) the competing solutions into a new solution. Making the evaluation matrix for the first time may also be the point where a whole new set of edge conditions and desires for the outcome is formulated. These may subsequently become part of the goals in a later stage.

SYSTEM IMPACT CHECK

What impact will the chosen solutions have on the system as a whole? Work with the entire team to formulate pitfalls, possible externalizations or system dynamics that may influence the solution positively or negatively, and see if you can make the solutions more resilient. It can be helpful to draw up additional system maps that trace the impact of a solution.

EXTERNAL EVALUATION

In larger projects, one can form a panel of experts to aid in maintaining quality at certain key points. External people will look at the solutions with fresh eyes and it's very likely they'll have insights that have not yet been considered. This does not alleviate the necessity of critical self-reflection at each stage in the process.

ITERATE OR TIME TO MOVE ON?

The evaluation step is the moment when we determine if we need an additional iterative cycle, or if we can go on with the rest of the process. In our experience, in the early cycles of the SiD method, we often realize that the goals should be redefined, that we need additional maps to answer our questions, or that we still feel 'lost' in the complexity of the project. If that's the case, we continue cycling the method. If we're confident (and enthusiastic) about our solutions, we decide to move on with the next SiD process step. These process steps are discussed in the next chapter.

MID-SESSION HARVESTS

An evaluation stage in the middle of SiD sessions helps to check if the process is going in the right direction, to cull excess ideas, and to refocus the session. This should be done several times during SiD sessions to effectively cycle through the process of both generating ideas and selecting and eliminating them.

During the facilitation of SiD sessions, it is helpful to gather the group every half day to recap the activities, and to re-list the goals, and the best ideas in the process that came up so far. Write these down on a sheet, to return to later, as a collection of 'best ideas at the time'. This is helpful to keep track of the shifting perspective of the group as the session progresses.

It also helps to evaluate the process itself at this point. You can do a formal review of the goal, the mapping, if the mapping is understood, what ideas for solutions have come forward, and/or if the roadmap is complete or missing something.

A rule of thumb is to at least perform the method cycle 3 times during a session, no matter if it is a session of 1 day or 5 days. This means, the evaluation also is performed three times. It helps if the facilitator sets up a scoring matrix or another kind of scoring tool to help evaluate the process and the content of the session with each cycle.

Another meaningful evaluation step at the end of a day, and at the end of a session, is to ask each participant to personally evaluate the process. This strengthens the understanding of each group member's perspective to one another and provides space for focused dialogue.

CASE STUDY: DESERT FLOWER

This case study is adapted from a project, executed in 2000-2001 in Western Australia.

Central kickoff question: What to do with a remote desert town in decline? A case study of a simple integrated solution process based on resource mapping, and lessons about why it didn't work the first time.

The city council of Merredin, a small desert town in Western Australia, had a problem. The town faced the upcoming renovation of an historical pumping station on the outskirts of town, and had received government funds to restore it, although not enough to do something useful with it. Since the town had no funds of its own, they posed the question: what to do?

At this time I was studying at the University of Western Australia. I had just started the first outlines of SiD and was eager to try out this new integrated approach.

We visited the town with a small team of people from the university and investigated the pump station first. While the town council focused on the historic pump station itself, we quickly realized the town had bigger fish to fry: It was suffering from economic and social decline, its infrastructure was faltering, and its younger population was leaving to seek better prospects elsewhere. It wouldn't be long before this problem got worse.

I set up a quick-scan investigation to determine the problems and resources. As part of the mapping stage, I drew up a matrix of several categories such as energy & materials, economy & culture, and health & happiness (which we later named ELSI) and went through these categories one by one. With the assistance of a few people in town, I tried to examine all the relevant subcategories I was able to find during a period of about three days. Together with some other students, we held a few interviews with a variety of people in town and because of its limited size, were quickly able to form a coherent picture of its issues and assets.

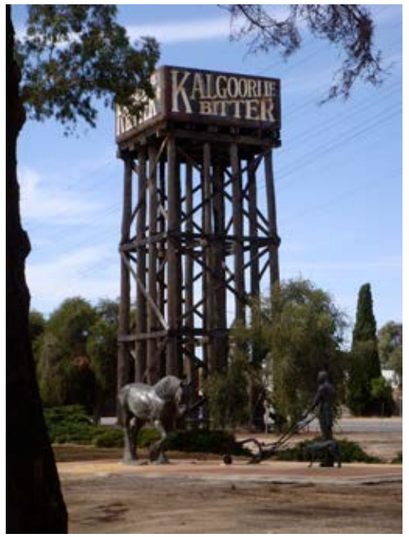
ANALYSIS: FIGURING OUT THE HIDDEN RESOURCES

Historically, the town's reason for existence was as a through-stop on the way to the mines deeper inland. It functioned as a truck-stop and supply station, offering various restaurants and motels. It hosted a small train station and maintained the water pumping station that brought fresh water from the coast further inland towards the gold mines. Over time agriculture sprung up, most consisting of wheat and other grains under irrigation, and the town had a branding strategy as a source of healthy foods. Because the mines had been established in the early colonial era, the town has an unusual rich history and accompanying cultural heritage.

Over time trucks got bigger and faster, reducing their numbers, while the town kept growing. As it goes, a system growing with a limited resource, ends up in trouble. Its largest factory shut its doors eventually, and youth left town as there were no career pathways. Its local historic theater, one of the first in the state, closed its doors.



The town of Merredin, Western Australia, with its characteristic water tower.



Below, an existing salt water basin, storing saline ground water to balance the ground water table of Merredin. On the right, the project team for the 2016 feasibility study, including Minister for Water for Western Australia Hon. Mia Davies, Shire CEO Greg Powell, Except's Camille de Luca-Schwartz and the author.





Another problem increased the issues of the town: an unusual high groundwater table, which seemed strange for a desert town. The town turned out to be positioned in an area with an invisible underground valley. While there is little rain throughout the year, the rain that does fall for miles around eventually flows towards the town underground, picking up salt from the desert along the way, resulting in a high saline groundwater table. This water seeps into roads and building foundations, and is sucked upwards, where it evaporates under the sun, leaving its salt behind. The salt cracks foundations and roads and causes a constant maintenance nightmare, and heavy costs.

DRAWING UP THE RESOURCE MAPS

With this rough analysis completed, the asset matrix could be filled: plenty of sunlight, an available labor force, its 'health' image, and access to a strong logistic network of road and rail. Other assets included the saline ground water and plenty of cheap land. The regeneration capacity of the groundwater provided for some sustainable use. Ecologically speaking the town didn't have many resources, but culturally it had interesting historic buildings worth visiting. Despite a lack of financial resources, there were plenty of eager and energetic people wanting to start a new enterprise, but few ideas on how to generate a viable economic model.

UNDERSTANDING THE SYSTEM

Lining up the problems and resources made a few things very clear: what was a problem in a certain light could be seen as a resource in another. Drawing up the resource maps in space, and considering the town's history in time gave enough resolve to state that the town really needed a brand new economic engine. Just relying on the trucks as a means of sustenance is a weak proposition, and makes the town vulnerable to the will of the mine's management and operations, resulting in a really low resilience score. Were the town to become healthy and flourishing, it would need to find autonomy in its own resources and become not just a through-stop but a destination in and of itself. I set out to find a solution that would provide the town with an economic resource that provides a solid foundation for its future, and resolve multiple problems at once, and secondarily create enough interest to attract those travelers that were currently passing by without stopping.

SOLUTIONING

I started searching for a solution by "cross-breeding" every asset with another, and see what would result. I investigated if using the available sunlight as a means to desalinate the saline groundwater would be feasible, which turned out to be too expensive and lengthy a process to make the water potable. I investigated new cultural possibilities for the pump station to make travelers stop, including a health spa using the salt water as a selling point, but this didn't seem a solid business case either. As the investigation went on, things started to itch while I became more and more familiar with the 'system' of the town. It was clear we needed something stronger, something perhaps less obvious.

I decided on a new strategy. We knew the saline groundwater was an asset somehow, as well as the land, sunlight and old pumping station. What element could we add as a catalyst in between these four resources that would achieve our goal? I started thinking of a wide range of options, technological, biological, cultural, and individual based on art and crafts. To do this, I progressed down SiD's ELSI ladder to consider all possible areas. I discovered that if we used a biological resource, we could add material value that sustains itself, because thriving biological systems generate value without human intervention if the conditions are right. If we could find something that would grow using the abundant sunlight, semi-arid land, and saline ground water, we'd be set. I then looked at more basic biological resources in the form of fungi, bacteria, algae, and so on. During this search, I narrowed in on the organisms that could grow in the saline ground water. And that's where I found our gem, an organism I never had heard of before, which seemed a perfect match: the Spirulina algae. Spirulina loves the saline water, loves the sunlight, and grows at breakneck speeds in open-air shallow basins that require a lot of surface area, and thus, land.

CONCEPT DEVELOPMENT

I studied the algae further and found that Spirulina has a variety of uses. It's used as an edible blue coloring agent in cosmetics, as well as a source of vitamin B12, and thus is considered a health-food product. Its various uses establishes a solid market value, and the algae are generally sold in a freeze-dried state, which keeps well.

I made the pumping station the headquarters of the Spirulina plant. The old water-agitator out back could serve well as a demonstration and test-tank while the empty lands around it were a perfect place to roll out large, outstretching algae growing pools. The algae would be pumped into the pumping station, where it would be freeze-dried and packaged, and would have direct truck-access to the highway from there. Looking at the business case, the Spirulina turned out to be so valuable, that a multi-million dollar a year enterprise could be established in a short amount of time, employing dozens of people, with a short return on investment (under 5 years).

EVALUATION

The Spirulina plant establishes everything set out in the goal. It provides for a solid economic resource, makes the town visible in a unique way along the highway to attract people, provides employment, and resolves the saline ground water issue, all with a completely renewable ecological resource that ties in to the health programme of the city. I presented the plan to the city council knowing it would work.



Spirulina plant showing the growth tanks



Spirulina tablets. It is also commonly sold in powder form.



LESSONS LEARNED

I learned two big lessons in this project. The first one is about using a systems approach. This was the first project where I applied an integrated approach, and it worked great, and beyond imagination. It gave me the conviction to continue to develop the approach in what today has become SiD, and perform many other projects in this fashion.

The second lesson I learnt came after I presented the plan to the town. Fully convinced of the plan's viability, I expected cheering and rejoicing but much to my surprise, town officials hardly took it seriously. This was 2001, and 'sustainability' was a word rarely used among general audiences. Algae seemed to them an outlandishly crackpot idea. Nobody cared to check the numbers or even imagine this would become a reality. My biggest mistake was that I developed this project without involving the stakeholders much in the process. When I communicated the plan, I thought everyone else would see the same potential I did. Rather, they couldn't imagine these weird 'algae' having a place in their community, they felt uninvested in the whole idea and to them it was nothing more than a crazy idea that dropped out of the sky. I failed at involving the people that I was doing it for, and because of that they, justifiably, rejected the proposal. I didn't build trust, understanding, and a shared solution. I learned a valuable lesson that day: without a collaborative process that involves the community and stakeholders, one is just building castles in the sky.

A consolation to this was that a decade later, we worked with the town to redo the feasibility study, seeing that the time was ripe for more general acceptance. This is another pattern we've seen over the years: it usually takes about a decade for an innovative solution to go from concept to implementation. After doing a number of these innovative projects it was clear we would have to have a lot of patience along the way. The new feasibility study, completed last year, showed the project is still profitable and feasible, and the town is now looking for investors to start the project.

To conclude, the early SiD approach worked beautifully, quickly, and efficiently, with amazing results when designing a solution... but my failure to involve the stakeholders resulted in an non-executed project. Since then we have taken care to implement both stakeholder involvement and communication strategy as central elements in the SiD system. So you don't have to make that same mistake.



3. SID PROCESS

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2
3
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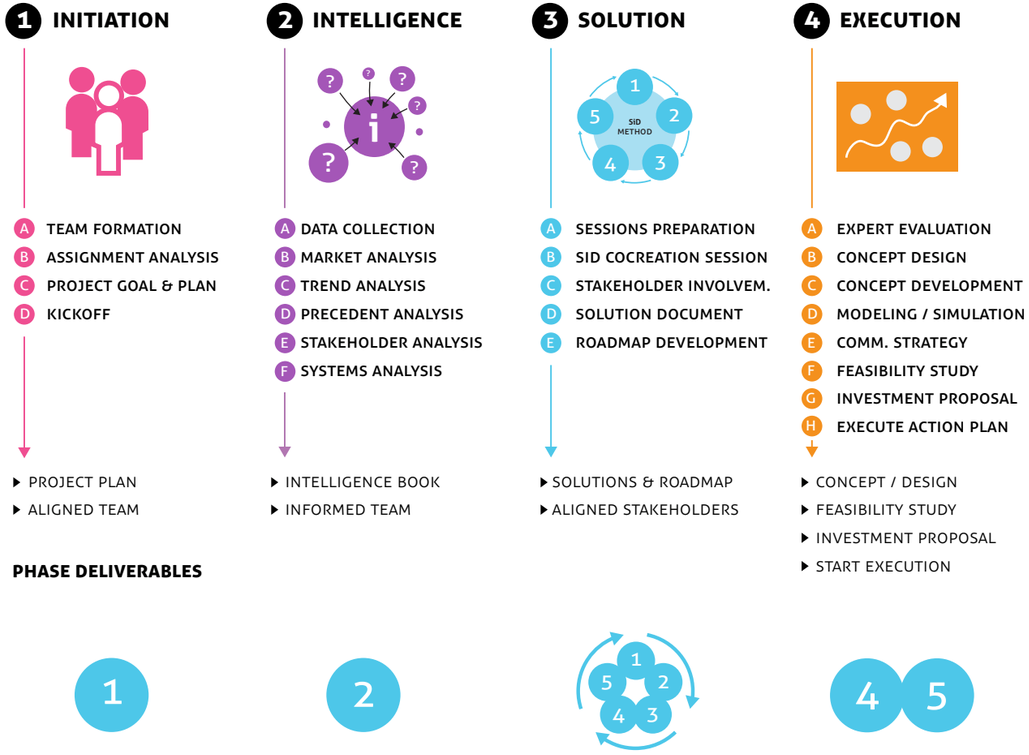
The SiD process is a planned, step-by-step execution of the SiD method. It is a modular system that allows you to quickly lay out a successful route to execute a complete project, calculate time and costs of the process, and make documentation to communicate the approach to stakeholders, clients, and other parties. Since the process greatly influences the results of a project, designing and managing the process well at the start is key to execute efficient and quality projects.

The SiD process design allows you to tweak your pathway to the needs of your project, from a quick one day project to projects that span several years. For each, you build a team, select and arrange the necessary process stages in time, assess their requirements, build in buffers for smooth dealings with problems, set milestones, and set schedules. In this chapter we discuss how to go about doing this.

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GENERAL SID PROCESS PHASES



3.1 PROCESS DESIGN

Designing a proper process is the foundation of doing a good job with the content. Process is the structure of 'getting it done'. By defining 'how' you're going to do something, you define the quality of what you'll do. Similarly, good wine (content) is not just the result of good grapes and barrels, but of the entire process of growing grapes, picking them; fermenting and storing for the right amount of time, the bottle design etcetera. It's all in the details. Each project requires its own tailored process. While it's useful to work off a template, every context requires some tweaking. This chapter is about how to design a suitable SiD process, tailored to your project's needs.

Building a SiD process is a little like playing with LEGO blocks: you stack little bits on top of each other to make a whole. The pieces themselves are process steps that are defined in this chapter. So, each process can be unique, while still made up from standardized pieces.

MAIN PHASES

The process generally goes through four main phases: initiation, intelligence, solution, and execution. On the left you see a diagram with a standard SiD process, its typical sub-steps, and below, the method cycle these phases correspond to.

THE IMPORTANCE OF THE PROJECT MANAGER (PM)

It all starts by appointing a suitable project manager, and briefing them with the basic project's boundary conditions: a project subject or question, time frame, and budget. The project manager is the process designer, and the most important decision maker in the project. If you're doing a one-man project, then that means it's you. If you're working with a team, it's good to make this a person that is experienced in project management. Also, experience with facilitating co-creation and stakeholder sessions is beneficial.

At the start of a project, the SiD project manager (PM) is appointed. The PM is the person that has the overview and end responsibility for the quality and delivery of the project. He or she has the necessary facilities at hand to make decisions and ensure smooth operation





of the project, and bears final responsibility. This is why the PM assembles the team and must be part of the entire development from start to finish. Needless to say, the PM is a professional, timely, and communicative person that preferably has prior experience in running complex processes, and preferably has practical experience with the SiD process.

Project managers know all team members well, have a solid grasp of the requirements of the project, and are familiar with the topic at hand. A PM without any content knowledge might not see trouble looming. When team formation is initiated, the process has not necessarily been designed. For large projects, designing the process is a group effort in most cases, which can warrant its own process design cycle. A process for creating a process sounds redundant, but seeing the importance of a good process, this makes a lot of sense.

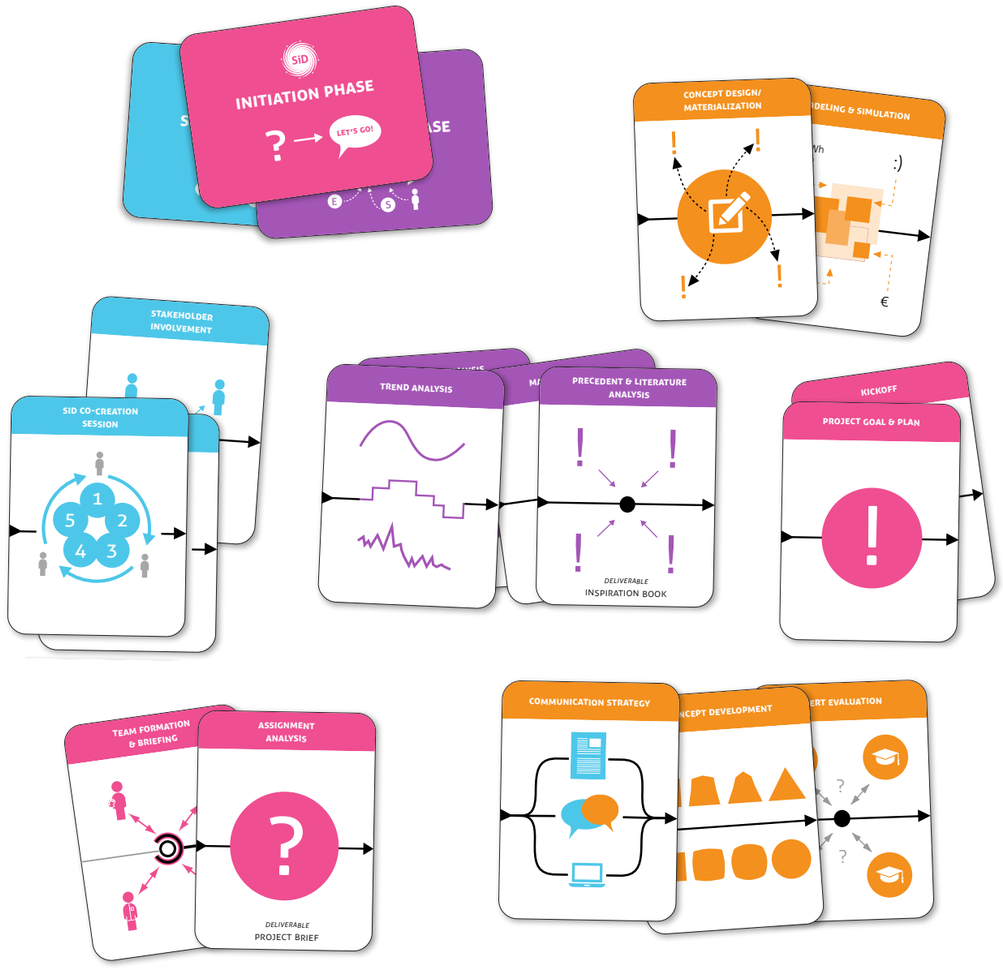
RESPONSIBILITIES OF THE PM

- Plan, schedule and communicate every stage of the process
- Assemble and manage the team
- Make the necessary materials and tools available
- Structure discussions and working sessions
- Be a point of communication for external parties
- Manage the project's budget
- Bear final responsibility for the project

GET A ROOM, YOU LOT.

When starting a project, it helps to reserve a room that's dedicated to the SiD process full-time; the SiD process room. Here you can keep all materials and the team can work together comfortably for the entire project. This room ties the whole project together both spatially and psychologically. Try to make this space available from the beginning, and put all the materials there, on the walls if possible. See the tools section about what a good SiD project room is like. Not to be confused with a SiD Session room, which we talk about later.





SID PROCESS CARDS & EXAMPLES

While each process is uniquely configured to fit each particular challenge, in the years of working with SiD we maintain a number of templates to work off from. These are mostly determined by the scope and budget of the project, ranging from a 1-5 day process for small projects, to a more common 3 month process with a co-creation session. Finally, a full fledged multi-session process involving an orchestra of stake-holders in multiple cycles. On the next few pages, we'll show the makeup of some standard processes for you to build off from.

THE SID PROCESS CARD DECK

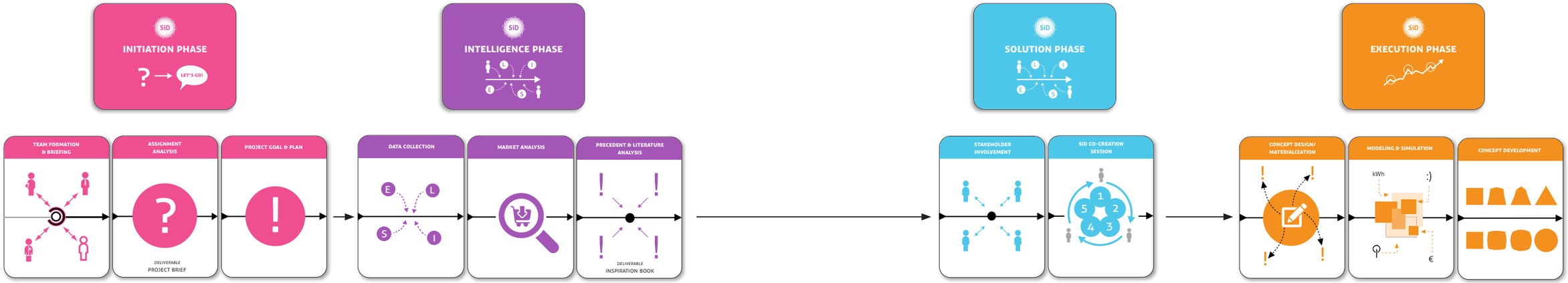
Since building a SiD process is a bit like stacking LEGO blocks, we made a simple card deck representing all the typical process steps. There's four phase cards, and each card is colored to their typical phase. You can use them how you please to help you and your team plan the process.

The color of the cards is just a suggestion as to which phase they are most often used in. It doesn't mean each process element can only be used in that phase, it happens often that they are used 'out of phase'.

You can print this card deck yourself, by downloading the free template from the ThinkSiD website. There you can also order a pre-made quality set of printed cards for your convenience. There's also a workshop card deck that has all the SNO elements in card form as a useful workshop tool.

EXAMPLE: PRODUCT DESIGN PROCESS

Below you can see a simple SiD process using the cards. This example is for a product development process, organized in typical phases of initiation, intelligence, development, and materialization. It is light on the intelligence phase, because the team has decided to maximize intelligence collection from the stakeholders. So, in the solutions phase, the stakeholder involvement comes before the SiD session. In the execution phase, the team follows their own well-rehearsed product design trajectory, taking the solution direction and vision found in the SiD sessions as their 'design brief'.



At the start the team is formed, and the assignment is analyzed. With the right project brief in hand, the team sets a project goal and a project plan.

Basic data is collected in the form of some spectrum-wide data on the product's system, the market is researched, and precedents and literature are investigated.

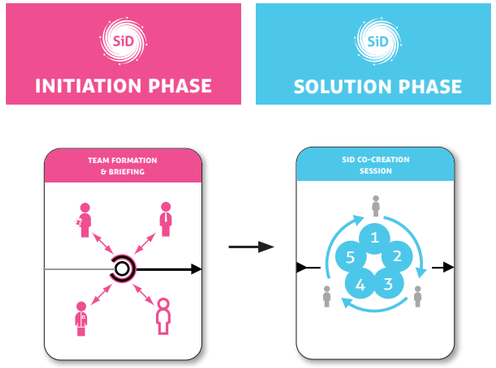
A stakeholder session is organized, which includes in this case a stakeholder analysis beforehand. Then, with the input of the stakeholders, SiD co-creation sessions are held, cycling through the SiD method and delivering concept plans.

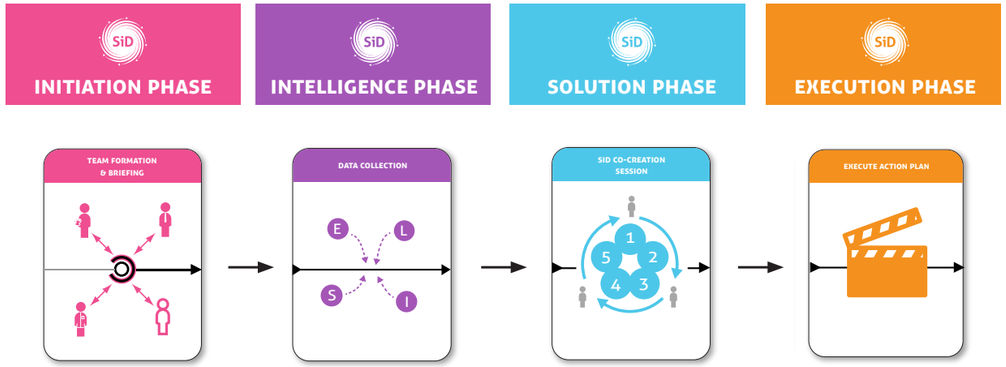
The materialization stage differs greatly, based on the intended outcome of a project. In this case, it's geared towards the design of a product in a concept phase, then modeling a prototype and testing, and then further development towards production.

EXAMPLE: SIMPLE IDEA SESSIONS

When you just want to get some ideas, explore, or find inspiration with a small team, you can run a short SiD process. The two examples on this page can be done in a half day to a day. The core of the process remains the co-creation part with the method cycle. It's also possible to execute these by yourself. In that case, try to take the position of a scientific, creative, and business mind on your own.

These short processes can also be used as a session to design the process of a longer trajectory together with your team. In our experience, this is helpful as a starting exercise with a team. Together you can explore what steps are valuable, when which step is done, and what the goals of the process should be. In this way, the SiD process is used as a process design tool for larger trajectories.





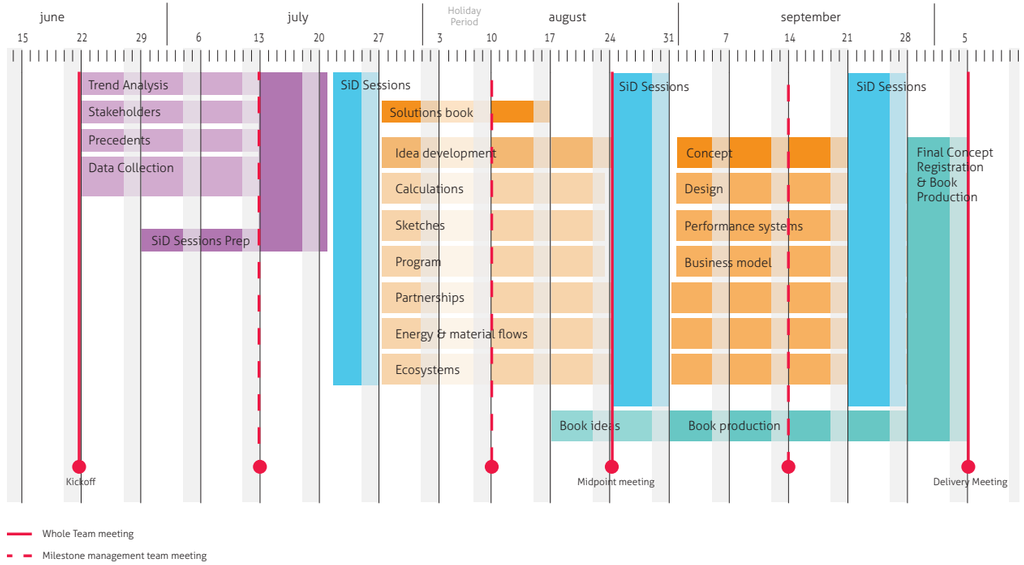
EXAMPLE: MULTI-CYCLE PROCESS

The time line below shows a condensed 3-cycle SiD process, executed to develop a concept for the most sustainable office building in the world for the Schiphol airport in Amsterdam. The challenge was to fulfill this ambition, while also aligning with, and gaining support from, 70+ stakeholders in the process.

This ambitious process was executed within time, and the results exceeded expectations of the client. The management of such a process does require some experience in process management, but the process is resilient to unexpected events and delays, because of built-in redundancy in the process.

The three SiD sessions in this process have a different focus. Session 1 was a 5 day session with only the core team and 2 client representatives. Session 2 had about 15 stakeholders present for 4 days, for a total of 22 people. Session 3 was a 4 day session with in total about 40 stakeholders in revolving groups.

The results of this process is the Schiphol Catalyst concept design, which set a new bar for hyper-sustainable buildings: the Catalytic Building standard. This has since been released as a separate whitepaper, initiating a new era in sustainable design.



3.2 INITIATION PHASE

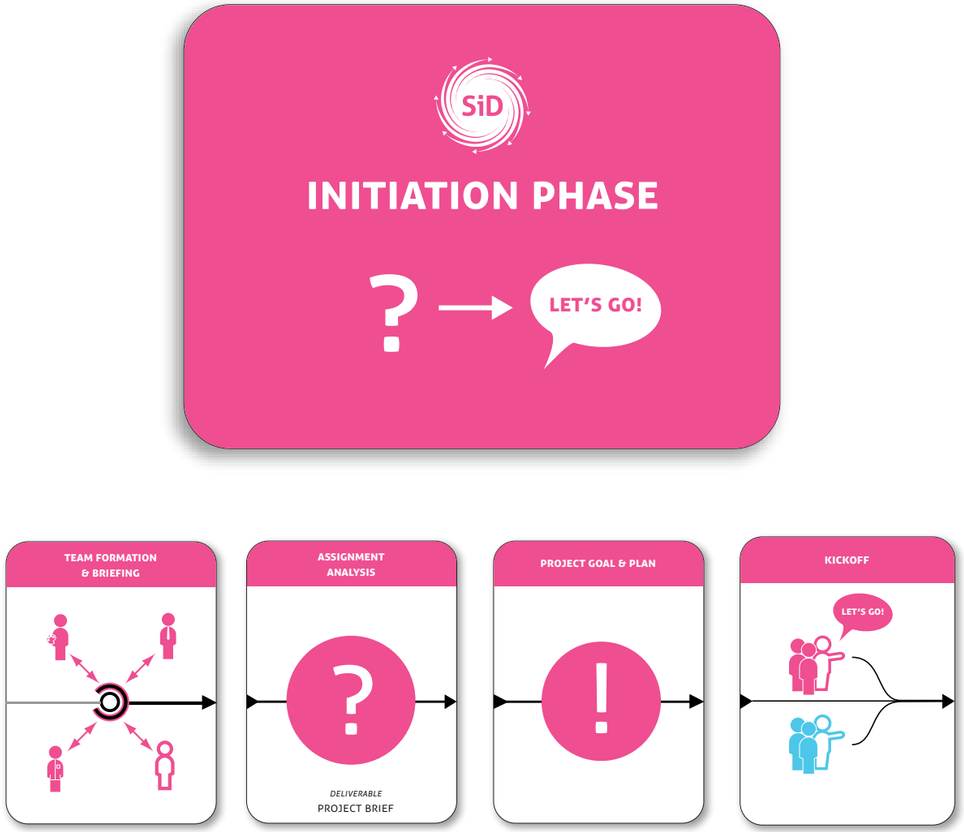
The initiation phase contains all the elements to plan, prepare and kick off the project. A good start is half the work, and that's certainly true here. In the initiation phase, the team is formed, the project is analyzed, and the process is planned. For large projects, a kickoff is usually planned for the whole team to come together, align and get going.

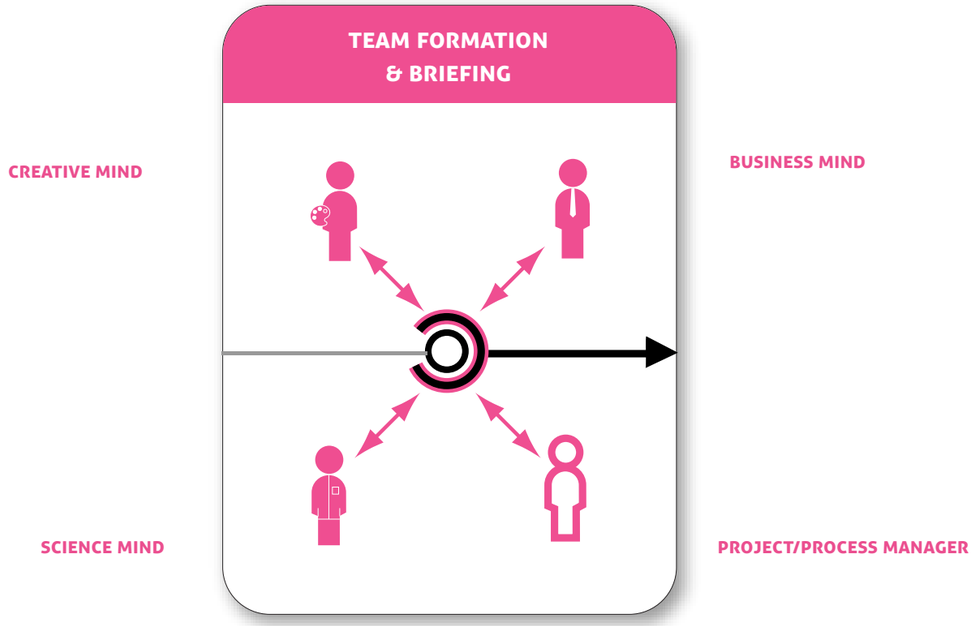
Typical process steps in the initiation phase are:

- Team formation
- Assignment analysis
- Project goal & plan
- Kickoff

This phase typically delivers:

- An aligned multidisciplinary team
- A project goal
- A project plan





3.2.1 TEAM FORMATION

Having the right people at the table as early as possible is vital to the success of any integrated process. It matters that the team is aligned on all major decisions from the start. That's why team formation typically happens at the very start of the project. The "core" project team consists of the people that develop the project from start to finish, as opposed to external experts, stakeholders, the client, or any other partner that may be interacting with the process along the way. The core team usually does include some of these parties, like a client representative.

The core team is rarely larger than four for small and eight for large projects. With four to eight people, you can change the world in a month, if they're the right people. Beyond that size, the level of management required to motivate, inform, and facilitate the group may become too large for a single project manager to efficiently manage. For larger groups, project management needs to be split up into two or more sub-groups, best working independently from one another, each with their own manager, with a single project director providing oversight. Needless to say, this is less efficient (but may be a necessity given external constraints).

Teams work best if they consist of people with diverse qualities. This includes aspects such as content knowledge, personalities, disciplines, and experience. We also recommend mixing team members with diverse cultural backgrounds, age ranges, and gender. For each team, a strong SiD recommendation is to have at least one person with a scientific/analytical mindset, a creative mindset, and a business/connectivity mindset.

All team members should be excellent team players, able to receive and give constructive feedback and be a positive influence on the process. People who are too critical or conservative will hold the project back. Personality can play a major role in the dynamics of a team, especially for longer and challenging projects. For this you can use various tools, such as the free Myers-Briggs personality and the 123test, and the commercial Belbin test, a powerful team roles test based on Meredin Belbin's research on ideal team compositions.

CONTENT KNOWLEDGE

In our experience, it's ideal if the project manager is the most experienced in the content of the project at hand. The PM can then guide the rest of the team through the idiosyncrasies of a particular disciplinary field. This way, the PM can also assess the quality of the work for this field of expertise (if applicable). It's best to also complement knowledge. People with knowledge from one or several aspects are complemented with people who have knowledge of other aspects. This usually results in a spread of disciplines and personality types as well. Generalists are more useful as a core team member than very specialized people.

MINDSETS

Next to including the right content knowledge, try to mix 'mindsets' in the team. These can be hard to define, but we generally make a distinction between mindsets like scientific/analytic, creative, socio/economic, engineering, business, and communication. For example, a scientific mindset is someone who likes to get to the nitty-gritty details, systematically unravels issues, and makes decisions based on rational approaches. A creative mindset is more of an explorer,



able to come up with unusual out-of-the-box ideas and make connections between different fields. The socio/economic mindset is used to the complexities of dealing with people and cultures, and the various, often illogical, structures they exist in. Engineers are great at seeking solutions, business thinkers to find the value proposition for stakeholders, and communicators seek the right words and communication structures necessary to create clarity.

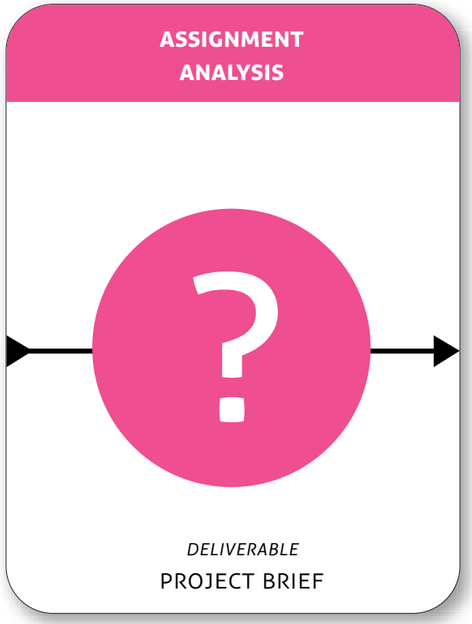
In our experience, diversity in mindsets is more important in the makeup of a team than what background people officially have. People with dual alignments are helpful in assembling a team (e.g. a designer/scientist). The chosen mindsets of course depends on the subject matter. For example, when working on sustainable cities, it's typical to have at least one urban planner be present (in the role of the creative, usually). When dealing with business strategy, we often include a business analyst. For a scientific mindset, we mostly rely on industrial ecologists, since they are well versed in a broad range of sustainability sciences and typically are familiar with a systemic world view. If we double up on disciplines, it's usually because the people have different and complementary mindsets, personalities, and skills.

SKILLS

Besides the diverse mindsets and content knowledge, a team works best if it has a variety of basic skills. This includes drawing, conceptualizing (drawing diagrams), mapping, abstract reasoning, writing, presenting, storytelling, and managing groups of people. Additional skills worth having are photography and video, information gathering superpowers, and, of course, life experience helps too.

TEAM PRIMING

If the team members don't know each other well, it helps to do a few exercises for them to learn to appreciate each other's values and insights, and to connect. This helps to smooth out the more intense project stages later on. We call this "Team Priming". Examples of doing this is to simply go out for a night on the town, or, more structured, for everyone to bring an abject that reflects their personal story, and share their view on the world. Make it fun and creative, and be sure to give each team member enough space to express themselves. These exercises are best planned during a kickoff session.



3.2.2 ASSIGNMENT ANALYSIS

The first thing the project manager (PM) does when a project is put on the table is a quick system-assessment: what the project is about, its time frame, potential budget requirements, etcetera. The PM scouts out the project requirements so that a team can be formed, the right tools will be at the table when work starts, and the team members can be briefed on the project. The result of this stage is the project brief for the team which contains all the information for the team members to be able to start working. If this is a project involving independent contractors, this is also the phase where preliminary agreements on responsibilities, budget and roles are drafted.

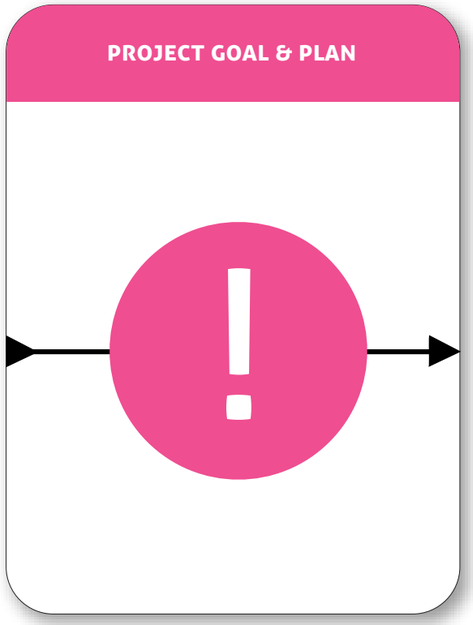
Questions to answer during this stage:

- How long will this project take?
- How many people will you need to complete it?
- What facilities and materials will you need?
- What role will the client and/or partners have in the project?
- What are the desired end results and deliverables?
- What are the edge conditions of the project in time, facilities, budget, etc?
- What legal responsibilities will fall upon the team, and how is this insured?
- How will contingencies be dealt with?

Step through the SiD method quickly, and fill in the following items. Use a spreadsheet or another organization tool to put in the disciplines and tasks you can foresee for now. This spreadsheet will be used later as a basis to expand upon with the team to refine the roles and tasks.

CONSULTING CONTEXT: PROPOSAL STAGE
In a consulting context, where a team uses SiD to provide a service to an external client, this is the stage where a quote is written for the client. It's possible that a project may not continue if the proposal is not accepted. Because of this, and the considerable time an assignment analysis may take, it's usually done iteratively: A quick assessment is made in a few hours with just a handful of people, documented, and communicated to the client. If agreed, the next phase is to work out details in collaboration with the client to suit the budget, deadlines, team, and responsibilities.

When embarking on a collaborative project with a client, it's imperative the client is informed and made aware of his or her responsibilities towards the project. Collaborative project development is vastly different from traditional project processes. The client has to engage with the project intimately, ensure the delivery of required data and other aspects that an integrated analysis and innovation trajectories require.



3.2.3 PROJECT GOAL & PLAN

You may recognize goal setting as a step in the SiD method cycle. We include Project Goal Setting as a process step outside of the development phase, to help steer the process of the project at the start. It differs, because in this process step, we try to identify the goal of the process itself, not so much of the subject the project is aimed at. Here we should be clear as to how long the process may take, which resources it may use, and what conditions it may work under. These goals can 'blend' a bit though, which can be a good thing, to get our feet wet in the subject matter of what the process is trying to achieve. Either way, this process step should be short and to the point, and not dwell too much on complex questions that will become part of the SiD method cycle later in the development stage.

Setting a project goal at first should go rather quickly. Start out with concrete edge conditions, such as how long the process is allowed to take, the amount of milestone meetings, the expected format of delivery, budgets, areas that can or cannot be influenced through the project, confidentiality in dealing with stakeholders, etc. A first attempt can be made at setting a system goal for the content of the project may help, by using the same rules as discussed in the method section. This may help in setting the tone, perhaps written in the agenda of a kickoff session for the team, or as a primer document before the SiD sessions.

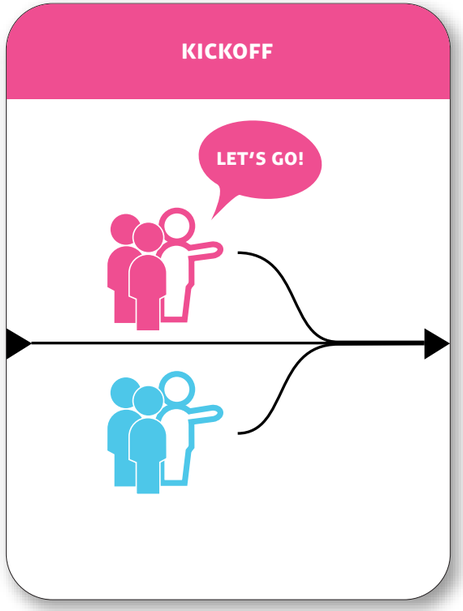
QUICK GOAL EXPLORATION SESSION

For larger projects, to set a rough initial project goal, it may be helpful to plan a rough system mapping session of about one to two hours with the team. In this meeting, a first taste can be had in exploring what exactly the system under investigation is, and how it is affecting the society around it. This may also help in finding the right wording that works in the given context of people or industry. This can also be done during a kickoff session.

GOALS EXTRACTED FROM BRIEFS

Some projects are driven by a brief of a client or partner. Be aware that these briefs are usually object-oriented and prescriptive documents, while we seek system level and performative goals. These briefs often give edge conditions, such as a deadline or a budget limit, which can be registered separately.

Object-oriented goals should be avoided at all costs, no matter how strict the brief is. The goal should be set to allow for systemic problem solving. If the partners that set the brief are not or cannot be fully involved in the project (such as with a government tender), this may be done internally for the process to work. The brief's requirements are then used as project boundaries only, and the goal is set on a system level. In reporting back the solution, they may be translated back to the language and framework of the original brief.



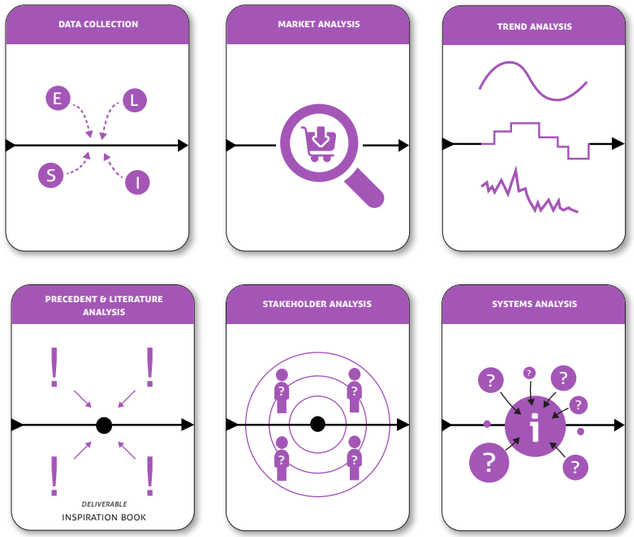
3.2.4 KICKOFF

After the team is formed, the brief is ready and the process can really start, it's wise to plan a central kickoff event. The PM gathers the core team together with the client representatives and any critical external partners or support, in one meeting. In this meeting, the PM informs everyone about the process ahead, asks for feedback, explains what is expected of each team member and discusses the project goals and the specifics. If the team members don't know each other, this is a good moment spend some time to get to know each other a bit better. For projects that involve many group processes, it's recommended to make a separate introduction session where each member can tell a little about what inspires them, their experience and passion for the project.

While some people on the team may have a role that lies further down the path, it's important to include them from the start. This way, they are able to reflect on the process, and feel like a member of the project as a whole. If this is a spatial project, this is best done in conjunction with a site visit. For a company strategy, a tour of the headquarters or production facilities may be a good kickoff event.

This is also a good moment to introduce the SiD room and make it available to everyone. After the kickoff a goal setting and visioning exercise can be held prior to the intelligence phase, to help explore the direction that helpful research may be found.



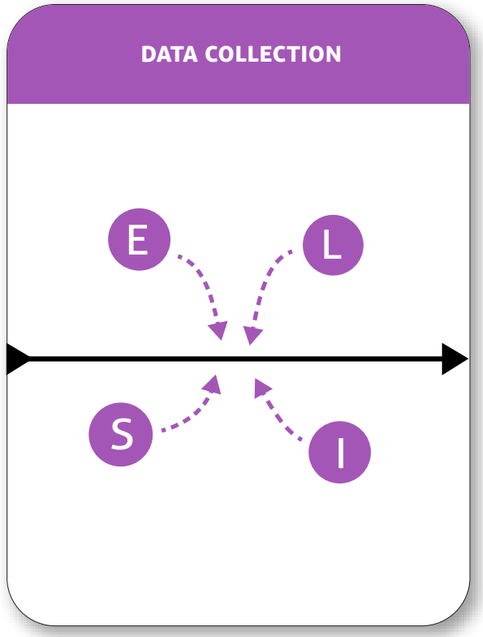


3.3 INTELLIGENCE PHASE

Once we have our team, and we agree on what it is we're doing, and how, we move to the intelligence phase. Here, we collect all the necessary information we require to do an analysis of the system, and to start working on a solution. The analysis itself is partly done in this phase, and partly done in the next, solution phase, as part of the iterative method cycling. This intelligence phase consists of determining what data to acquire, sourcing the data, and preparing it for the system mapping to be as effective as possible. Also, in this stage stakeholders are identified, and in some cases, aligned for the next phase.

The steps in this phase may consist of:

1. Data collection
2. Market analysis
3. Trends analysis
4. Precedent analysis
5. Stakeholder analysis
6. Systems analysis



3.3.1 DATA COLLECTION

For every project, we need data. In this step we identify which data we need, make an organizational structure for it, divide the collection tasks among the team members, and get it all together.

Data can include maps of an area, statistical information, climatic data, demographics and economic data, prior research reports, etc. In order to figure out what data you need, it helps to do an ELSI and/or SiD system sweep just to check what data you think you may find (see tools section). This also helps in setting up a documentation structure to keep making sense of things, when a lot of documents and data are to be collected.

Sometimes, acquiring data can take a long time, as it's often dependent on delivery from outside institutions. So, it's best to start collecting this early. Once we have the data, we can process it into a single reference document or database, so that all team members have easy access to it.

LOCATION DATA (SPACE)
This includes climatic data, cultural information, soil conditions, biodiversity levels, resource availability, and more. This data can directly be used to make spatial, temporal, and contextual system maps.

TIME DATA
What has been planned for the organization, topic, or location at hand for the near and distant future? Are there any visions or strategic outlook documents present? What historical data is present that we can use? These kinds of questions are asked to obtain to our time data. We can use tools such as backcasting and scenario planning to help estimate what data we may want to use in the process ahead. For organizations, read year reports and extrapolate certain development curves. Also, review any government policies that may be relevant in the future, review current events about the subject, and potential laws that are being created.

RELATIONAL DATA (CONTEXT)
What's the decision-making structure of the topic at hand? Where does it sit in the supply chain or life cycle? What stakeholders are involved, and what third parties may be affected by it? What geopolitical circumstances may influence the topic?



3.3.2 MARKET ANALYSIS

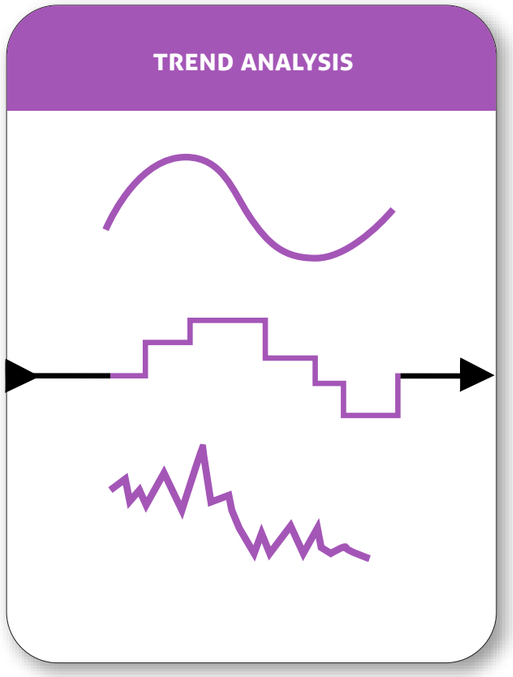
In this step, we analyze the market from an integrated perspective. Depending on the challenge, this may be more or less important, and the depth of the analysis can vary greatly. Parts of an extended market research may include scanning the existing market, analyzing the competition, looking at market regulations and voluntary standards of sustainability in the market-place, as well as looking at existing material supply chains and value chains.

MARKET DATA ELSI ANALYSIS

Just like the data analysis, and the other analysis phases, the market research can be helped by departing from an ELSI inventory indexing what market forces are present in each category. This way, you automatically encounter aspects such as employment and job market, natural capital, resource pricing and availability, etc.

LIFE CYCLE, SUPPLY CHAIN, AND VALUE CHAIN

A useful analysis to perform in virtually all projects is to make analysis maps of the challenge subject set in its connected primary chains. This may include the life cycle of the challenge subject from primary resources to its end of life, a mapping of its supply chain, from root to end user, and a mapping of the value chain and business models surrounding the challenge subject.
If the analysis is set up in a way to produce graphic material of the current state of the market system, this can be a great tool to use during the SiD sessions. They can be treated as the 'before' maps in exploring what an ideal 'after' map can be like. This can then provide a main drive for developing new systemic solutions that hook into existing life cycles and value chains.



3.3.4 TREND ANALYSIS

The trend analysis scans for long-term societal dynamics that influence the project in the long run. The trends are used to steer the resilience planning of the solution and concept development. It brings awareness to the team of system dynamics that lie beyond the project's boundary, and helps to align the project to global, regional, and locally perceivable trends.

A trend analysis is not a means to predict the future. It's a way to ascertain a shift in a pattern that is diverging from its normal situation. Based on these scenarios, we can test our system for resilience.

Performing a trend analysis is vital for medium to large sized projects. For small projects it may be sufficient to reuse the trend analysis of previous or similar projects.

Trend analysis is very sensitive to geographical and temporal scale. A pattern in a certain local area may be the opposite of the overall global pattern. Likewise, a pattern on a short term may be opposite to the trend of a long term development. Both ends of the spectrum are valuable. Small scale and short term are useful to align the start of the roadmap, and the long term is used to align the long-term goals and strategies of a project.

Global and large trends are not easy to develop, but fortunately we can rely on public research from various institutions such as the World Economic Forum, Amnesty International, the United Nations and so on. Many globally operating consultancies also provide periodic trend analyses. Be vigilant and scrutinize these reports, their content, direction, and scope. They're usually not covering the full spectrum. Combine international reports where possible to build a more solid case. See the next page for examples.

Local and short-term trends can usually be best extracted from local stakeholders, surveys and data analysis. In these cases, the trend analysis and the stakeholder involvement processes are co-dependent.

There are two examples of trend analysis on the next pages.

EXAMPLES: TRENDS ANALYSIS

A trend analysis can be anything from a short bullet point list to an extensive research program. Here are two examples, both just stating their index. First, the World Economic Forum's top ten global trends of 2015, and the top ten trends for Schiphol Amsterdam Airport made by Except in 2015.



WEC TOP 10 GLOBAL TRENDS (2015)

1. Deepening income inequality
2. Persistent jobless growth
3. Lack of leadership
4. Rising geostrategic competition
5. Weakening of representative democracy
6. Rising pollution in the developing world
7. Increasing occurrence of extreme weather events
8. Intensifying nationalism
9. Increasing water stress
10. Growing importance of health in the economy

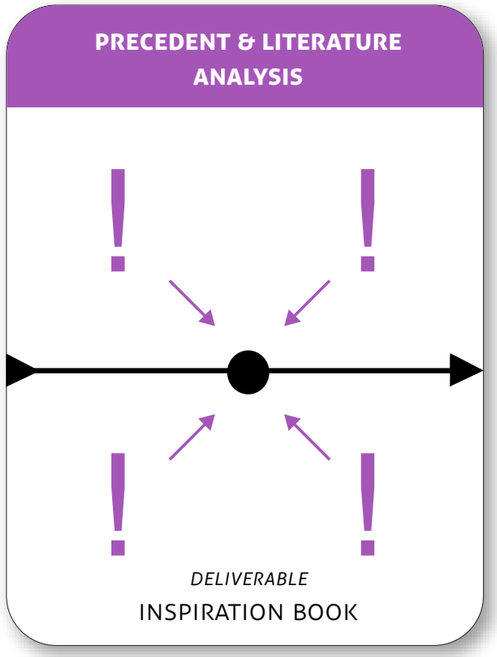
Looking at the WEC trend list on the left from an integrated SiD perspective, we can see that this is a biased list. Firstly, this top ten focuses on trends in the realm of policy, economics, and markets only. Not surprisingly, as it's a list made by the World Economic Forum. Yet, one would hope for a more holistic approach at such an institution. If the world's largest trespassing of planetary boundaries, for example, is the decline of biodiversity, one would expect a mention of this in the top ten lists of any 'global trend list'.

Using ELSI to secure a more balanced report on trends is a useful approach to obtain a balanced perspective. You can see that ecosystems and species are entirely absent from the WEC top 10 global trends. In this case, we'd advise to find a number of other sources, combine these lists, and make a new selection based on ELSI and the weight of each particular trend.

An example of a trend analysis aggregate from our own work for Amsterdam Schiphol Airport is listed below. These were originally derived from an ELSI sweep.

TOP 10 SCHIPHOL AIRPORT TRENDS 2015

1. Decentralization
   - › Internet of things
   - › Self-driving vehicles
   - › Individual empowerment
   - › Servitization & Online Everything
2. Resource depletion
   - › Water scarcity
   - › Energy Shifts & Smart Grids
   - › Shift to electricity
3. Transport shifts
   - › Transport as driver of economy
   - › Movement patterns shifting in time and space
   - › People move to live, not to work
   - › Leisure and user experience
4. Circular Economy (CE)
   - › Increasing local production & supply
   - › Industrial symbiosis
   - › Rapid growth of CE business models
   - › System wide shortening of supply chains
5. Bio-based economy
   - › Biodiversity dropping alarmingly
   - › Nature Deficit Disorder
   - › Biophilic building elements
   - › Urban agriculture
   - › Specific pollinators & beneficial insects
   - › Protein sourcing
   - › Economies of Abundance & the Blue Economy
6. Sharing Economy (SE)
   - › Netherlands sharing economy in startup phase
   - › Netherlands facilitating serendipity
   - › Drive for community increases
7. Population growth
   - › Tourism increasing exponentially
   - › Increasing food & water demand
   - › Urbanization
   - › Silver Society
8. Health & happiness focus
   - › Healing environments
   - › Air quality & productivity
   - › Lifestyle changes; be the best you can be
   - › Care Robotics
   - › User experience focus
9. Flexitization
   - › Flexible buildings, flexible society
   - › Off-site production, micro production
   - › Increasing independent work & flex spaces
   - › Performance-based procurement contracting
10. Climate adaptation
    - › Renewable energy developments
    - › Water management
    - › Netherlands: enforced by the people, the people's lawsuit against the state



3.3.5 PRECEDENT ANALYSIS

The reason for precedent research is to prevent reinventing the wheel, and to get inspired by great examples. In this stage, all members of the core team go out and search for available resources, existing research, solutions related to the challenge, and collect inspiration along the way. The results are recorded and organized in overviews, often in the form of an inspiration book.

Depending on the complexity and depth of the project, precedent research takes anywhere from a few days to a few weeks. At Except, precedent research is one of the required phases in every project. We find that history is our best teacher and laboratory. This usually results in an inspiration book, that helps to inform and inspire new team members and stakeholders along the way.

ORGANIZING THE SEARCH

When organizing your search, remember that existing solutions may not reside in the areas you expect them to be. For example, a great solution for a challenge may come from an entirely different field. When searching for precedents, do not narrow your scope too much. In order not to miss any critical developments, a methodical search over a broad spectrum of topics will help in capturing relevant developments.

For big projects, in addition to finding case studies and precedents that address the whole of the problem, try to break it up into meaningful sub-challenges. One way of doing this is to use ELSI, divided in space, time, and context in the search. An additional advantage of this is that team members unfamiliar with the SiD process have a first chance at learning to work with ELSI's categorization. Team members can then be assigned an ELSI category to research, and they may remain 'keepers' of this category until the end of the project.

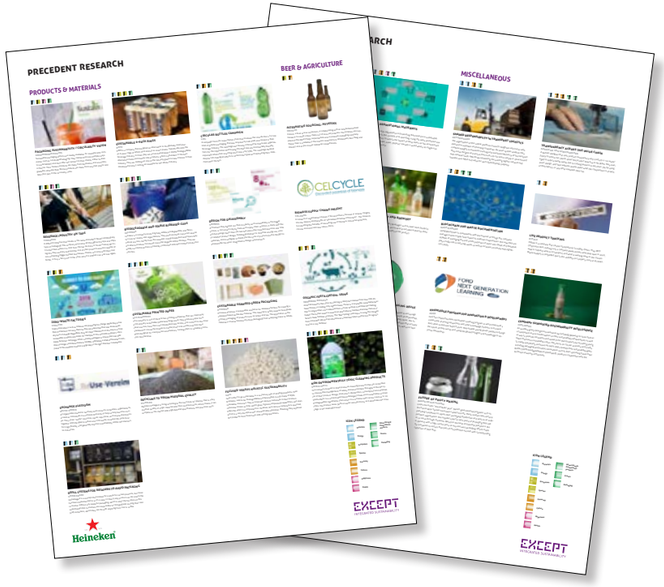
DEFINE THE RECORDING FORMAT

It's wise to clearly define a strict recording format for each precedent search. Doing so will allow each team member to work entirely independently, while making sure everyone records the same kind of information. This will ease the creation of a uniform database or inspiration document. It makes sense for organizations that repeatedly execute SiD processes to have a standard recording format and perhaps even a formalized database for precedents that keeps growing over time.

We usually make a shared online spreadsheet, divided horizontally in ELSI categories. For each precedent we



Example of a precedent book for distribution before a SiD-session, and documentation. These can serve as an inspiring leave-behind that is a side-delivery of the project process. These books can be made as a cost-effective working document (as the example on the left), or as beautifully designed and printed inspiration documents. Often, these are not printed at all, but distributed digitally to the participants. It's best to have each participant send in their own inspiration projects, to include them into the process.



Example of precedent posters during a SiD-session. These were for strategy and roadmapping for the Heineken brand.

At a session, we usually spend some time to walk past al the trend, stakeholder, data, and precedent posters, and give a global indication of what's information they contain, but we do not go through their contents in detail. Those seeking inspiration will do so themselves during breaks and working sessions.

find, we capture name, author/developer, date, a short description, its source, and preferably some images.

EXECUTING THE SEARCH

Team members research their respective fields, coming together a few times to discuss what they've found, and to check whether modifications need to be made to structure or recording format. Precedents are put together with succinct descriptions about why they are relevant to the project, and what can be learned.

PROCESSING THE RESULTS

After the search, all of the precedents are captured in a precedent book that's handed out to the extended team when they get involved, and stored to be used for other projects in a database. In addition to this, we often make summary posters to use in the SiD sessions to follow (see left).





Relevance

TThe Last Mile is a progressive step for Singapore's Garden by the Bay as it enhances the experience for tourists and improves productivity. The investors aim to engage more organizations that follow this example in employing self-driving technology to transform their operations around Singapore.

THE LAST MILE

Location
Singapore

Provider
EZ-10 of EasyMile

Year of completion
2015-ongoing

Maximum speed
20km/hr

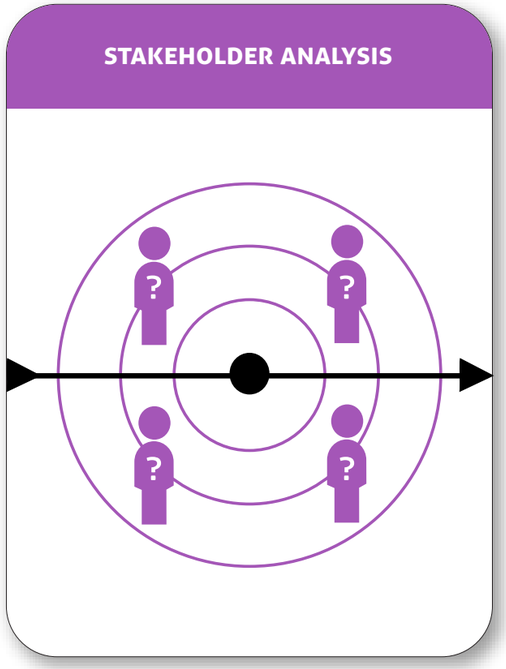
Client
Gardens by the Bay, ST Engineering

Line position
Public pedestrian road

Project description

This project is a collaboration between Gardens by the Bay, ST Engineering, and Robosoft. The EasyMile driverless shuttle began its public trial in December 2015 and is targeting full scale deployment for mid-2016. This project is co-funded by the Ministry of National Development and National Research Foundation, with technical advice from A*STAR's Institute for Infocomm Research (I2R). Each vehicle has a capacity of 10 people, comprising seats for six passengers and standing room for four. Fully enclosed and air-conditioned,passengers are taken around the gardens in comfort. This service aims to strengthen the connectivity within the gardens and enhance mobility for the elderly and physically challenged people.

Example page from a precedent book, in a section for urban mobility, showing some key data points, and an icon classification for impacts.



3.3.6 STAKEHOLDER ANALYSIS

Whether you're working on policy development, on a product of some kind, or on improving the operations of a company, there are always stakeholders involved. These range from direct users or clients to people at the other end of supply chains or affected by ripple effects. Eventually, systemically, everyone is affected in the long run. In the stakeholder analysis phase, you detect which stakeholders have which importance in the project, what their needs seem to be, and how we can involve them. We can then activate this in a stakeholder involvement stage in the solutions phase, or do desk research to try to include them.

WHO ARE YOUR STAKEHOLDERS?

This is the central question of this stage. To answer it, we usually work towards making a stakeholder map, that shows different stakeholders, their 'proximity' to the challenge, their relationship to the subject and each other, their influence, and, if possible their needs and wishes. This will help involving the right stakeholders later in the process as well.

We typically identify four levels of stakeholders, listed below with some examples. These help to identify strategies per group. Note that these do not denote importance levels:

Primary (closest, participating, 1-10)

- Clients
- Investors
- Residents
- Primary users/decision makers
- Team members

Secondary (directly affected, 10-100)

- Customers
- Employees
- Primary suppliers
- Neighbors
- Local flora & fauna

Tertiary (usually anonymous, 100+)

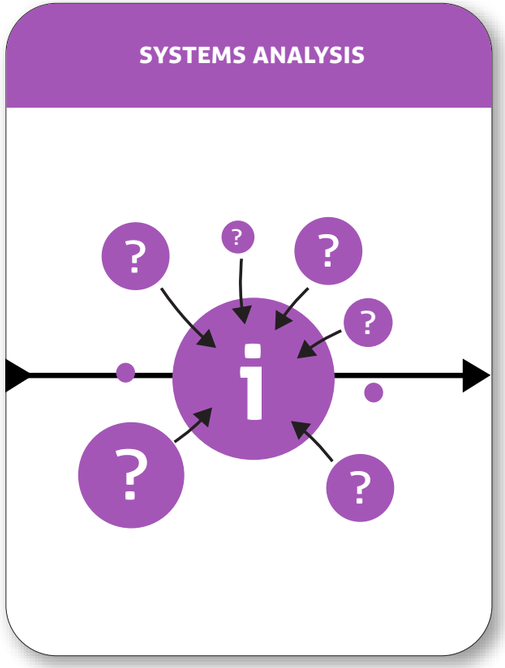
- All downstream and upstream value chain and supply chain partners
- Regional residents

Society

- All people and living things
- Future generations

MAKING A STAKEHOLDER MAP

Now, typically, here we would describe how you can make a stakeholder map. But, since making a stakeholder map is the example used in the mapping section of the method chapter on page 278, we can save some paper by referring you there.



3.3.7 SYSTEMS ANALYSIS

This systems analysis phase is an execution of the theory chapter of this book, which comes after all the primary intelligence collection. Usually, it is intended as a preparation for the SiD session, to do a systemic quick-scan over the research, and to produce system maps that are useful in the solution phase as templates, inspiration, and accessible intelligence input. On complex projects, this may include making tools, such as calculation spreadsheets to test various business models during the SiD sessions.

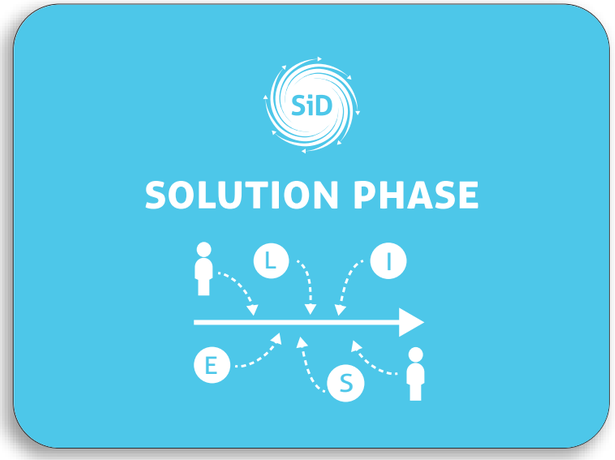
The execution of this phase is highly project dependent. As a departure point, consider which system maps you are likely to want to have access to during the SiD sessions. With this in mind, execute a mapping cycle as described in the System Mapping section of the Method chapter. Start with making a map of maps, see if the available research data supports the creation of these maps, and then try to make them.

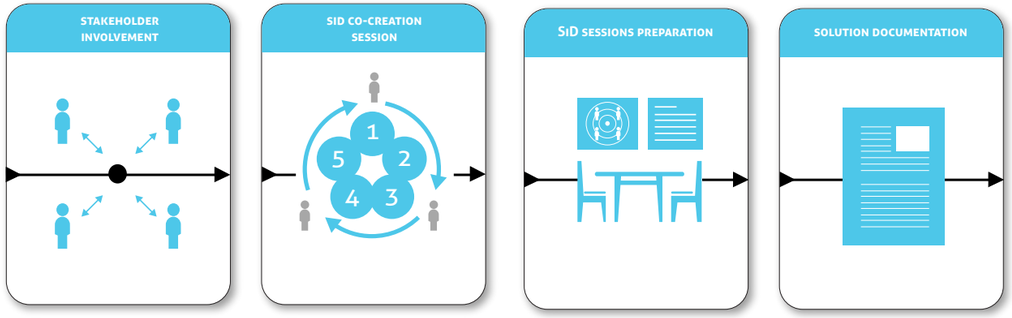
TYPICAL MAPS TO MAKE

As preparation for SiD sessions, typically useful maps to make at this stage are:

- Context: A stakeholder map showing all primary to society stakeholders.
- Context: For production systems, a complete supply chain / life cycle map.
- Context: An energy/material flow map (can be combined with life cycle map).
- Space: Geographical maps of relevant locations and the surrounding program on small, medium, and large scales.
- Time: timelines showing historical development of relevant market and/or policy trends.
- Time: for products and user oriented systems, a timeline of usage.
- Network level analysis map, showing the critical weaknesses and strengths of each relevant network parameter related to each ELSI category.

Make posters for each map to display at the SiD sessions, and prepare them to print out on A3/Tabloid format to draw on top of.



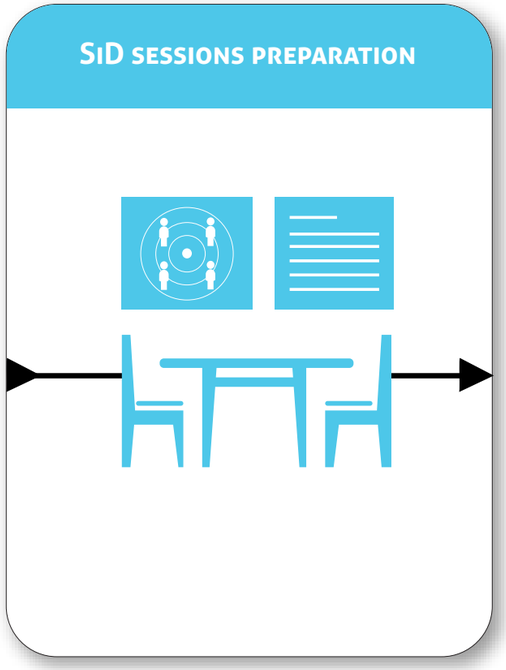


3.4 SOLUTION PHASE

The solutions phase is the heart of the process. Here, the information from the intelligence phase comes together, we involve the stakeholders, and dive into the co-creation. This is where the SiD method is cycled in iterations. The output of this phase is concrete solution concepts, roadmaps, and action plans. Even the smallest, most minimal SiD process contains this phase.

The steps in this phase may consist of:

1. SiD sessions preparation
2. SiD co-creation sessions
3. Solution documentation
4. Stakeholder involvement
5. Roadmap development



3.4.1 SID SESSIONS PREPARATIONS

A thorough preparation before the SiD sessions greatly helps maximizing their effectiveness. The best preparation focuses on finding and preparing a great SiD session room, making sure working material is present, and last but not least, to process all the research material from the SiD Intelligence phase into usable materials for the sessions.

SID SESSIONS ROOM AND MATERIALS

For a detailed working material list and description of an ideal SiD Sessions room, refer to the tools section. The following list of content material is a basis to have ready in printed form in the SiD sessions. It's useful to have these in large poster format as well as smaller, A3/ Legal paper sizes to draw on:

SYSTEM MAPPING MATERIAL

- If not yet developed in the System Mapping step in the Intelligence Phase, make drawing templates for systems analysis in time, space and context. For example, maps of the area, prints of corporate structure, supply chain diagrams, etc. Make light semi-transparent prints that are easy to draw on.
- Data tables and reference documents, e.g. existing vision and strategy documents.
- SiD tools template prints, some pre-made templates that are generally useful, free to download from the ThinkSiD.org website.

POSTERS AND BOOKS

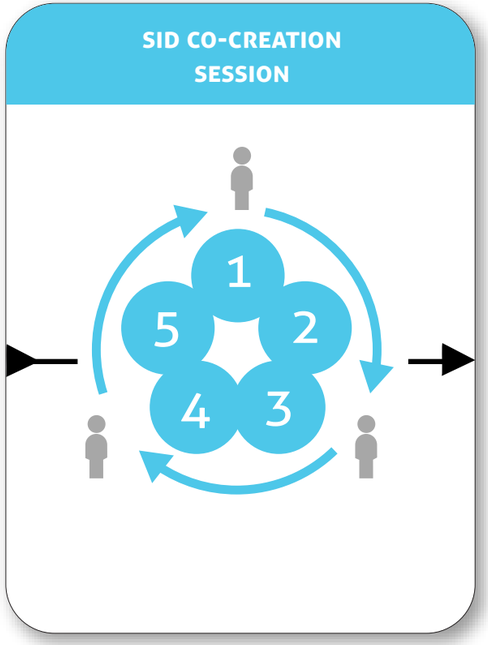
- Inspiration/precedent book, and posters
- Data book and poster
- Trend book and poster
- Marketing analysis book and posters
- SiD Posters (ELSI poster, SNO Diagram, etc)

ATTITUDE AND PARTICIPANT PRIMING

A week long collaborative session can be either miraculous for all involved, or a painful experience if the collaboration doesn't work well. This depends entirely on the motivation, attitude, and 'click' the team members have with one another. A session works much better if it's done with people that have done it before, know each other's strengths and weaknesses, and are able to be open and constructive. The attitude of people at the sessions makes all the difference.

Because of this, it is useful to organize a small get-together a week before the sessions. At this get-together, inventorize everyone's perspective on the sessions, their hopes for the outcome, possible concerns, and so on. Review the material to be present, and if the team members don't know each other, use this to introduce people, break the ice, and do an exercise for people to be able to show a bit of themselves.

Send a program to all participants at least a week in advance. It helps to include all the poster material, for the team to pre-read the documentation. This also saves on time reviewing the material at the start of the sessions.



3.4.2 SID SESSIONS

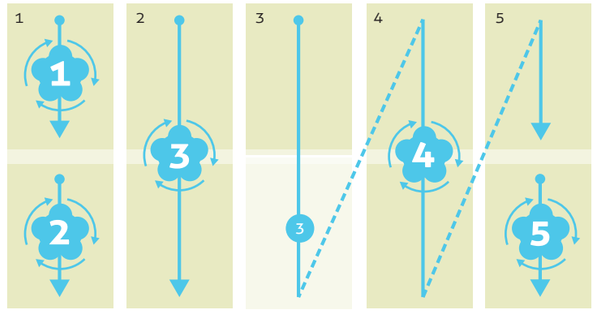
The SiD sessions form the heart of the SiD process. The steps before the sessions are preparations for the sessions, and the steps after to activate the solution found. SiD sessions ideally consist of five days of intense collaboration of the core team in a single room, preferably with representatives of the client and stakeholders present. In this room the team cycles through the method: from goal setting, through mapping, understanding, to solution phases, in several iterations. The results are elevated insight, systemic understanding, a roadmap, and clear action plans on moving forward. In most cases, a SiD session delivers very solid, agreed on outcomes that can then be fine-tuned in a more regular work pattern.

WHY A SID SESSION?

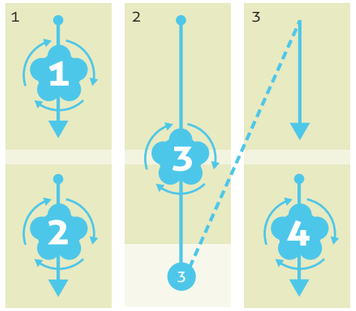
If you've come this far in this book, you know that true sustainable development and innovation requires perspectives from multiple disciplines, and an immersion into the dynamics of the system. That doesn't come easy in a regular working environment. That's why we explored a special working approach. Over time, we tuned the SiD sessions to be the ideal approach for such a process.

We've experimented with different formats, group sizes, lengths, and ways of facilitation in order to achieve the best results. From that experience, for serious challenges, we've found that the sessions are best when they are 5 days long, ideally with 6-7 people (max 8), including a facilitator. Deviation from this format is possible, but reduces its effectiveness. On the next pages, we describe a 5 day session as a main focus, and provide some tips for 4 and 3 day sessions.

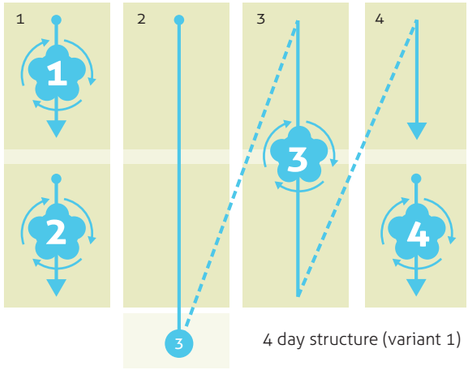




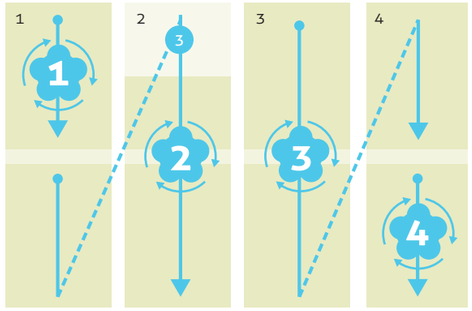
5 day SiD session structure



3 day SiD session structure



4 day structure (variant 1)



SESSION DAY STRUCTURES

Above you see a diagram of a typical 5 day SiD session structure, day by day, as well as two 4 day variants and a 3 day session. These are examples only, each facilitator designs his or her own structure,

The 5 day session is the ideal, with ample time for the critical step 3 at the end of day 3. In the 4 day variants, step 3 is compromised by being either in the evening or on the morning of day 2. Evening program is energy draining, and mornings are not ideal for step 3 either, but these are working options.

In variant 1 of the 4 day session, step 3 is performed in the evening after dinner. This works, but will put extra pressure on the energy levels of the team members. The same can be done for the 3 day session. The 3 day session, in general, is an extremely intense process that should only be chosen if there is absolutely no way to perform a 4 or 5 day session.

See the next page for an example of a day-by-day program for a 5 day SiD Session.

WHAT HAPPENS IN A SID SESSION?

During the sessions the team works from 9am to 5pm on the challenge, without distraction, in a separate environment. In the evenings, the team has dinner together, discusses the subject, and preferably sleeps at the location to not disturb the 'bubble'. Work in the sessions is intense, usually on paper only, alternating between individual work, small groups of 2 or 3 people, and whole group processes. Groups are constantly mixed to allow cross pollination of thoughts and ideas, and to find synergetic personal dynamics. The processes try to minimize group discussions because they can be inefficient, and energy draining. The sessions are led by an experienced facilitator that steers the team towards formulating a strong solution for the challenge. This usually results in a concept solution, a roadmap, and at the end, a presentation to a jury to evaluate and refine.

ATTENDANCE

The people attending the session consist of the core SiD team, led by the project manager as the facilitator, with at least one scientific thinker, design thinker, and business thinker present. If the project manager is not an experienced facilitator, he or she can become a participating member, with an external facilitator running the session. The role of the facilitator is to facilitate and structure the process, but the facilitator is not the decision maker, just the person structuring the decision making process. Added to this core team are usually client and stakeholder representatives, and often one or two external content experts. All this should not add up to more than 9 at the most. Ideally, there are 6-7 people. Sometimes, having a person present that can do quick concept sketches is also valuable. Everyone should try to join for the full session, not part of it, as this disrupts the dynamics.

SETTING AND ROOM

The best SiD sessions are in a place that is unfamiliar to everyone, in a natural setting, where everyone also spends the night. For example, in a hotel with a workshop room. The sessions are held in a single large room, with plenty of material to write and draw with, large sheets of paper and space to stick them up on the walls. All working materials are there, fast internet, projector, screens, music device, whiteboards and flipovers, as well as plenty of fruit, water, tea, and other brain nourishment. Ideally, this room has access to the outside, and will not be disturbed during the entire session by outsiders. A good SiD session room looks like a mess in half a day.

Present in the room should be the maps made during the pre-development phase, all the data, as well as the precedents that were found, hung up on the walls (see the SiD session room checklist in the tools chapter).

RUNNING THE SESSIONS

Running the sessions is a process of closely involved group facilitation. While the first day is usually strict in planning, the remaining days shift in program depending on the 'movements' of the group. Because of this, it is usually best to program day 1 carefully, and for the facilitator to set aside some time in the evening to plan for the program of the next day, as well as during lunch.

THE FIRST MORNING

The first morning is an important one. A tight program runs through a process of welcoming everyone, and then inventorizing the desires and expectations of each team member (or reviewing if done before). Then, the sessions start with goal setting. While this has already been done in the initiation phase for the project as a whole, it's important to revisit the goal, how it's set up, rework it based on gathered intelligence, and prepare to develop sub-goals and boundary conditions.

After this, the prepared system maps and posters are investigated, getting to know the issue at hand. The project manager takes the team through a tour of the problem, and explains the agenda for the sessions.

After this introduction, it is a good idea to do a short individual exercise to express the vision of each person. These can be sketched on an A3 piece of paper and hung up on a wall to keep in mind. This serves as a brain-dump, to get initially present ideas out, and out of the way.

THE REST OF THE SESSION

What follows next is highly dependent on the project, and can include system mapping, serious games, roadmapping exercises, or design exercises. To give you an example of what the process could look like, on the next page, there is a complete itinerary for a 5 day session. Below here, there is another suggestion, in text. These are not the same examples. It's useful to consider the differences of each.

EXAMPLE: 5 DAY PROGRAM 2

- Day 1, Morning: Introductions, agenda; discuss the project goals. Reach agreement on the goals.
- Day 1, Afternoon: Everyone scans through pre-made data; precedents, sketched preliminary system maps.

- Day 2, Morning & Afternoon: Make system maps in small groups, discuss the maps together at least two times; switch around team members.
- Day 2, End: Evaluate system maps, find new insights; mark them down.
- Day 2, Evening: Go out together, share dinner; continue discussion.

- Day 3, Morning: Revisit the system maps shortly, then go on joint 'journey' to clear the head, discuss and process the understanding of the system (e.g. stroll through a forest).
- Day 3, Afternoon: Discuss the new ideas and commit them to paper.
- Day 3, Evening: Go out together, share dinner; continue discussion.

- Day 4, Morning: Set out the solution pathway framework, line up the intervention ideas; start drafting a timeline.
- Day 4, Afternoon: Make a roadmap together, with short term actions and a long term vision.
- Day 4, Evening: Go out together, share dinner; continue discussion.

- Day 5, Morning: Evaluate the results of the map; make refinements.
- Day 5, Afternoon: Divide roles; make action plan for further steps.

TIPS FOR A GREAT SID SESSION

Lastly, here are some tips to help get the most out of your SiD sessions:

- Ensure everyone is knowledgeable about the standard brainstorm rules (see tools section). Print them out and pin them up on the wall to remind everyone. The most important rule is that members should reserve negative criticism, and always try to be constructive. Saying 'no' to something may put the process to a dead stop. Instead, try to say 'What if we do it this way?'

- Do not stick to structure too much. Allow for organic shifting of the program as the need arises. Often small reviews of the goals, stepping back to the analysis during solution phases, and so on, is useful. In some cases, it helps to break the groups apart, having some work on further analysis, while others start working on formulating solutions. Do make sure that no participant is stuck in the same method step. It's tempting to make the 'scientific mind' focus on the systems analysis phase mostly, but everyone should participate in all steps.

- For groups larger than 9, for example when doing second round stakeholder sessions, design processes that break the groups up into sizes of 8 or less. Keep the moments when all people together do something to a bare minimum.

- Make sure to mix work with 'reflection' and creativity, such as drawing. Include some leisure activities, like taking a walk in nature together, planning an evening out, and make sure everyone feels comfortable. Stress is the biggest block of a SiD session. If a single person turns out to be disruptive without foresight of improvement, consider removing them from the team.

- Encourage that participants voice preferences in terms of breaks, coffee, reflection moments, take a short walk, and so on.

- Ask, and stress with, all participants to not be late, don't leave early, and to try to be well rested. Do not work on other things during this period of time.

- Leave your phone off, and if you really do need to check messages, take a break out of the room for it.

EXAMPLE: 5 DAY SID SESSION PROGRAM

Day 1

- 1 Welcome / Warmup
  Personal Expectations
  Personal Vision Braindump
  System level Goal Setting
- 2 ELSI Harvest Issues/Opport.
- 3 Review & Select
- 4 ELSI Harvest Sub-Goals
- 5 Review & Select
- 1 Goal/Sub-Goals Review

LUNCH

- 2 Map of Maps
  System Mapping (x2)
- 3 Group review
- 4 Solutions braindumps
- 5 Group Review
  Day Review & Day 2 prog.

DINNER

Day 2

- 1 Warmup
  Day Goals & Program
- 2 System Maps Select & Make
- 3 Group Review & Insight Exchange

LUNCH

- 4 Part-Solutions Harvest 1
- 5 Group Review
- 4 Part-Solutions Harvest 2
- 5 Group Review
  Day Review & Day 3 prog.

DINNER

Day 3

- 1 Warmup
  Day Goals & Program
  Solidify all goals & Subgoals
- 2 Final System Maps & System Dynamics Detection
- 3 Group Review & Insight Exchange

LUNCH

3
System Understanding
(Walk in Forest / Play/
Open One-On-One Talk)

- 4 Integrated Ideas Harvest 1
  System Dynamics Review
- 5 Day Review & Day 4 prog.

DINNER

3

Day 4

- 1 Warmup
  Day Goals & Program
- 4 Integrated Ideas Harvest 2
- 5 Group Review
- 4 Integrated Ideas Harvest 3
- 5 Group Review & Selection

LUNCH

- 4 Ideas Elaboration
  Placement on Timeline
- 5 Group Review on Timeline
- 4 Road Mapping per channel
- 5 Group Review
  Day Review & Day 3 prog.

DINNER

Day 5

- 1 Warmup
  Day Goals & Program
- 2 Review Systems Analysis
- 3 Review Solution Logic
- 4 Review Road Map
  Define Road Map on Poster
- 4 Review Road Map
  Action Plan on Poster
- 5 Final Material Review

LUNCH

- 5 Prep Presentation
- 5 Jury Presentation
- 5 Jury Evaluation
- 5 Group SiD Session Review
  Distribute Tasks Action plan
  Joint Drinks

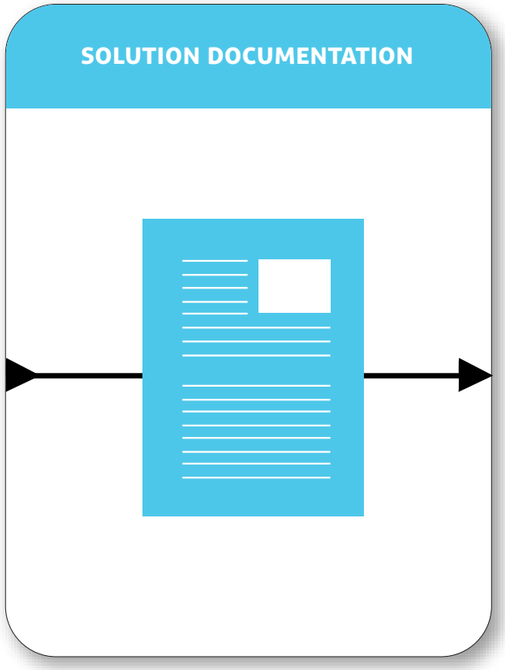
DINNER

Post-Session

- Document all material (Photos, scanning, etc)
- Write Outcomes in central doc
- Clean and clear room
- Send results to team

REST

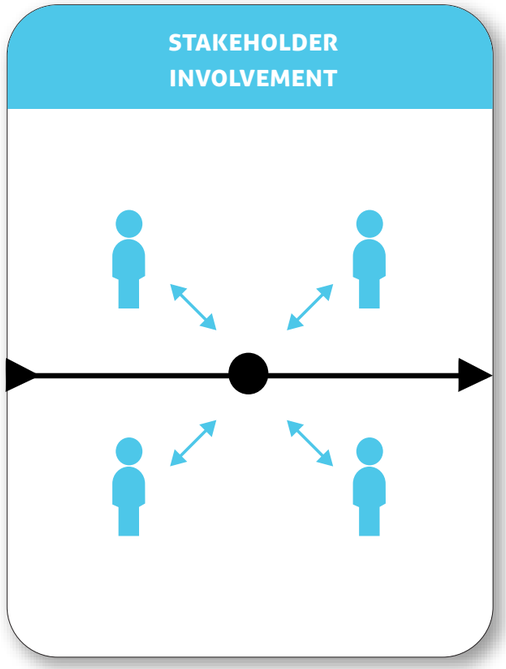
SiD
SYMBIOSIS IN DEVELOPMENT



3.4.3 SOLUTION DOCUMENTATION

After the SiD sessions, it's worthwhile to spend some time making a complete summary document of the solutions, roadmaps, and the analysis and insight that led up to them. This document is best made in the first week after the SiD session, and spread around the teamfor feedback. This document then becomes a treasured source of information for the execution phase, and to inform stakeholders.

If there is a stakeholder session planned after the SiD sessions, this document becomes the source for making a briefing for the stakeholders. Often though, stake-holder sessions are performed before SiD sessions. In those cases, the solution document is there to register and document the outcomes of the SiD session, and as input for the execution phase.



3.4.4 STAKEHOLDER INVOLVEMENT

Involving your stakeholders in the development process is a powerful, and often required part, of developing a successful project. This may be done through processes like user feedback panels, community involvement sessions, or mass online surveys. Many books have been written on stake-holder involvement, which goes beyond the scope to cover so much about it here. In this section, we'll just touch upon how it impacts and sits within a SiD process, and give some tips for along the way.

WHY INVOLVE STAKEHOLDERS?

In the case study 'Desert Flower' on page 314, we show why involving stakeholders is so important, even in a small research project. For some of you reading this, it may be obvious as to why involving stakeholders is important. In countries such as the Netherlands, it has become a defacto standard, especially for projects in the public domain. But, in many other places, this isn't the case. In those circumstances, you may need convincing arguments as to why to spend time and resources to involve stakeholders. In that case, this may be of help:

1. **Involved Stakeholders Care**
   Primary stakeholders that are engaged in the process end up with rich new insights, feel connected to the challenge, and by being able to contribute, make it part of themselves. Those that get to participate in SiD sessions usually become a strong pioneer of the project, which helps decision making and project support along the way.

2. **You will learn vital success factors**
   You will learn things from stakeholders you would never have come up with yourself. Stakeholders are related to and look at a topic in a different way than your team does, guaranteed. Involving them will deliver experience and insight, and prevent potential issues in the future. They will teach you the finesse of the success factors for the challenge, and you will learn about hidden patterns of behavior you cannot otherwise get.

3. **You will speed up the process**
   Usually, there are stakeholders that have a deciding vote in a matter, that need to be involved in the decision making process, or that will need to implement aspects of the solution later. Doing a proper stakeholder process will onboard them, smooth out the process later, save time, and increase positive outcomes.

4. **You save on communication efforts**
   An enthusiastic stakeholder communicating to other stakeholders can be a more effective means to explain the intentions of a project, and create a positive buzz. Doing this through other means may be costly and time consuming.







HOW TO INVOLVE STAKEHOLDERS

Once you have your stakeholders mapped out, you can determine who you want to include in the process. You can do this based on impact assessment for each group, their willingness to cooperate, the knowledge and experience they may contribute to the process, and other considerations. We recommend including the most important stakeholders as soon as possible. You may want to select stakeholder-group representatives to become part of the core team if you warrant their opinions relevant enough to go through the entire process. In other cases, you can bring stakeholders together and do mapping and solutions exercises with them separately, and use these as inputs for the SiD sessions of the core team.

Each project will warrant a different way of involving stakeholders. There are specialized agencies that have perfected the craft of finding, addressing, and involving various groups of people, and manage this process. We recommend you make use of their skills where appropriate. Be aware though, that these agencies use their own way of assessing who stakeholders are, and may not include the full spectrum approach SiD aims for. For example, this means they rarely take into account remote stakeholders in the system, future generations, animals, and so on, so keep an eye out for this. When involving people, such as direct user groups, the skills of these agencies may prove to be valuable.

When dealing with a sizeable number of stakeholders, such as with residents of a city district, it may be hard to have everyone's voice heard and included in the process. Depending on the stakeholder involvement methods used, some groups may be more likely to respond than others, skewing the feedback you receive. Make sure to account for possible discrepancies. Just doing interviews is unlikely to discover the true nature of a community, for example. Always try to use multiple methodologies and ways to involve stakeholders. Better be safe than sorry; a single individual from a stakeholder group may severely upset even the largest processes. Try to design stakeholder involvement trajectories in ways that draw out the largest critics and those that have serious grievances, and cater for them to have their grievances heard and taken along.

In some cases, stakeholders do not have a voice (animals, for example). When this presents itself, consider involving someone that may make the interest of these parties known and insightful as their 'agent'. Otherwise, try to figure out what their needs and wishes are, and include them in the process as far as possible. If these parties do not have a voice, ensure their interest holds its ground in the process.

In our work, we've often combined different stakeholder involvement processes in a single project. For example, when dealing with an entire production chain, we've organized events to get as many representatives of that production chain in one room. We did this for several times over a period of a few years, and performed system mapping together each time. At the same time, a few chosen representatives of core elements of the supply chain were included in the actual SiD processes, as ambassadors of their section. In addition we held interviews and questionnaires among potential end-users, and did spot-checks in stores and with suppliers to check our findings. This gave us the support of the whole chain, in a manageable and effective process.

HOW TO INTEREST AND MOTIVATE STAKEHOLDERS

Not all of your stakeholders are going to be enthusiastic about participating. Some of them may not even care or find it a nuisance, while they hold important positions or opinions. Therefore, it is essential to motivate your stakeholders. SiD's distinctive character in its focus on systems as a whole and in the long term (as opposed a mere focus on objects and short term) may not be easily understood by stakeholders. You may have to translate your goals for them to understand why it's important for them to participate. In all cases, try to provide your stakeholders with the following:

- Insight
- Drive
- Incentives
- Alignment
- Fun

INSIGHT

First of all, it is important to provide stakeholders with the insight as to why this project affects them, and why their contribution matters. This may require making materials that places the stakeholder in the center of the system or situation. In addition, when involving the stakeholders in the actual mapping process, it helps to make stakeholders aware that this process may help them to see the entire landscape of the problem and discover win-win solutions for themselves.

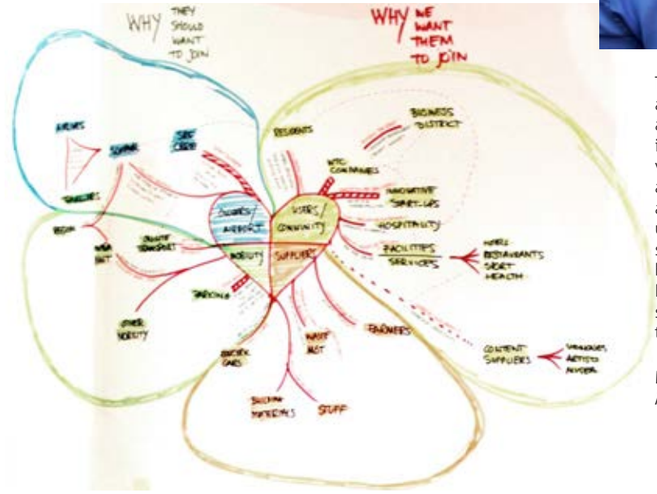
DRIVE

Next to understanding the aims and value of the project, it is important to create a vision that not only guides the content of the project, but also drives the stakeholders in cooperating and realizing the project. Besides the system goal (e.g. "a sustainable neigh-



Above an example of a stakeholder session room. This photo is included to show an example of a less-than-ideal location. The room is too small and closed in. In this room it was hard to organize breakout sessions, and the crowded space had a significant tiring effect on the participants. Read in the tool section about ideal room setups.





The stakeholder map on the left is a hybrid of a value map and a stakeholder map. Made by a stakeholders themselves in a SiD session, it shows not just stakeholders, but also their value relationships with the subject, desired, and undesired. This combines both analysis and a value argument in one map. This sort of unexpected map is the result of truly engaging stakeholders in the process, and proves to be invaluable in understanding the context. In this map, by using a heart as an organizing shape, it also expresses a passion in the desire to make the ambition happen.

Made by Willem van der Ven, Director Schiphol Airport Real Estate

borhood") to work towards, a more concrete goal (e.g. "create a closed energy loop in this neighborhood") energizes people in the short term. It helps to formulate these motivations in such a form that it connects people and touches their drives, thereby creating intrinsic motivation for the project.

INCENTIVES

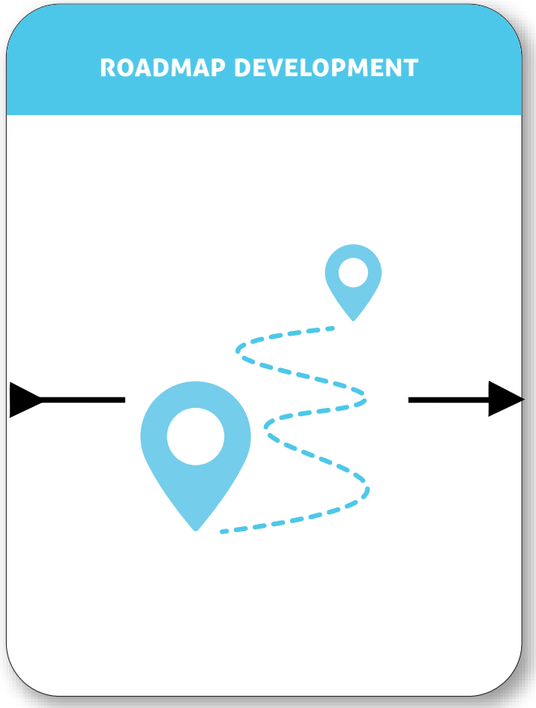
In realizing projects, intrinsic drive of stakeholders is rarely enough. Even though it creates the emotional commitment, this can crash on the shores of everyday reality quite quickly (no time, no money, etc). Providing stakeholders with real tangible incentives is one of the most powerful ways to move a group. Incentives can involve money, goods, status, time savings, market position, and any other 'value' they appreciate. It makes sense to scan each stakeholder and list their most important values. Often they can be played out to support each other. Be aware that there may also be negative incentives that need to be overcome, and that some incentives are weak, and others strong. For example, a financial investment today can be a strong negative incentive, and if the payback is very far into the future, not many will be willing to do this. Try to pit short-term, long-term, weak, and strong incentives against each other in the process.

ALIGNMENT

Understanding the added value of the project, creating a compelling vision, and the right external circumstances may not be enough to engage the stakeholders. In order to truly engage stakeholders on the long run, it is essential to align the project with their personal and organizational context. Make sure you adjust the language you use to their own jargon and show how their interests are served. It also helps to relate to their experience, strengths, and values, and to include these in the project as much as possible. In complex social settings where there is tension or large opposing forces are at work, tools such as Spiral Dynamics (see tools section) can help in unraveling the language, understanding and position of each party. This form a cohesive communication structure that allows each stakeholder to understand and participate.

FUN

Finally, try to make the stakeholder participation a fun experience. This will greatly help participation and energy levels. Try to engage stakeholders in the different stages of analysis and solutioning, and try to show them the fun of grasping complexity through immersion, generating creative ideas, and mapping their ideas on a route towards realization. Spend time to celebrate the small successes as well as the big ones, and remember that learning can be more important than finding an answer quickly. Failure is good; it leads to insight, so try to fail quickly and often. Try to keep it fun in the entire process, and you'll have a team and stakeholders that will continue working together even when the project is officially over.



3.4.5 ROADMAP DEVELOPMENT

Roadmapping creates a plan of attack to realize a systemic change over time, establishing the required steps towards the goal and plotting them out in time. Roadmapping is part of the SiD method cycle, but can be important enough to warrant a separate phase in which one or more team members dedicate separate time to refine, adjust and evaluate the roadmap.

WHAT ROADMAPS DO

Some recap from section 2.4: A roadmap is a pathway in time, defining action points in the short-term and performance goals in the long-term. Roadmaps are where all solutions come together in a comprehensive plan: the materialization of all the strategies, ideas, and interventions, and an important document to communicate intent and milestones to all parties involved.

ROADMAPS EXPRESS AMBITIONS

A roadmap typically contains a timeline, the goals to reach in each time frame, and the interventions to reach these goals. By plotting the goals on the timeline an ambition is set. For example, in the case for a roadmap for a city, choosing to become energy neutral within ten years is highly ambitious, while choosing to reach that goal in only 50 years is on the conservative side. By plotting all the goals in the same timeline synergies can be found and milestones can be formulated.

HOW TO MAKE A ROADMAP IN A SID SESSION

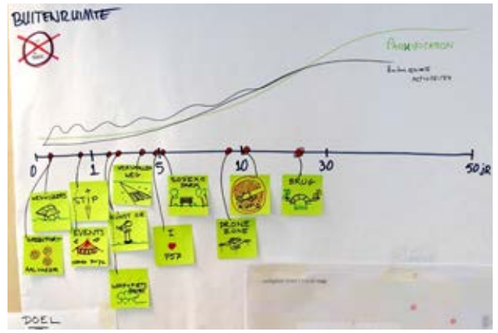
How to make a roadmap is covered in the method chapter in detail. How this works in a SiD session is as follows. Starting a roadmap in a session is relatively easy. After some interesting solutions have been made in earlier iterations, we start mapping them on a timeline. Take a large piece of paper, stretch it out over a wall of a room, and draw a timeline of about 20-50 years. On this, start placing the goals, interventions, and milestones to determine where we want the system state to be. If there are not a lot of interventions yet, this is also a good exercise to just do with the goals. Placing the goals on the timeline creates an opportunity to backcast and figure out which interventions are necessary to reach each of those goals in time. In the next method cycle these can then be refined.

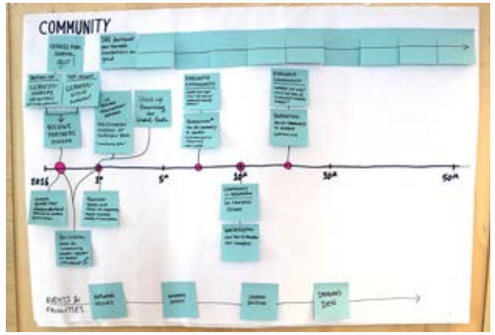
If there are a lot of solutions, write them on post-its and place them in time. Then, review if they are realistic, place missing steps to reach them, and in this way start building out the roadmap. Detailed step by step instructions for this are in section 2.4.4.

For simple roadmaps, a few hours during a SiD session may suffice. For complex trajectories, consider setting up separate sessions to further develop the main channels and milestones of the roadmap, to review and adjust these with stakeholders, and to do the research required for evaluating the different pathways.

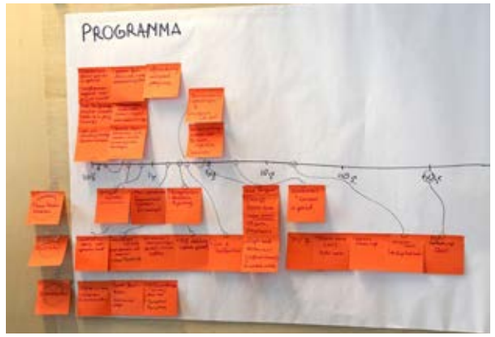
ROADMAPS AS OFFICIAL DOCUMENTS

After its use as a creative, planning and strategy tool in SiD sessions, the roadmaps can be formalized, and a detailed design drawn up. This can range from a simple drawing of a timeline expressing the main ambitions to a comprehensive action plan document with pages of details for each phase of execution. These documents can then be used to inform and involve stakeholders in another round of optimization and definition. As the process moves forward, the roadmap becomes the single most important document that ties everything together.









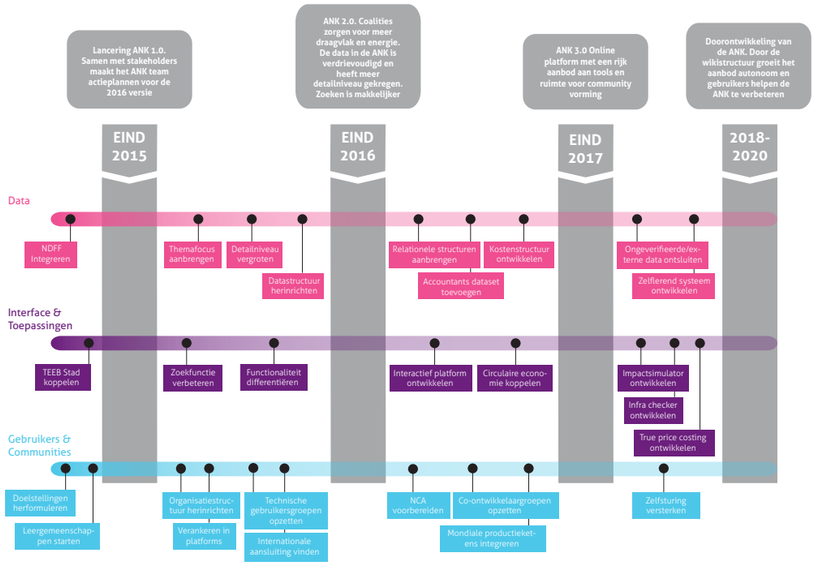
Here we see images from a SiD session to develop a roadmap for an area redevelopment plan. The roadmap timeline items have been split up in four themes: spatially, community, connectivity, and program. These themes were themselves the outcome of a goal, system, and solution cycle. In the second cycle ideas were explored, and in the third these ideas were bundled and combined into connected concepts. In this final stage these timelines were made, which became the 30 year roadmap for the redevelopment of this area.



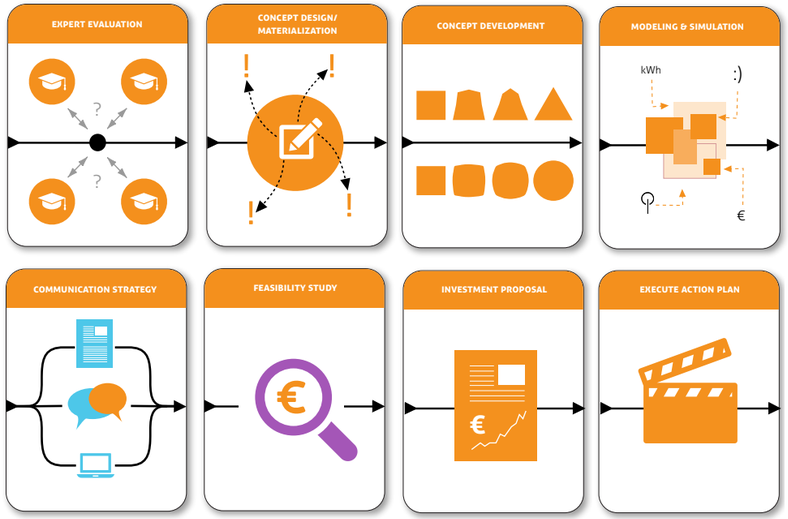


Above, a 20 year roadmap for circularity under development in a strategic SiD session.

On the right, a communication version of a roadmap for a digital Natural Capital tool.





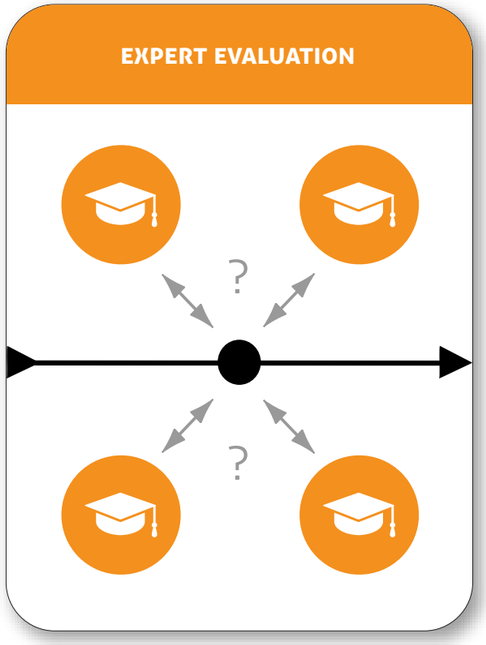


3.5 EXECUTION PHASE

In this phase the roadmap is activated. A great number of different activities can take place here, rolling into more traditional working processes such as construction planning, investor acquisition, and so on. We just provide for a few typical steps here with some useful cards in the planning process, without going into too much detail on each step

Each project culminates in one or more execution phases. One of the typical execution phases is usually communication of the outcomes of the process via a book, website, presentation, or other medium. Feasibility studies are common, as well as investor pathways. Example steps in this phase may include:

1. Expert evaluation
2. Concept design/Materialization
3. Concept development
4. Modeling & simulation
5. Communication strategy
6. Feasibility study
7. Investment proposal
8. Execute action plan



3.5.1 EXPERT EVALUATION

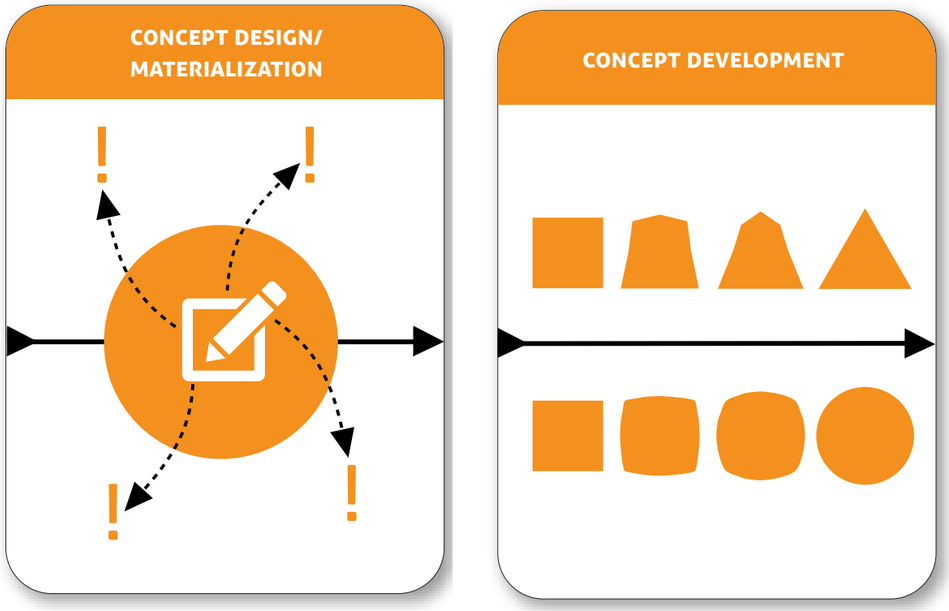
The result of the SiD sessions are integrated concepts and roadmaps. We recommend including a jury review in the SiD sessions, but it's better to have a formal evaluation review in the execution phase. Here, the outcomes are checked on their validity, missing parts are added, and things like closed loops and business models are evaluated further.

EVALUATING THE ROADMAP

A good roadmap has systemic, abstract measures in the far future, concrete measures for immediate implementation (action plan), and a number of steps in between. First, check that the measures for the far future are checked against the goals, its sustainability evaluated, realism checked, and preferably, ran past the stakeholders. After this, the action plan is checked with all those involved, until all measures have been evaluated to actually do what was intended. Often, external experts are useful to help review and refine these items. This is an iterative process, where engineers, economists, ecologists, and other experts work together to try to determine if the measures will work.

ASSESSING SYSTEMIC EFFECTS

Systemic effects can be (partially) quantified by stepping through the network parameters one by one and evaluating what the influence of the measures chosen may have on each indicator, and how this will affect the overall system. While certain system dynamics may be hard to estimate, remember that the essence lies in picking solutions that improve the general network structure to be more resilient, autonomous and equitable. It may help to check the results with an experienced systems analyst.



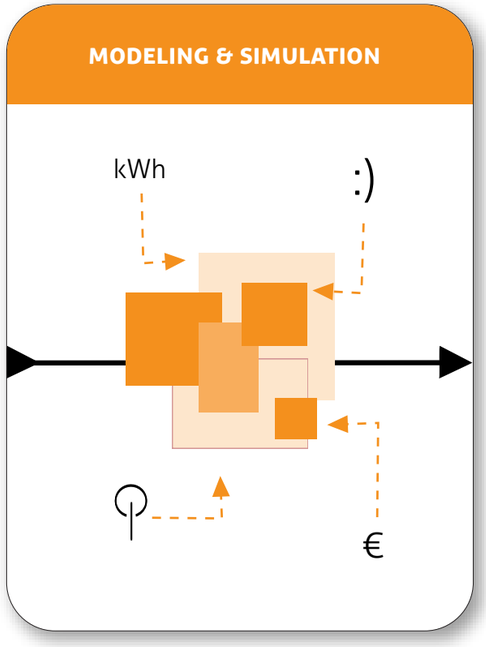
3.5.2 CONCEPT DESIGN & DEVELOPMENT

Projects often require a certain amount of further development. This may include design phases for physical development, the writing of concept reports for policy development, or making business plans and models. For example, in the case of a building, the SiD sessions deliver the central strategy, business plan, roadmap, and action plan, but it still will need detailed design. Concept design is the first step in this process. Concept development comes after this, and deepens the development level. After this, various other steps of development can take place, towards execution.

Depending on the subject, this phase looks very different. This is a phase which is most commonly present in normal development and most team members and organizations will be familiar with which steps to take to develop the concepts towards their execution. The cards can then be used to signal these familiar development steps.

During the concept development phase, you may rely on any of a number of tools to inform detailed decisions, such as LCA data for material choices, calculation models to test system response, and so on. In large projects, such as overhauling entire industries or urban developments, this phase is still done largely by the core team, which will be able to present a strong, holistic concept at the end of it, which informs subsequent sub-projects in their execution. The essential thing to keep in mind during this phase is to try to achieve a balance between all the components of the system. When 'landing' a solution in a physical form, this goal should be carried through in each sub-project, and oversight from a core team member is required to ensure that the systemic goals are being achieved.

The concept may be the end of the SiD process at this stage, or continue into more execution stages. Typically, the team plays largely a monitoring and refinement role in conjunction with the partners chosen for the execution of the sub-projects.



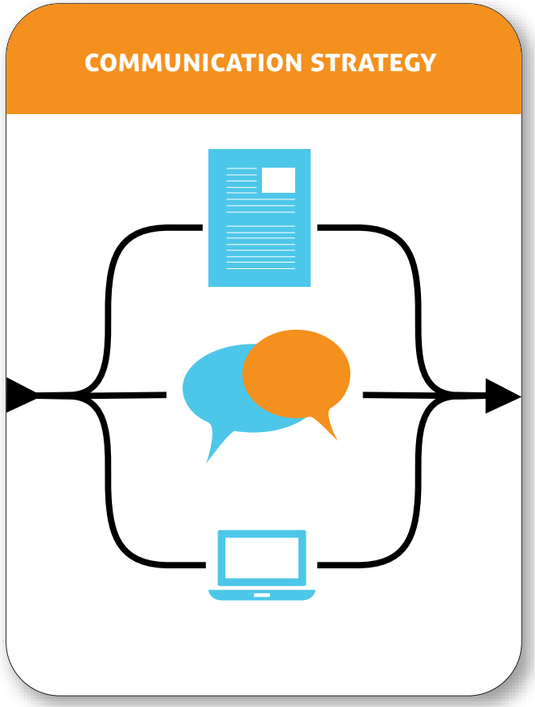
3.5.3 MODELING & SIMULATION

The modeling & simulation step builds analytical models on a system or an object level to test and improve the performance of the concept, do accurate calculations, and so on. This often involves experts from outside the group to help with accurately modeling the scenarios and testing for potential outcomes. This is especially useful for challenges that involve resource loops, new product designs, buildings, and urban interventions.

MODELING CLOSED RESOURCE LOOPS

In cases where resource efficiency should be optimized, for example for circular economy applications, urban sustainability, or industrial supply chain applications, using resource modeling techniques and software is useful. Be aware of the network and system effects with these tools, as they do not account for them by themselves. For instance, object-level loops, such as the energy, material, and ecological cycles can be modeled, and their social and economic self sufficiency can be determined alongside using different techniques. Modeling these loops can be done using various software and analysis techniques. For example, you can study how the waste of one factory can be used as a resource to supply others using a material flow simulation. When the results are presented in diagrams similar to the system maps made earlier in the process, this creates a direct overview and insight. The solutions at this stage can be rudimentary. The point is to do an early exploration to see in which ways the system may behave, the available direction, and a rough idea of orders of magnitude.

In our experience, other subjects of frequent modeling are the modeling of business models, the thermodynamic modeling of buildings and infrastructure, and the modeling of production systems and industries.



3.5.4 COMMUNICATION STRUCTURE & STRATEGY

We've learned from the Desert Flower case study that communication is a vital component in the success of a project. Setting up a communication structure and/or strategy during the project can be a great help in the process. This can be done at the beginning of the process in the initiation phase to smooth the project's reporting and publication during its course, or at the end to communicate the project's results to the right people, with the right message.

COMMUNICATION STRUCTURE

A communication structure is a framework in which the team registers and stores information in order to be easily communicated. This can be a digital framework involving a variety of tools and databases to fit the nature of the project. The essence is that it both fits the information generated by the team, and the communication requirements to achieve its goal. A team member or external communication expert can then quickly assemble this information and publish it in a variety of ways, such as an online system, in books, presentations, and so forth.

COMMUNICATION STRATEGY

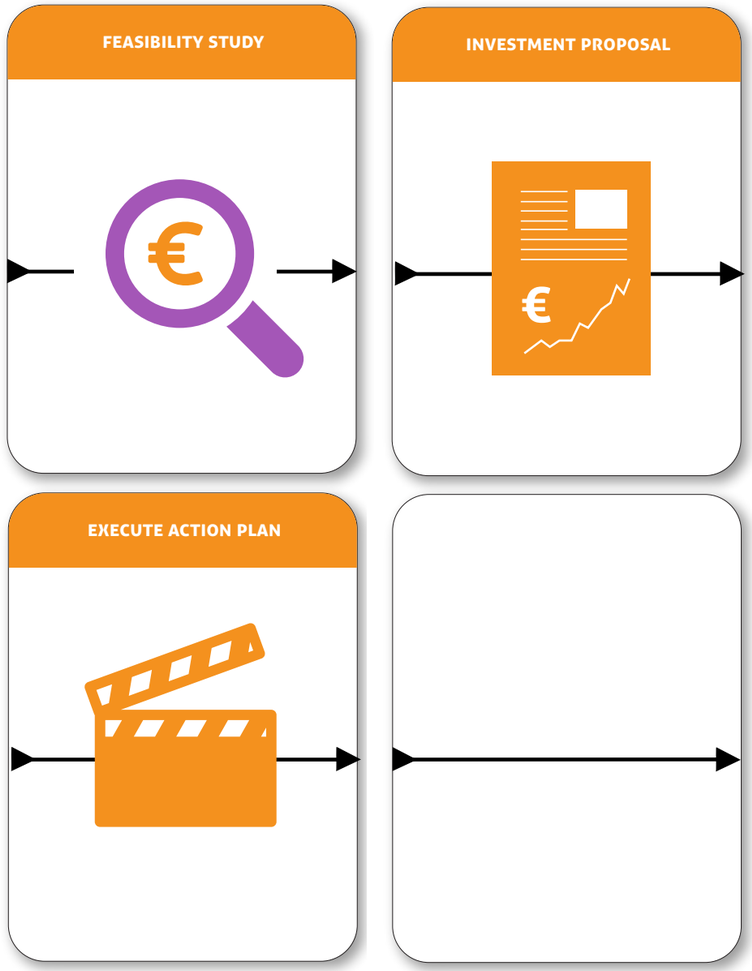
SiD projects are usually performed in situations in which many stakeholders and sometimes opposing interests play a role. Communicating clearly about what the project is about, its intent, and possible outcomes, is an important part both to inform interested parties and to protect the team from unnecessary inquiries that may disrupt the process.

This is what the communication strategy is for. It's a single, well-written and edited outline of what the team is doing, ready for publication. It may be referred to by members of the team to answer questions, and to create a unified voice when details about the solution are not yet clear. It will help in informing the stakeholders as to what's going on and engage them to participate.

AREAS OF APPLICATION

Depending on the deliverables of the process, setting up a communication structure and/or strategy for the team may help a number of aspects, for instance:

- Streamlining stakeholder involvement
- Streamlining communication of the project's progress
- Assembly and communication of knowledge collected
- Running registration of the process, analysis, and solutions
- Help with communicating to third parties during and at the end of the process



3.5.5 FEASIBILITY, INVESTMENT, AND EXECUTION

Feasibility studies and investment proposals are common items to make at this stage. Each industry has its own standard, and if these are required outputs, its useful to have the template for those documents ready before the SiD sessions. This helps in working towards 'filling in the blanks' for these documents. Executing the action plan is the typical end of the SiD process cycle, which may then continue in another cycle, planned anew from the start. And with that, this is the last process step we include in the SiD process.

The development of feasibility studies, and investment proposals is well covered in many great books, courses and online documentation. We hope the cards on the left will help round out the SiD process deck, and that the whole set is useful to cover a wide area of applications.

MAKE YOUR OWN CARDS

We included blank cards in the deck to help you make your own. Rename process steps if you need to to fit a certain professional context, or make entirely new cards. Try to clearly define new process steps and assign people to it to independently execute it. If you have any important process steps you feel are missing, help us expand SiD by sending us your card design and description.



4. TOOLS

This section offers a variety of tools that are helpful in certain parts of a SiD project, and for sustainable project development in general. Some tools are practical and can be directly used, such as the SiD Spectrum Sweep, others are more general background knowledge on sustainable development, such as the FSSD framework.

This chapter is a reference section. If you are looking to become an all-round sustainability professional, it is worthwhile to read the description to all the tools, and check out details about them online. Each tool in this section offers value, and every sustainability professional should be aware of all of these tools, especially standard industry practices such as the GRI, Life Cycle Assessment, Biomimicry and the Circular Economy. Please note that some tools are included to be sure the reader is aware of them, while their use is discouraged.

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4.1 SID PROCESS ROOM

The SiD process room is a working space where all the materials of the project are kept, where the team can come together to work on the project, and that allows for good group processes. It is different from the SiD session room in that it doesn't have to be as large, only needing to accommodate the core team. A SiD process room is typically available throughout the SiD process, not just for the SiD sessions. A SiD process room is not mandatory, but it is a great help in the development of a good project.

WHY A SID PROCESS ROOM?

Just as the reason for developing special co-creation session for SiD, the room is a device that helps to channel and improve the mental capacity of the team to understand, manage, and work with the challenge. By having a room during the entire project where all the project material 'lives', is on display, can be worked on day and night, the challenge has a stronger presence in the world and thus invite more intense and deeper collaboration. It is also a good device to stimulate group processes, latent information absorption, and as a device to introduce and keep up to date members that are not part of the core team or are introduced at a later point.

SID PROCESS ROOM PROPERTIES

1. Is big enough for the core team to have ample space to work.
2. Has plenty of wall space to pin up the important posters, drawings, etc.
3. Can be closed off from outside interference.
4. Is preferably an inspiring, pleasant place that can be workshop-messy and stay that way.
5. Is 24 hours accessible to the team members and entirely dedicated to the challenge. The materials should remain. It's possible to put multiple challenges in one room though, as long as each has its own dedicated section on the walls.
6. Has all content and working materials present at all times.

STANDARD SID PROCESS ROOM ASSETS

- Flipovers and plenty of flipover-paper
- Cupboards for filing workshop content materials
- A4, A3 sized paper (11x14 / Letter)
- Colored thick felt pens, pencils, flipover markers
- Projector
- Speakers to play music
- Large table for brainstorming
- Post-it notes in a variety of colors and shapes
- Printed and hung SiD posters A1 or A0 sized (PDF for poster printing freely available from ThinkSiD.org website)







Three photos of a SiD session room in action. All intelligence posters are hung around the space, and there's plenty of tables and breakout places. The space is open, light, and invites collaboration through the presence of lots of creative tools and background intelligence.

4.2 SID SESSION ROOM

A good room is a prerequisite for a good SiD session. The team will be spending a lot of time in there, and to keep the mental flow going, the following guidelines help.

LOCATION

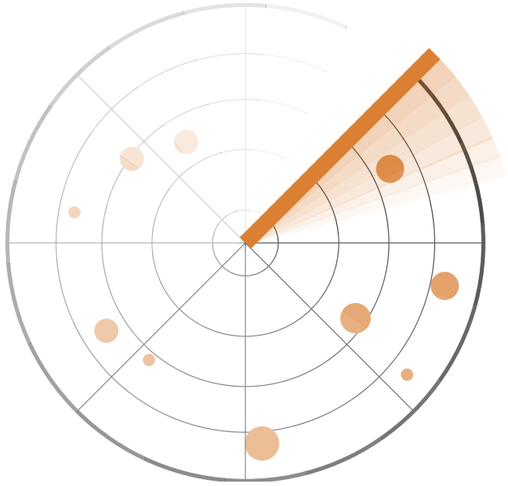
1. Choose a location that has ready access, or even better, is within nature.
2. Choose a location that is inspiring, and that provides for a good night's rest, and inspiring food.
3. Choose a location that allows plenty of flexibility in spaces. A single room is often not enough, breakout spaces are desired, as well as sitting on the lawn to draw or discuss, or a forest to go for a walk, etc.
4. If the session's topic is a spatial challenge, it's best to place the room in the vincinity to be able to take a walk or a tour.

THE ROOM

- The room is more than large enough to accommodate twice the amount of people as the session contains. This allows for movement and flexibility in doing small group work. So for a 7 person SiD session, get a conference room that seats at least 14 people.
- The room needs to have large surfaces to stick paper to, walls or windows. A delicate museum space therefore isn't suitable, unless panels are brought in to stick paper to.
- The room needs to have enough large tables for 3-4 groups to work independently, and draw on flipover paper.
- The room preferably has direct access to the outside
- The room should have good, adjustable lighting. Just fluorescent lighting will make everyone tired soon.

WORKSHOP MATERIAL

- Flipovers and plenty of flipover paper
- A4, and A3 sized paper (11x14 / Letter)
- Colored felt-tipped thick pens, pencils, colored markers for flipcharts
- Post-it notes in a variety of colors and shapes
- Projector plus a laptop or computer
- Good quality loudspeakers (tp play music during working sessions and breaks)
- Plenty of water, coffee, juice, fruit, cookies / snacks
- Digital camera for recording drawings
- Printed and hung SiD posters A1 or A0 sized (PDF for printing freely available from ThinkSiD.org website)
- All the intelligence materials as discussed in the Session Preparation process step.



4.3 SID SPECTRUM CHECK & SWEEP

The SiD Spectrum Check is a tool that is useful at the start of any project to get a grip on the 'feel' of the system. A SiD Spectrum Sweep is its bigger brother which is used after the Spectrum Check to comprehensively inventorize the elements of a system, and determine useful indicators. They are essentially the same but differ in their level of detail and resolution. In the text below, a Spectrum Sweep refers to both a SiD Spectrum Check and a Sweep, unless a difference is indicated.

A SiD Spectrum Sweep inventorizes the systemic characteristics of the topic at hand from both a top-down and a bottom-up perspective. It helps to get a general sense of the subject, and to detect potential system mapping opportunities. Often, a Sweep becomes a good to-do list for the rest of the project, and also allows the distribution of work on a large systems analysis.

A SiD Spectrum Sweep follows the SiD structure closely, and the results can be considered a system context-map, although it usually functions as an index of maps rather than a map itself. Through this, a comprehensive understanding of the breadth of the topic at hand can be gained.

HOW TO

A Spectrum Check can be performed in a few hours as a collaborative effort by a project team, or by a single individual. If performed by a single person, it's recommended that, especially in the case of larger projects, various experts and generalists from other fields are invited to check and add to the results.

The easiest way to do a simple and quick Spectrum Check on the object level only is to stick a poster of ELSI on the wall, and ask the group to populate each layer with whatever question you have in mind. For example, as a way to generate ideas, concerns, or stakeholders. See the next page for some example pictures of that.

For a more complete Spectrum Check, including the network and object level, make a table showing the object level, network level and system level. You can do it as a simple grid on a flipover, or digitally, usually in a spreadsheet. Draw the table with a vertical axis containing ELSI4 or ELSI8 topics, and a horizontal axis with the object, network, and system impacts, both in Time and Space.

This matrix is then filled out to provide the 'spectrum overview' of the object level. A second matrix is made for the Network level, with the relevant network level parameters vertically, and Space and Time horizontally once more. For a Spectrum Check the system indicators are can be put in the same matrix as the network parameters, and for a Spectrum Sweep a separate page is made for the system, containing the system indicators and the most influential network and object indicators.

A rigorous Spectrum Sweep may benefit from performing a Spectrum Check first (e.g. with ELSI4), subsequently a Spectrum Sweep (with ELSI8), and several consecutive passes with increasing number of categories for each iteration. Doing this is also an excellent way to learn the tool and to create a mental structure of the relations between the categories and

the indicators. You start with a single category, and keep dividing each element in two smaller aspects. In other words, you continuously refine the matrices with increasing resolution, while the scope stays more or less the same.

DOS AND DON'TS

A Spectrum Check and Sweep's value lies not just in its content, but also in its structure. The ELSI tool was first developed while struggling to choose categories for Spectrum Sweeps. We found that choosing the categories to use taught gave us great insight into the subject. Therefore, a great deal of freedom can be taken here, as long as you understand that the categorization needs to cover the 'entire spectrum'.

Just like trying to map the entire system, being complete is impossible, so choices need to be made as what to put in and what not to put in the matrix. The most important consideration there is that the point of a Spectrum Sweep is-well, to sweep the entire spectrum, and not just part of it. Therefore, whichever categorization is chosen, we usually try to expand and contract in resolution and detail rather than in breadth. We therefore recommend to always use ELSI or an equivalent to 'construct' the categories, but there are occasions where you want to zoom in on a particular aspect within a certain category more than others. For example, if we're doing a quick study of a transport logistics software system, we may do the Spectrum Check with ELSI8, and after this, the economy section is expanded to include details about transportation, storage, handling, processing, auctioning, vehicle maintenance, road systems, etcetera, to provide increased resolution, while other areas, such as happiness, stay at a more abstract level.

A misconception may lurk in between the matrix lines of the Spectrum Sweep. This is a similar issue as we've brought up before when discussing deterministic system modeling and complexity system modeling. This misconception is that if only the categories are expanded sufficiently, a 'complete' picture of the system can be made, and when applying this, we've covered all aspects we need to take care of when making decisions in the world. This is a dangerous line of reasoning which effectively relegates the responsibility of decision making onto the tool, rather than using the tool to support responsible decision making. No spectrum sweep, system map or system analysis can ever be considered complete, and completeness can never be its purpose. There's rarely a replacement for common sense and experienced insight, which at all times need to remain the primary focus.



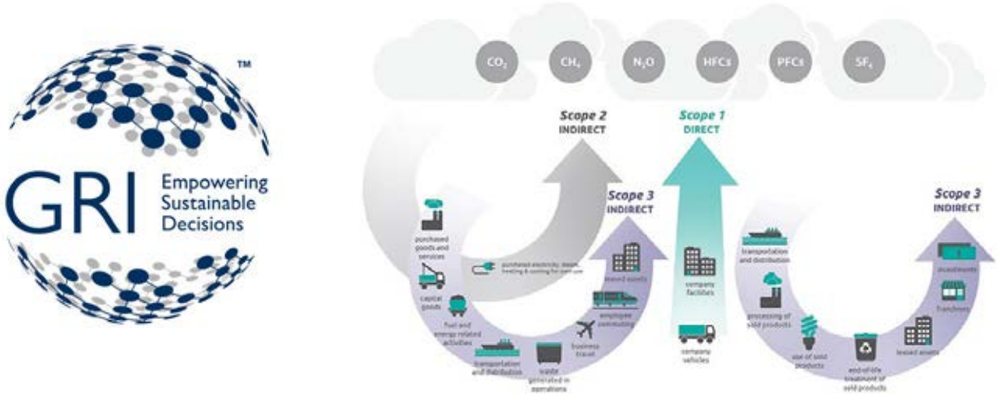


SPECTRUM SWEEP EXAMPLES

The two ELSI8 index sheets above show the workshop result of two 10 minute spectrum checks on ELSI alone. Doing this with a group is fast, and is a great way to quickly harvest ideas, concerns, stakeholders, or any other subject.

It also gives immediate insight in possible focus bias, and allows the team to balance its perspective. The group of lower image has a clear focus imbalance in the Society area. It's typical for a group to be biased towards this section. Often, the Life section receives the least amount of ideas or concerns, even though it is a fundamental section. Using time to focus on this section alone can then help to even things out in subsequent iterations.

4.4 GLOBAL REPORTING INITIATIVE (GRI)





The GRI is an international standard for organizations to help reporting their sustainability related impacts such as climate change, human rights, and corruption. First released in 2000, it is developed by a non-profit organization of the same name. It is a freely available set of guidelines that structures, regulates, and standardizes sustainability and CSR reports. The GRI is now widely used, and has become a near mandatory standard among multinational corporations. In 2017, 75% of the global fortune 250 companies reported applying the guidelines.

The GRI is applicable to organizations of all sizes and complexities. Yet, its complexity does require an organization of a certain size to be affordable in its application. The documentation is vast, deep and extensive. It is worth noting that the application of the GRI does not in itself improve environmental and human rights impacts, but it is primarily a standardized form of transparency that helps organizations across the board to have comparable standards of reporting. Also worth noting is that the GRI is focused on reporting itself, and not so much on better reporting in terms of use, insight, or encouraging action.

The GRI itself depends on various other standards for environmental impact measurement, such as various ISO standards, and for health and safety the OHAS standards are used.

The GRI standard has helped to standardize scales of supplier relations, which it identifies as 'tiers'. It helps to gradually increase sustainability intelligence by increasing information collection per tier. The degree to which tiers are included are called 'scopes'.

A USEFUL BUT WEAK STANDARD

The GRI is mostly applied as a voluntary standard. Decisions need to be made as to what aspects will be reported, the scope to which these aspects are reported, and their depth. Also, the context of impact reporting is a choice. This means that the impacts the measured items are held against, for example the planetary boundaries, are a voluntary choice. This means that for those organizations wanting to obfuscate or even make their reporting provide a false positive result, that is easy to do. This makes the GRI, as it stands in its current G4 version, still a weak standard and requires stringent and closely curated application to be effective, as well as external independent third parties for audits and review.

THE GRI PROCESS

The GRI process, in summary, consists of three major phases, starting with identification of impacts, then the prioritization of impacts, and then the validation of impact data. These are then reported using a set of guidelines and standardized formats. The GRI website contains extensive information and documentation about these processes.

SiD can be used to help in the identification of impacts, the setting of impact measurements, to ensure an integrated set of impact measurements, and to provide actual systemic insight into the causes and possible solutions to improve the impacts.

Source & more info: https://www.globalreporting.org



4.5 LIST OF SUSTAINABILITY LABELS & CERTIFICATES

This is an incomplete list of several popular sustainability labels and certifications. Their quality, transparency, effectiveness, and rigor varies wildly. Investigate any label considered to be applied closely and carefully. No single label truly guarantees sustainable performance, and some may detract from true sustainable impact. Virtually none regard sustainability on a systems level, and falter in this regard. This means the label may score high but may negatively impact system level societal sustainability. On the other hand, labels can be a useful tool to move the bottom of an industry or area upwards, and standardize base quality levels.

In general, it is good to be aware of the various methods and mechanisms used out in the field. There are various aspects of labels that change their transparency and leverage, such as being a voluntary or involuntary standard, their focus and scope, and methods of accreditation and auditing. An extended list of eco labels can be found on: http://www.ecolabelindex.com.

FOR COMPANY IMPACT PERFORMANCE

DOW JONES SUSTAINABILITY INDEX (DJSI)
Since 1999, DJSI scores more than 1000 companies on their own sustainability index, giving an idea of global sustainability consciousness in the business world.

ISO 14001 (1996)
Voluntary international standard for organizations (mostly industry) focused on environmental impact.

B CORP.
B Corp. is a volunteer standard for organizations wanting to pioneer sustainable business and operations.

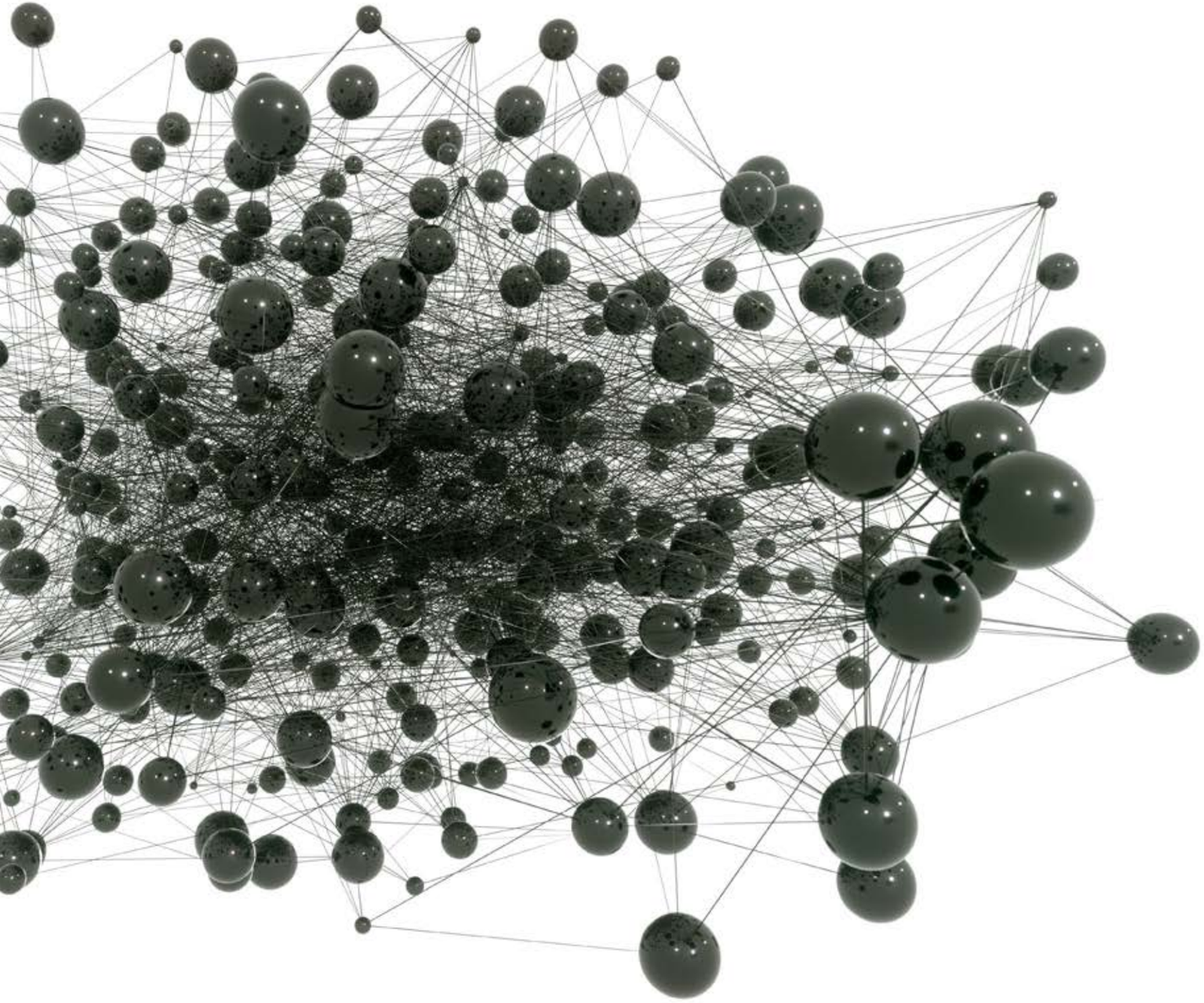
CARBON TRUST / GOLD STANDARD
Two of great many carbon certification labels and organizations. These mostly only focus on carbon, and are often connected to tradable carbon offset markets.

FOR PRODUCTS

FOREST STEWARDSHIP COUNCIL (FSC) AND PROGRAMME FOR THE ENDORSEMENT OF FOREST CERTIFICATION (PEFC)
Two of the oldest, and most respected sustainability labels, focused on sustainable forestry and forestry products such as paper and timber. Both work very different, yet with the same goal, an interesting case to research for new labels.

MARINE AND AQUACULTURE STEWARDSHIP COUNCIL (MSC & ASC)
Two labels you find on environmentally responsibly sourced fish, MSC is for wild caught, and ASC for farmed fish. Strong certifications that place little (ASC) to no (MSC) focus on social aspects or animal welfare.

FAIRTRADE & MAX HAVELAAR
Formed in the 1960's, focuses on socially equitable supply chains for products. Max Havelaar was the first formal initiative and label (1988) from the Netherlands.



OEKO-TEX
Various labels for the textile and leather industry by the International Association for Research and Testing in the Field of Textile and Leather Ecology (1992).

EU ECOLABEL
A voluntary standard for products focused on ecological impact in their life cycle (1992). Has localized offshoots with country specific requirements and standards.

ENERGY STAR
Established in 1992 by the EPA in the USA, Energy Star focuses on promoting and labeling energy-use conscious products.

FOR REAL ESTATE

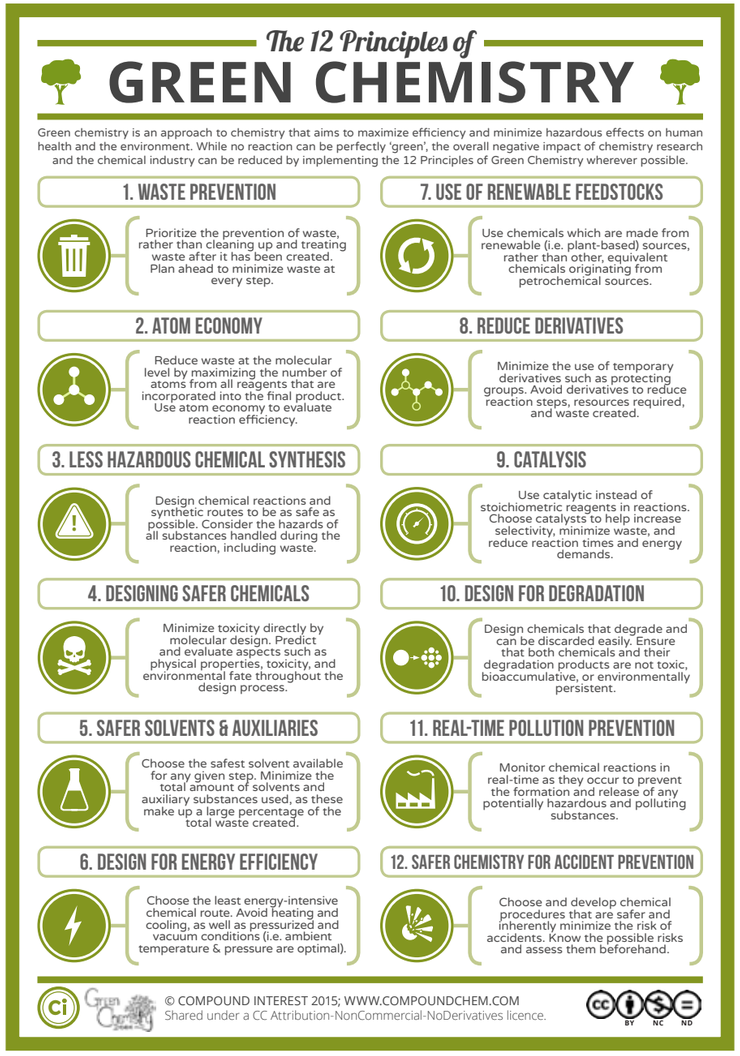
BREEAM (BUILDING RESEARCH ESTABLISHMENT ENVIRONMENTAL ASSESSMENT METHOD)
Established in 1990 in the UK, one of the first voluntary green building standards. Since then expanded into various other labels for neighborhoods and reconstruction, as well as other countries. Focuses almost exclusively on direct environmental impact of a building.

LEED (LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN)
Voluntary green building programme from the United States in 1992, similar to BREEAM, it is more centralized in its process of accreditation. Since expanded and updated into various sub-areas. Also focuses almost entirely on direct environmental building performance through checklists.

LIVING BUILDING CHALLENGE
From 2006, the LBC is a more rigorous, ambitious, and modern certification standard for buildings than BREEAM and LEED. This also includes health and wellbeing and social justice aspects.

WELL STANDARD
The WELL standard launched in 2003 focuses on the wellbeing and health of people due to their occupancy inside of buildings. May soon be combined with BREEAM.

GREEN KEY
Voluntary self-reporting standard for hotels and hospitality industry. Generally a weak standard within an industry that is slow to respond to sustainability challenges.



A sister set to the 12 principles of green engineering are the 12 principles of green chemistry, printed to the left. They were conceived by Paul Anastas and John Warner.

4.6 PRINCIPLES OF GREEN ENGINEERING

Paul Anastas and John Warner made a beautiful set of principles for green chemistry during their long career of finding sustainable solutions for industrial applications. Paul and Julie Zimmerman have adapted these rules to the "12 rules of green engineering", a generic set of guidelines helpful for anyone working on designing and optimizing physical systems.

1. **Inherent rather than circumstantial**
   Designers need to strive to ensure that all materials and energy inputs and outputs are as inherently nonhazardous as possible.

2. **Prevention instead of treatment**
   It is better to prevent waste than to treat or clean up waste after it is formed.

3. **Design for separation**
   Separation and purification operations should be designed to minimize energy consumption and materials use.

4. **Maximize efficiency**
   Products, processes, and systems should be designed to maximize mass, energy, space, and time efficiency.

5. **Output-pulled versus input-pushed**
   Products, processes, and systems should be "output pulled" rather than "input pushed" through the use of energy and materials.

6. **Conserve complexity**
   Embedded entropy and complexity must be viewed as an investment when making design choices on recycle, reuse, or beneficial disposition.

7. **Durability rather than immortality**
   Targeted durability, not immortality, should be a design goal.

8. **Meet need, minimize excess**
   Design for unnecessary capacity or capability (e.g. "one size fits all") solutions should be considered a design flaw.

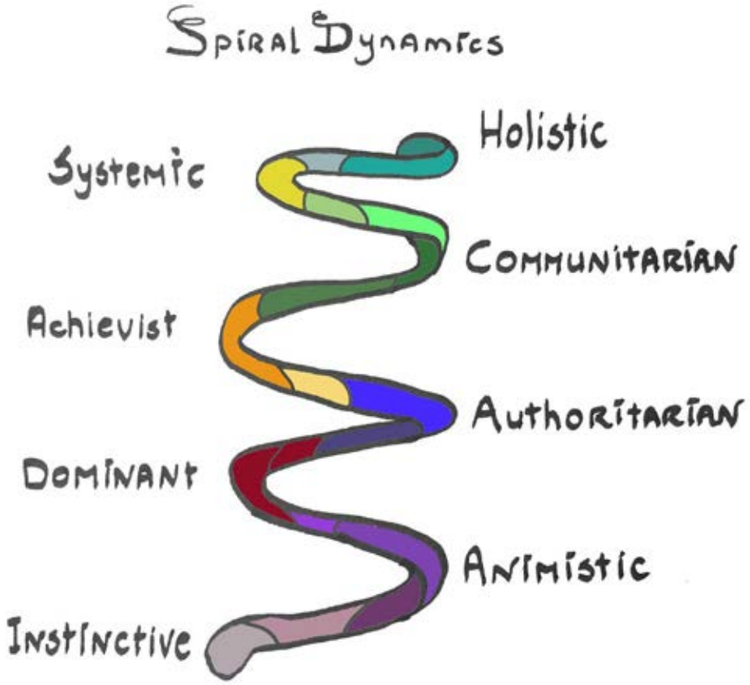
9. **Minimize material diversity**
   Material diversity in multicomponent products should be minimized to promote disassembly and value retention.

10. **Integrate material and energy flows**
    Design of products, processes, and systems must include integration and interconnectivity with available energy and materials flows.

11. **Design for commercial "afterlife"**
    Products, processes, and systems should be designed for performance in a commercial "afterlife."

12. **Renewable rather than depleting**
    Material and energy inputs should be renewable rather than depleting.

Source & more info:
www.acs.org/content/acs/en/greenchemistry/about/principles/12-principles-of-green-engineering.html



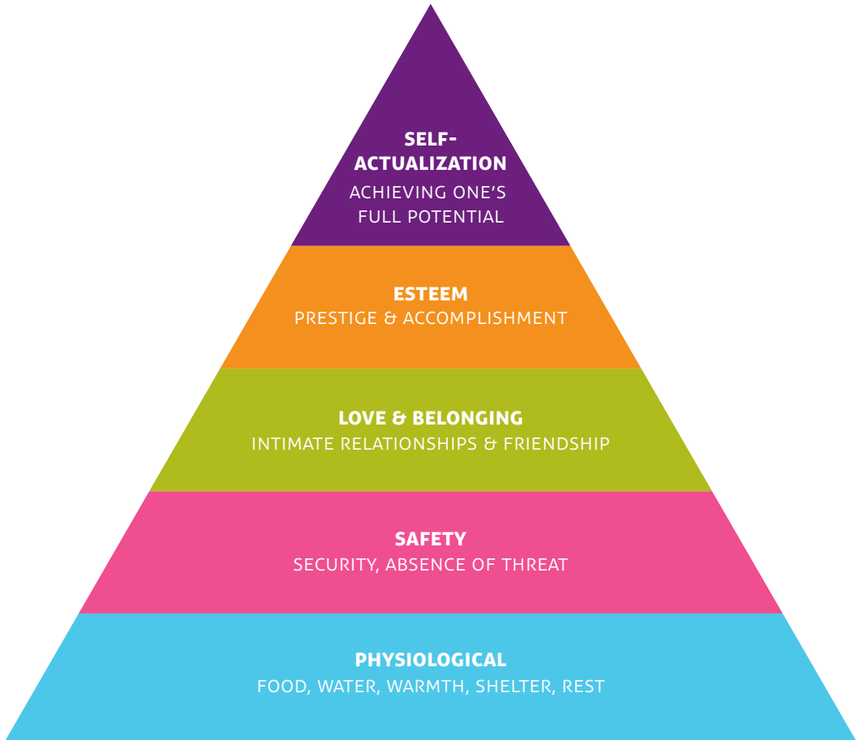
4.7 SPIRAL DYNAMICS

Spiral Dynamics is a theory of human development developed by Don Beck and Chris Cowan, introduced in 1996. It is helpful in understanding and resolving friction between groups and individuals that have differing or opposing world views. As a theory, it provides a great set of 'glasses' to observe behavior, interests, and group dynamics. The theory is based around the concept of stacked ideologies, or 'memes'.

"Cultural memes" function as a sort of cultural gene that's passed on within people of a certain group. These memes contain things like values, songs, fashion, and perspective, but most importantly a core value ideology. They live within people, sometimes over many generations, and evolve with their environment. They evolve through time in reaction to one another, and many are present within each individual and group at any given time, with a single meme, the top one, dominating. When a cultural system is under pressure, a group or individual may fall back into underlying memes. In this way, changing behavior of a system or a person under stress may be explained. Spiral Dynamics organizes these memes in categories, each with a color code. From the base color of beige, each subsequent color contains all the preceding ones, effectively nesting the memes into one another. The central memes are (from Wikipedia):

1. **Beige** (Archaic-instinctive—survivalistic/automatic/reflexological), time of origin: c. 100,000 BC
   "Express self to meet imperative physiological needs through instincts of Homo sapiens."
2. **Purple** (Animistic-tribalistic magical-animistic Tribal order), time of origin: 50,000 BC
   "Sacrifice to the ways of the elders and customs as one subsumed in group." This is the level of traditional cultures."
3. **Red** (Egocentric-exploitive power gods/dominionist), time of origin: 7000 BC
   "Express self (impulsively) for what self desires without guilt and to avoid shame." Expressed by the mentality of street gangs, Vikings, etc.
4. **Blue** (Absolutistic-obedience mythic order—purposeful/authoritarian), time of origin: c. 3000 BC
   "Sacrifice self for reward to come through obedience to rightful authority in purposeful Way." Embodied by fundamentalist religions.
5. **Orange** (Multiplistic-achievist scientific/strategic) time of origin: c. 1000 AD on (as early as 600 AD according to Graves and Calhoun)
   "Express self (calculatedly) to reach goals and objectives without rousing the ire of important others." Expressed in the Scientific Revolution and the Industrial Revolution.
6. **Green** (Relativistic-personalistic—communitarian/egalitarian), time of origin: From 1850 on (surged in early 20th century)
   "Sacrifice self-interest now in order to gain acceptance and group harmony." Expressed in 1960s pluralism and systems theory.
7. **Yellow** (Systemic-integrative), time of origin: 1950s
   "Express self not for what self desires, but to avoid harm to others so that all life, not just own life, will benefit."
8. **Turquoise** (Holistic), time of origin: 1970s
   An integrative system which combines an organism's necessary self-interest with the interests of the communities in which it participates. The theory is still forming.

Source & more
http://spiraldynamics.org



4.8 MASLOW'S HIERARCHY OF NEEDS

Maslow's hierarchy of needs is a hierarchical structure of human needs in the form of a pyramid. In 1943 Abraham Maslow ranked universal human needs in this hierarchy and as his theory goes, a human being would only strive for satisfaction of needs higher in the pyramid if lower-ranked needs were met. Several terms were used to described the universal pattern human motivations move through:

1. Physiological needs are at the bottom of the pyramid. These entail the need for sleep, food, but also sex and other physiological things like sports.
2. Need for safety and security are the next layer of needs, where an individual would seek safety and security in property, employment, the family, etc.
3. The need for love and belonging entails the need for friendship, family and love.
4. The need for esteem means that an individual has the need to get respect from others and build confidence and self-esteem.
5. The need for self-actualization means the need to develop oneself personally, in knowledge, and in valorization of this knowledge.

Maslow's hierarchy of needs may be useful for those working with systems with an evident social and psychological side. It might be helpful to see why certain people behave the way they do and what should be changed in the system in order to change behavior.

CRITICISM AND SUPPORT

There are different views on the hierarchy depedning on cultural context: "Maslow's hierarchy of needs fails to illustrate and expand upon the difference between the social and intellectual needs of those raised in individualistic societies and those raised in collectivist societies. The needs and drives of those in individualistic societies tend to be more self-centered than those in collectivist societies, focusing on improvement of the self, with self-actualization being the apex of self-improvement. In collectivist societies, the needs of acceptance and community will outweigh the needs for freedom and individuality." [3]

In other models, the need for parenting is sometimes put at the top, which again met with much criticism. But recent data support Maslow's original theories. Makenna Berry: "It strongly suggests that not only should self-actualization be put back on the top of the pyramid, purely psychological needs should be given even greater emphasis than Maslow originally suggested."

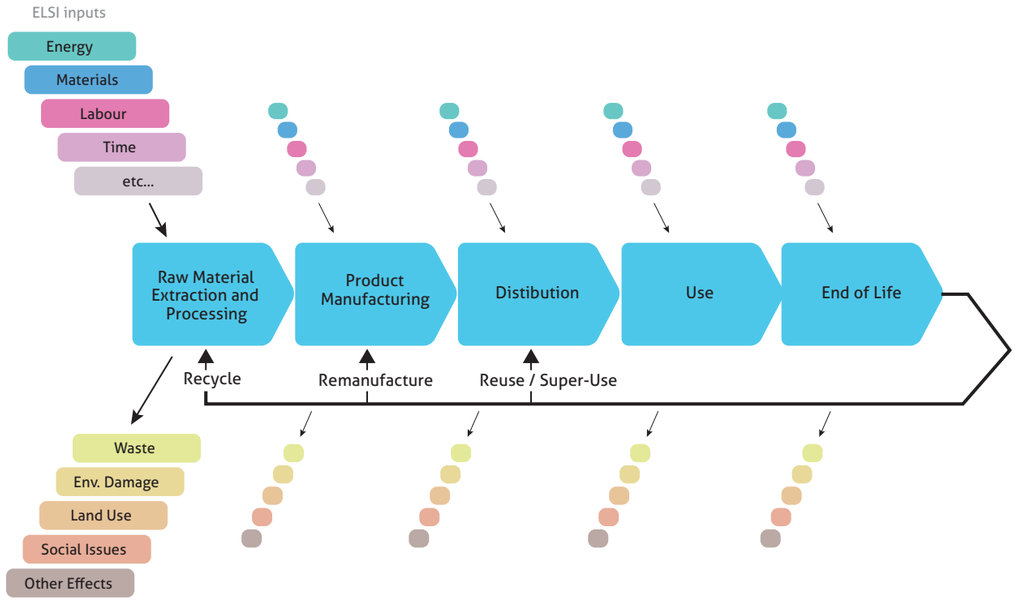
> *"When our basic needs (food, shelter etc.) are met, individuals in the study reported that their lives were better. They reported less negative feelings. What they did not report was an increase in life satisfaction. Improved life satisfaction was related to having all of one's needs fulfilled. In addition, Tay and Diener found that these needs do not need to be fulfilled in a particular order."*

Source & more

http://en.wikipedia.org/wiki/Maslow%27s_hierarchy_of_needs

http://www.saybrook.edu/newexistentialists/posts/07-22-11

SID ROCKET
A diagram of the life cycle of a product in the system and its impacts.



4.9 LIFE CYCLE ASSESSMENT (LCA)

Life-cycle assessment (LCA, also known as life-cycle analysis, ecobalance, and cradle-to-grave analysis) is commonly-used technique to evaluate environmental impacts from products and services throughout their life cycle, from resource harvesting via production, transportation, use and its end-of-life. The method has been around for a few decades and several libraries of pre-calculated LCA data exists for a wide variety of resources and applications.

LCA is useful for direct resource comparison, for example, when choosing between two materials or products to apply to a given situation. It gives insight to the impacts associated with those materials or products and areas where the product is most impactful or can be improved.

LCA's are great for object-oriented decision making and evaluation, and less for systemic evaluation. LCA's are less useful as a general sustainability approach as they do not take context-sensitive aspects into account, nor do they typically evaluate spatial sensitivities or systemic side-effects. They also discard any impacts that cannot be quantified in their established standards, such as impacts on quality of life, etc.

LCA's are structly standardized and their quality closely guarded. Performing an LCA is a time-consuming and expensive process, best executed by a trained and experienced professional. For a product of medium complexity, the costs of a single LCA can range between 0.5-1.0 million euro/dollars, and about a year's time.

The process typically goes as follows:

1. Compiling an inventory of relevant energy and material inputs and environmental exchanges (called an LCI, from all suppliers and suppliers of suppliers, etc);
2. Evaluating the potential impacts associated with identified inputs and releases;
3. Interpreting the results to help make a more informed decision.

LCA SOFTWARE

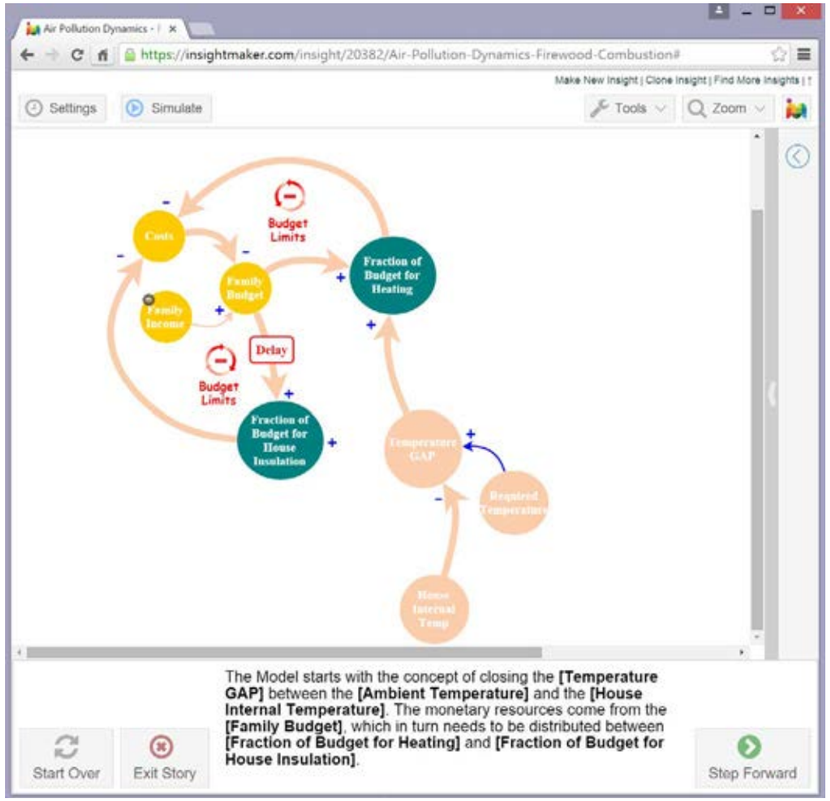
Both software and data for LCA analysis can be costly, but there are free alternatives being developed. SimaPro is the reigning commercial LCA software, and OpenLCA is a free alternative, managed by GreenDelta in Berlin, Germany; www.openlca.org

LCA DATABASES

There are a variety of LCA databases available, mostly commercial due to the cost of performing LCA analysis. The two large commercial LCA databases are EcoInvent and GaBi, starting at several thousand dollars/euro's each for commercial application. For free LCA data, check out nexus.openlca.org. Here are some other LCA data sources: Food, bioproducts: www.lcacommons.gov, USA Energy: www.nrel.gov/lci,
Europe LCI's: eplca.jrc.ec.europa.eu

COMPARING LCA DATA

Be careful when comparing LCA data from different sources. If the methodologies used and the system boundary of the analysis are different, the data may not be comparable. Read up on LCA methods or involve an LCA expert when unsure.



INSIGHT MAKER
Air pollution dynamics in Chile Causal loop systems model

4.10 SYSTEMS MODELING SOFTWARE

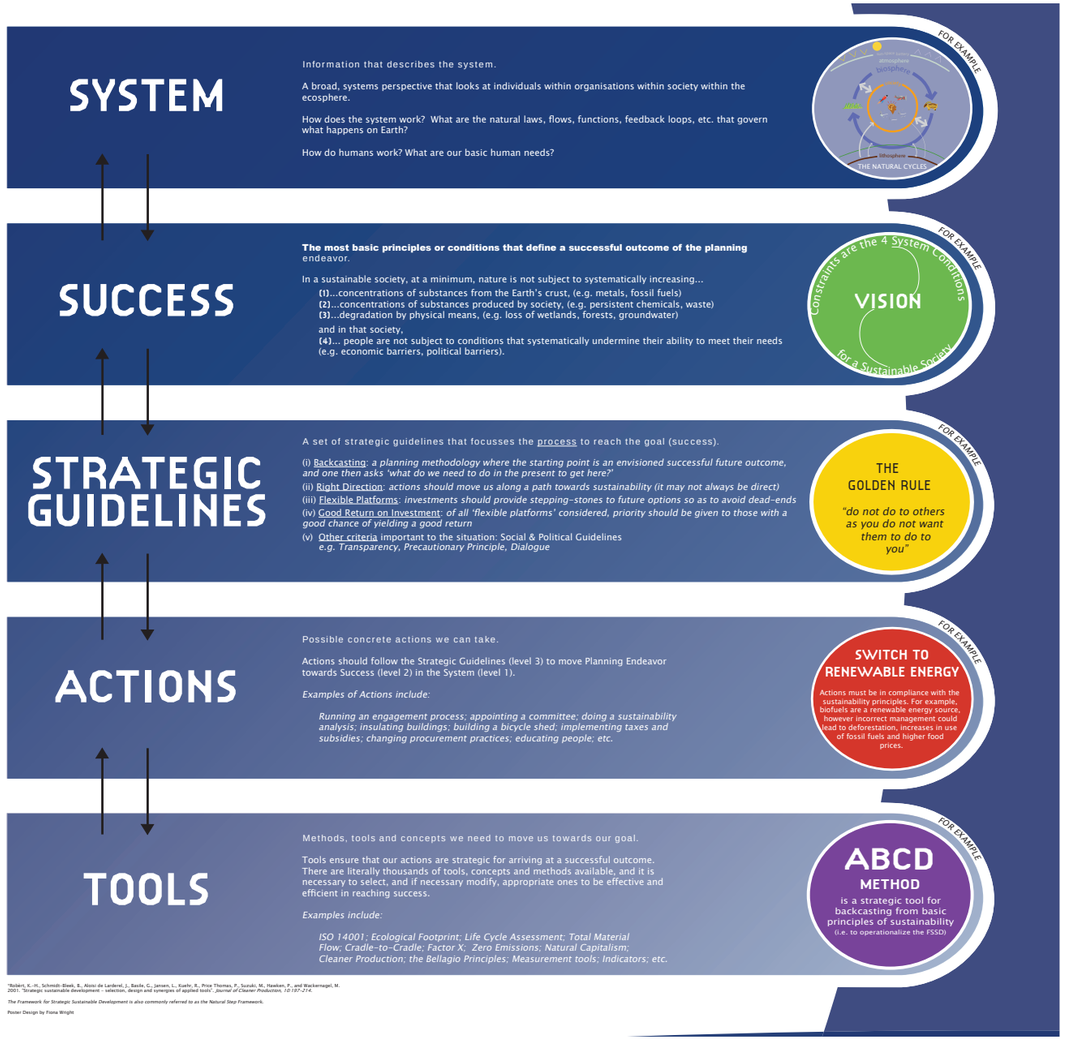
Sometimes modeling a (linear) system is useful to understand its dynamics, to learn about specific properties, to define design requirements or to test certain hypotheses. With the understanding that social systems cannot be modeled and/or predicted, here's a few system modeling tools we've found useful.

INSIGHT MAKER
Insight Maker is a free web tool for building system maps in a clear, graphical way by inserting objects and relationships between them. With Insight Maker you can model dynamic systems by inserting stocks and flows and run simulations. Next to that, you can conduct agent-based modeling to see relationships between agents, for example geographically. Insight Maker can also generate results in graphical way, like tables, plots, or diagrams. The website has a large number of examples to inspire and inform.

Source: www.Insightmaker.com

TRUE
TRUE is a freeware systems modeling and simulation program for Windows developed by Patrick Houel. As far as systems modeling software goes, TRUE is reasonably intuitive, and quite powerful. Its wealth of examples and ready to download models make for a great tool to get familiar with systems modeling and simulation. While TRUE still requires a base knowledge of mathematics, making simple models is straight-forward. There's also a supportive community which can help starters on their way.

Source: www.true-world.com



Robèrt, K.-H., Schmidt-Bleek, B., Aloisi de Larderel, J., Basile, G., Jansen, L., Kuehr, R., Price Thomas, P., Suzuki, M., Hawken, P., and Wackernagel, M. 2001. "Strategic sustainable development – selection, design and synergies of applied tools", *Journal of Cleaner Production*, 10:197–214.

The Framework for Strategic Sustainable Development is also commonly referred to as the Natural Step Framework.

Poster Design by Fiona Wright

4.11 FRAMEWORK FOR STRATEGIC SUSTAINABLE DEVELOPMENT (FSSD)

The Framework for Strategic Sustainable Development (FSSD) is a science-based method to work on complex sustainable solutions and targeted mostly at urban communities and businesses. The FSSD is more commonly known as The Natural Step Framework. After its inception by Dr. Karl-Henrik Robèrt, the FSSD has been further developed and maintained by the Department of Strategic Sustainable Development at the Blekinge Institute of Technology.

FSSD is a mature and proven method that shares some approaches with SiD's method, including some parts of roadmapping. It relies on backcasting from principles as an exclusive technique to develop a strategy. FSSD also contains elements of theory, method, and process, like SiD, but is mostly an element comparable to SiD's method.

In comparison with SiD, FSSD is a light and fairly easy to understand framework that is directly applicable in cases where a roadmap of action is desired using backcasting, and in areas such as product development. The FSSD does not prescribe how to do systems analysis, mapping, or develop network parameters. It does not have process or co-creation tools specifically.

The FSSD framework was originally mostly directed at material, energy, ecosystems and species, but has over more recent years developed the principles that guide the social dimension of sustainability. Here, SiD and FSSD can be used in conjunction with one another, for example by using SiD tools in a FSSD trajectory, or using some of FSSD's conceptualizations in a SiD session.

The Natural Step approach has formed itself around the FSSD method over time, in order to maximize its positive impact, in a similar way that Except Integrated Sustainability has been formed around SiD. For anyone interested in sustainable development methodologies, we recommend reading up on FSSD and using its valuable resources where possible.

Source & more
http://www.alliance-ssd.org/framework-for-strategic-sustainable-development-fssd/



LIFE'S PRINCIPLES

Biomimicry DesignLens

Biomimicry.net | AskNature.org

4.12 BIOMIMICRY & THE DESIGNLENS

Biomimicry, or biomimetics, looks at the structures and operating principles in nature as lessons to be learned in order to provide solutions for problems from products to societal issues. It's a technique used throughout history with many great examples ranging from inventions by Leonardo da Vinci to modern applications.

Biomimicry holds specific value for those working on product design, or other physical design challenges. It was popularized through the work of Janine Benyus who has been an active proponent and supporter of the knowledge and communities around biomimicry. She lists nine laws of nature products should try to emulate.

JANINE BENYUS'S NINE LAWS OF NATURE:

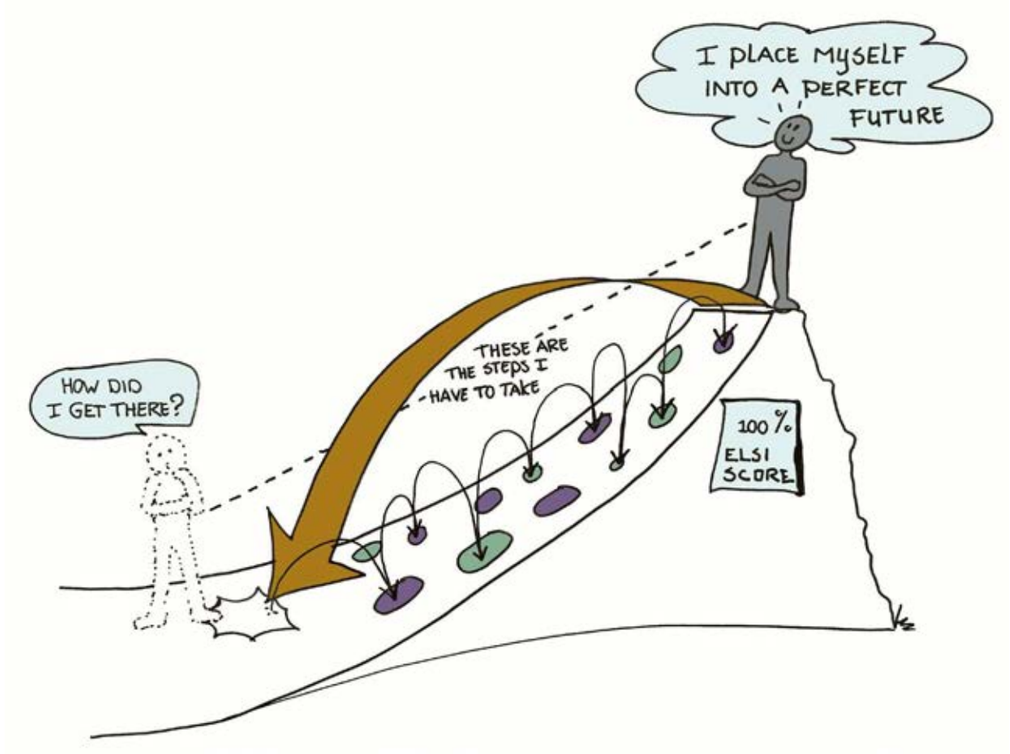
1. Nature runs on sunlight.
2. Nature utilizes only the energy it needs.
3. Energy fits form to function.
4. Energy recycles everything.
5. Nature rewards cooperation.
6. Nature banks on diversity.
7. Nature demands local expertise.
8. Nature curbs excess from within.
9. Nature taps the power of limits.

THE BIOMIMICRY DESIGNLENS

The Biomimicry DesignLens is a set of diagrams to visually aid people in understanding the basic Biomimicry design approach. They are free to download from the website of the Biomimicry organization. One diagram of the DesignLens is shown to the left.

Source & more

http://biomimicry.net



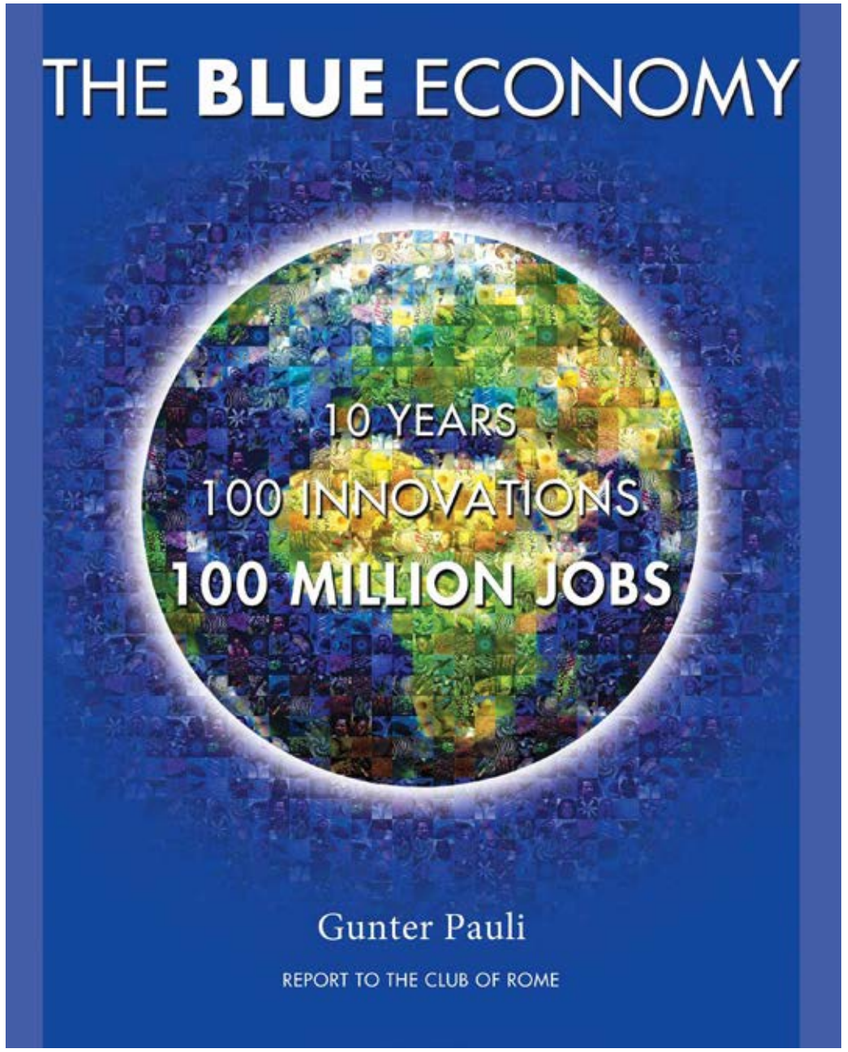
4.13 BACKCASTING

Backcasting is a technique used in visioning and strategy trajectories intended to produce steps to arrive at a desirable future. The five-step SiD method incorporates backcasting in its cyclical setup. It works by envisioning or or several desirable futures (usually 50 years into the future), and then going backwards in time, step by step, to determine what is necessary to achieve it, until the present day is reached. This development roadmap can then be used as a guide in moving forward.

Using a backcasting technique instead of a forward-thinking technique can break a strategic cycle where only incremental improvements are made towards an unclear goal. Backcasting requires a strong and clear vision of the future, and care needs to be taken that this future scenario is both realistic and doesn't externalize aspects that may in turn cause larger problems. When backcasting is used in SiD, it doesn't project a physical, material future state, but a performative state. It's a useful tool in roadmapping workshops and visioning processes, and at Except backcasting is used in a variety of ways.

Backcasting was first named by John Robinson in 1982, and is used in a variety of sustainability frameworks, including FSSD, and Amory Lovin's the soft energy path.

Instructions on backcasting
http://forlearn.jrc.ec.europa.eu/guide/4_methodology/meth_backcasting.htm



4.14 BLUE ECONOMY & ECONOMIES OF ABUNDANCE

Economies of abundance, also known as the 'Blue Economy' as named by Gunter Pauli in his book of the same name, is the idea of a world economy fueled in closed loops by materials and resources that are locally available in abundance, such as salt water, sunlight, and various biological processes. It is built on the notion that we can achieve material wealth if we harness the abundance of renewable resources to power cycles of materials and energy in value creating cycles.

The blue economy aims to be a practical framework for design and engineering, and as several other movements rests on a series of principles as its working method. The blue economy principles are:

1. Solutions are first and foremost based on physics. Deciding factors are Pressure and Temperature as found on site.
2. Substitute something with nothing – Question any resource regarding its necessity for production.
3. Natural systems cascade nutrients, matter and energy – waste does not exist. Any by-product is the source for a new product.
4. Nature evolved from few species to a rich biodiversity. Wealth means diversity. Industrial standardization is the contrary.
5. Nature provides room for entrepreneurs who do more with less. Nature is contrary to monopolization.
6. Gravity is main source of energy, solar energy is the second renewable fuel.
7. Water is the primary solvent (no complex, chemical, toxic catalysts).
8. In nature the constant is change. Innovations take place in every moment.
9. Nature only works with what is locally available. Sustainable business evolves with respect not only for local resources, but also for culture and tradition.
10. Nature responds to basic needs and then evolves from sufficiency to abundance. The present economic model relies on scarcity as a basis for production and consumption.
11. Natural systems are non-linear.
12. In Nature everything is biodegradable – it is just a matter of time.
13. In natural systems, everything is connected and evolving towards symbiosis.
14. In Nature water, air, and soil are the commons, free and abundant.
15. In Nature one process generates multiple benefits.
16. Natural systems share risks. Any risk is a motivator for innovations.
17. Nature is efficient. So sustainable business maximizes use of available material and energy, which reduces the unit price for the consumer.
18. Nature searches for the optimum for all involucrated elements.
19. In Nature, negatives are converted into positives. Problems are opportunities.
20. Nature searches for economies of scope. One natural innovation carries various benefits for all.
21. Respond to basic needs with what you have, introducing innovations inspired by nature, generating multiple benefits, including jobs and social capital, offering more with less.

Source & more
http://www.blueeconomy.eu/page/dieprinzipien

4.15 CIRCULAR ECONOMY

The circular economy is a general thinking framework launched most recently in 2012 with the Ellen MacArthur foundation's report 'Towards a Circular Economy", although it can be traced back to the mid 60's. It relies on knowledge and theory from industrial ecology, biomimicry, cradle to cradle, and the blue economy, and specifically Walther Stahel's work performed in the '60s and '70s on closed loop economies and recycling.

The circular economy is not a method or process, but more of an idea gathering framework, also called a community of practice. It aims to rethink industry towards a closed loop economy, and is an open-source brand to protect and distinguish it from similar but commercial exploits (such as Cradle2Cradle™). While the circular economy principles itself do not offer practical application or approaches, the various tools, reports, research, and knowledge platforms are launched under its flag, make it a worthwhile resource for industry and business primarily. Various communities of practice around the circular economy have started up in many countries round the world, and provide localized support for closing resource cycles.

FOUNDATIONAL PRINCIPLES

- Waste is food
- Diversity is strength
- Energy must come from renewable sources
- Systems thinking

COMPATIBILITY WITH SID

Most of the elements from the circular economy are useful in improving and optimizing the Autonomy aspects of SiD, and as a result, influence the resilience of a system positively. This is covered under the 'circularity' network parameter.

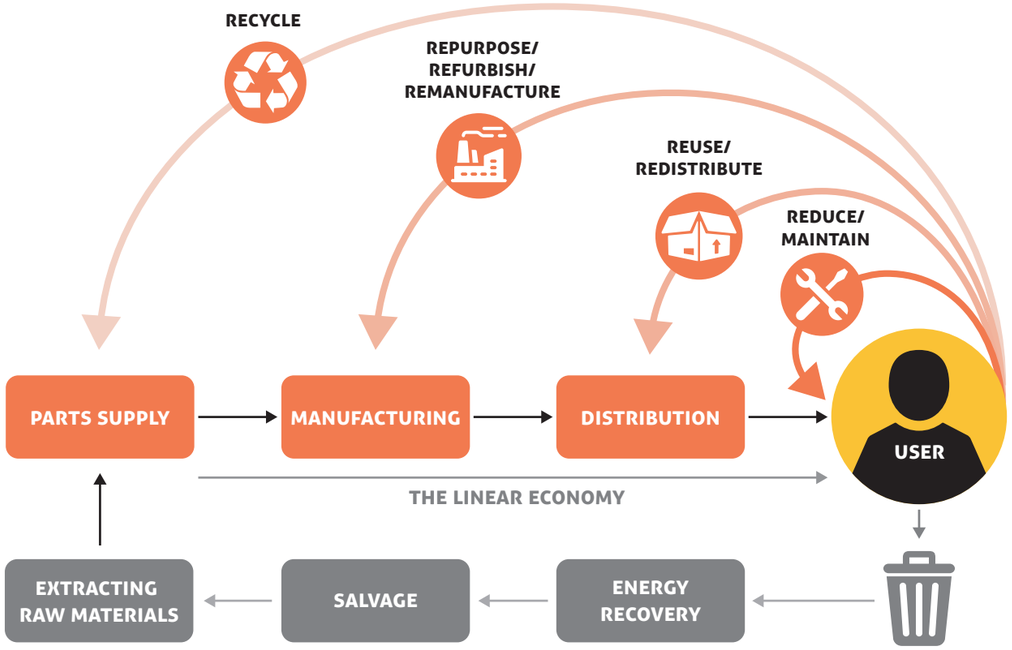
Some elements of the circular economy are not scientifically supported, and thus not compatible with SiD. For example, the idea present in the circular economy of a separation between a technological cycle and an ecological cycle has produced the notion that certain toxins may be used as long as they are kept strictly in the technological cycle. Criticism on this includes that in reality such a construct of a separated techno-cycle and bio-cycle does not exist and under the influence of entropy there is always a chance that these cycles 'leak' into one another, exposing ecosystems, species and people to the toxins. Minimizing the chances does not guarantee a fail-safe approach. This is why SiD does not support such a construct. But, even without this, the circular economy has many valuable resources to offer any sustainability professional.

Source & more

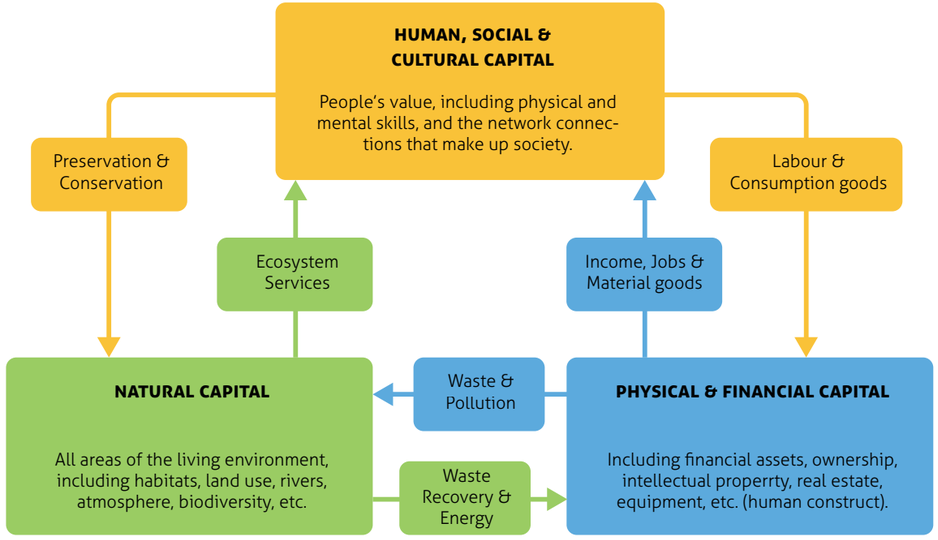
More information: Ellen MacArthur Foundation:
www.ellenmacarthurfoundation.org/circular-economy

Look up partner organizations and local resources on the CE network map:
www.ellenmacarthurfoundation.org/networkmap/

THE CIRCULAR ECONOMY



SIMPLIFIED DIAGRAM OF THE NATURAL CAPITAL FRAMEWORK





4.16 NATURAL CAPITAL

The land we grow our food on, water that flows through it, animals and plants living in this environment, and the oceans - the birthplace of life. This, and more, is our natural capital; the value represented by our ecosystems, species, and everything in between that we rely on to persist on this planet. All of our natural systems are declining fast, and this threatens our future. It puts at risk the continuation of any business with a complex supply chain, and jeopardizes the resource availability of any nation.

The Natural Capital (NC) movement attempts to halt and reverse this trend by embedding the value of natural systems into economic systems as a financial value. Here we discuss how NC works, what its pitfalls and opportunities are, and how we can accelerate implementation in government and business.

While there is debate about NC as a concept, it is one of the few answers we have. Organizations around the world are moving to implement it because of rapidly increasing ecological destruction. But there is much to be done, and progress is slow. There are opportunities to accelerate and improve Natural Capital based on innovative systems solutions for business and policy alike. Solutions that not only conserve nature but that put front runners of NC in a position of significant advantage, both in business and policy.

WHY NATURAL CAPITAL?

The concept of Natural Capital has been around for more than a century, and is not without controversy. Debate about its ethical foundations has been going on for decades, raising ethical questions without clear answers. Can we value nature in financial terms at all?

But, the global decline of nature pressures us for action. Nature currently is given limited economic value, causing it to be regularly sacrificed. This 'tragedy of the commons' plagues conservation efforts and the debate has delayed solutions resulting in preventable losses.

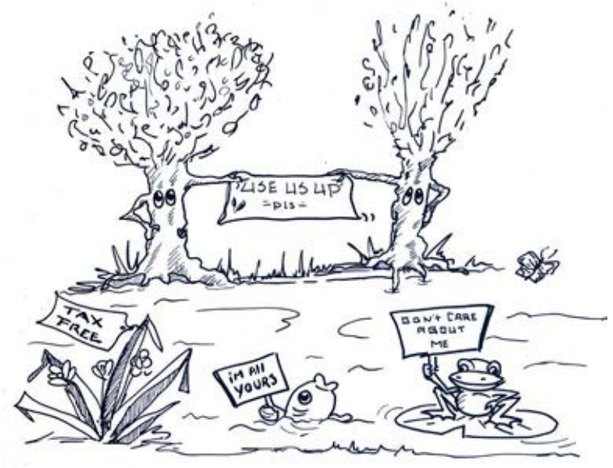
At the 2013 World Forum on Natural Capital in Edinburgh, organized by the Scottish Wildlife Trust, most policy and business representatives agreed it's time to take action, putting the ethical discussion to the background. Barry Gardiner, UK shadow minister for the environment, said it most poignantly:

> *"We use nature because it gives us value, and we destroy it because it's free. Nature should be given the rightful value it deserves, it's the only real way we can safeguard our natural resources for the future."*

Because NC is one of the few tools that allows direct action to be taken, the message is to implement it as fast as we can. How can we do this? The challenge can be summarized as follows; what mechanisms can we use to make natural capital work, how to value nature in all its facets, and how to create an advantage for policy and business for rapid implementation?

WHAT MAKES NATURAL CAPITAL WORK?

The solution supported by the largest NGO's introduces national NC profit and loss balance (EPL) sheets in each country and company, and tracks this balance as is done with finance. These balance sheets express Natural Capital both in terms of quantity and quality of resources (amounts of forests, water, biodiversity, etc), and, where possible, as currency. For every asset that disappears from the balance sheet, something else



needs to be brought back. This functions to increase awareness and transparency about the state of our natural resources, and improves their management. When successful, Natural Capital Accounting (NCA) injects a balancing system for our planet's physical limits to growth into an economy currently aimed at capitalizing on limitless growth.

Implementing Natural Capital is not without risk, as demonstrated by the carbon credit scheme that often creates perverse incentives, shifting damage from one place to another due to incomplete valuation. To prevent this, NCA needs to take into account the full spectrum of value we recognise today, and leave room for values that appear in the future. Similarly, NC practises need to account for system dynamics and prevent perverse consequences. Values that cannot be expressed in a monetary equivalent need to appear on the balance sheets in their qualitative form. It will not be possible to account for all value, but this should not hold us back. As Professor Dieter Helm explained at the forum in Edinburgh:

> *"We do not need to be entirely correct in our assessment of Natural Capital. Even if we're only 80% or even 50% in the ballpark, that's at least better than the value of zero we have currently. We need to act, now, to prevent further losses to an already marginalized system, regardless of not being able to accurately value Natural Capital."*

HOW DO WE VALUE NATURE?

This is undoubtedly the greatest challenge of Natural Capital as a concept. What value does a tree have? Ask a hundred scientists and economists and you will get a hundred different answers. In order for NC to work, we need to agree on a basis of valuation.

A tree is worth more than just the price of its wood, as it provides a home to many animals, it acts as shade in summer, it buffers and filters rainwater, it cleans the air, and it also supplies a number of other ecosystem services. It may also be valuable in other terms, for example culturally, and for its role in the ecosystem as a whole. Therefore, the value of a tree in its entirety isn't the same as the price for its wood in the store, and can be expressed in a different manner, for example in liters of water buffered and filtered, its contribution to biodiversity and well-being, and so on.

Quite a few studies have attempted to account for some of these values and converted them into currency. Research conducted by Johnson and Wardle gave the Canadian Boreal forest a value of US$ 3.7 trillion for all of its ecosystem services and carbon sequestration. Another study from 1997 by Costanza et. al put a price tag of US$ 33 trillion on the world's biosphere's ecosystem services. These and other studies give starting points for value estimation, while there are certainly large gaps to cover. To find and fill these gaps, a more inclusive framework to assess value is necessary.

SID AS A STRUCTURE FOR VALUE

The Symbiosis in Development (SiD) systems analysis framework is such a tool. It can be used to assess the full spectrum of value for any given subject, including the relational values of the system as a whole. Its flexible structure allows room for future discovery while providing clarity to start valuing with limited insight today.

Using SiD the value of the tree can be seen on three 'scales': the object (direct physical) value, the value of its network (services and relations), and its systemic value as a whole. The first being the easiest to assess, and the last the hardest but having the most impact. Combining these three scales results in a estimation of the tree's Natural Capital value.

This diagram is a simplified example of the structure of SiD's value assessment when applied to a tree.

Using SiD, there are opportunities for other values to join the party, such as transparency, diversity, health, and wellbeing. SiD reserves room for these values, allowing them to be slotted in once research makes them available. Because it is a universal framework, it works for other measurements as well, allowing it to be inclusive of other movements such as social justice or poverty alleviation and stand stronger together. This flexibility prevents the system becoming solidified once adopted, preventing perverse incentives that occur when real value and value in the system are dissonant (an issue that plagues carbon trading). Tracking the flexibility of the Natural Capital system is therefore essential.

To help fill in the framework, we can rely on existing research and data collected in tools such as the Natural Capital toolkit, developed by the WBCSD, which is hosted in Shift here: https://shift.tools/contributors/551

GIVING NATURAL CAPITAL TEETH

There are frameworks for valuation, which can be filled in using existing research. Then, incentives are needed for organizations to implement them. Using systemic innovation strategies, the most effective approaches can be explored. As a trial, a small interdisciplinary team at Except, a sustainability strategy firm, held a short systems exploration session and came up with a few approaches. It was discovered that effective solutions are those that make Natural Capital a base economic requirement for growth, rooting it into the core of the economy.

One approach is to create a secondary currency backed by Natural Capital rather than gold. This means Natural Capital is not expressed in Dollars, Euros or Yen, but in its own currency, for example called the GreenBack. This currency is purely digital, relying on similar technology as BitCoin, and coupled to the balance sheets of nations, capturing both qualitative and quantitative values in separate indicators. When demand for this GreenBack goes up, a direct increase in demand for Natural Capital results. This creates a natural marketplace where the only way to grow wealth is to grow Natural Capital. This currency thus couples economic growth to its necessary precursor: the resources our planet needs to sustain economic growth.

Solutions like these accelerate the implementation of Natural Capital, but both business and government have their own challenges. What are the opportunities for countries and companies to implement NC?

OPPORTUNITIES TO ACCELERATE NCA IN POLICY

> *"In 50 years' time we will look back and say that our governments were economically illiterate. They simply did not understand the true value of the most important service providers on our planet. We will marvel that they failed to capture and make explicit the value of Natural Capital and ecosystem services in their national accounts." - Barry Gardiner, MP*

Several projects researching the role of NC in policy are underway, for example TEEB, a global research project through the European Union. But progress is slow, hampered by lack of oversight, tools for valuation, accessible knowledge databases, and stakeholder awareness. These challenges can be more effectively solved with innovative systems-thinking than traditional approaches, saving resources and time. And time is of the essence here. One way to speed up the process is to apply distributed innovation mechanisms, such as crowd-solutioning and serious gaming. These approaches have managed to resolve in weeks highly complex problems such as unraveling the secrets of protein folding, which previously took teams of scientists many years. If strategies such as these were to be applied to the issues that hold back Natural Capital, solutions could be implemented at a much faster rate, and Natural Capital Accounting could be in place in many countries within the next decade.

But, Natural Capital can only be effective if it's adopted voluntarily by both government and business. Enforcement takes too long and the stick causes loopholes, while the carrot accelerates the process. Why would a profit driven company be interested to implement and invest in Natural Capital?

ADVANTAGES OF EMBEDDING NCA IN BUSINESS

At first sight, business may not seem to have an interest in Natural Capital or Natural Capital Accounting, as it does not directly lead to profit. But there are several reasons why this is not only advantageous, but critical to the survival of business today and tomorrow.

In complex supply chains, change comes quickly and strikes hard. Most companies rely on one or more natural resources somewhere in their supply chain, yet may not be aware of where and how. Tracking NC is essential to ensure continued business in the short and long term. If a sizeable business is not tracking this, it is not conducting proper risk management.

In addition, business can use NC to find valuable ecosystems services while improving CSR performance at the same time. For example, companies have found bio-based alternatives to artificial or fossil resources that save money and provide long term sourcing security.

It is also good for businesses to be ahead of the curve when it comes to issues that governments will eventually demand. Waiting to be forced into something through regulation risks costly solutions being enforced. Also, being one of the first to start NC accounting has its perks. It allows an organization to shape the conversation, be more opportunistic with investments, and get public recognition for leading the good fight. This has been shown by Puma, which started publishing the first Environmental Profit & Loss Account (EPLA) under direction of their holding company Kering, and already tracked 145 million in environmental impacts in 2010. This resulted in positive press globally, several companies following suit, and creating a catch-up game for everyone else.

Lastly, insurance companies are becoming interested in Natural Capital Accounting. After all, threats to resources that a company relies on are threats to the company, and insurance will go up or become unavailable. And it is not just insurance firms. Standards & Poor's, one of the Big-Three credit rating firms, is investigating Natural Capital Accounting as a new input for the same reasons, directly affecting a company's credit rating. That should be reason enough for the big players out there to start moving.

MAKING IT HAPPEN

There are many reasons to start implementing NC as fast as possible. A structured and systemic approach is critical to make it succeed. This is why solutions like SiD exist. We call on the front runners of NC to aim higher and gain the advantage of using innovative systems tools and implementation strategies, such as natural currencies, crowd-solutioning and systemic risk assessment. The front runners in policy, business, and NGOs should be brought together to collectively accelerate the process and support each other. It is in our joint interest to do so. We have the tools, expertise, and manpower to do this, so let's make Natural Capital accounting a reality within a few years, and gain huge benefits for each organization and society alike.

NATURAL CAPITAL RESOURCES

OPENNESS FRAMEWORK

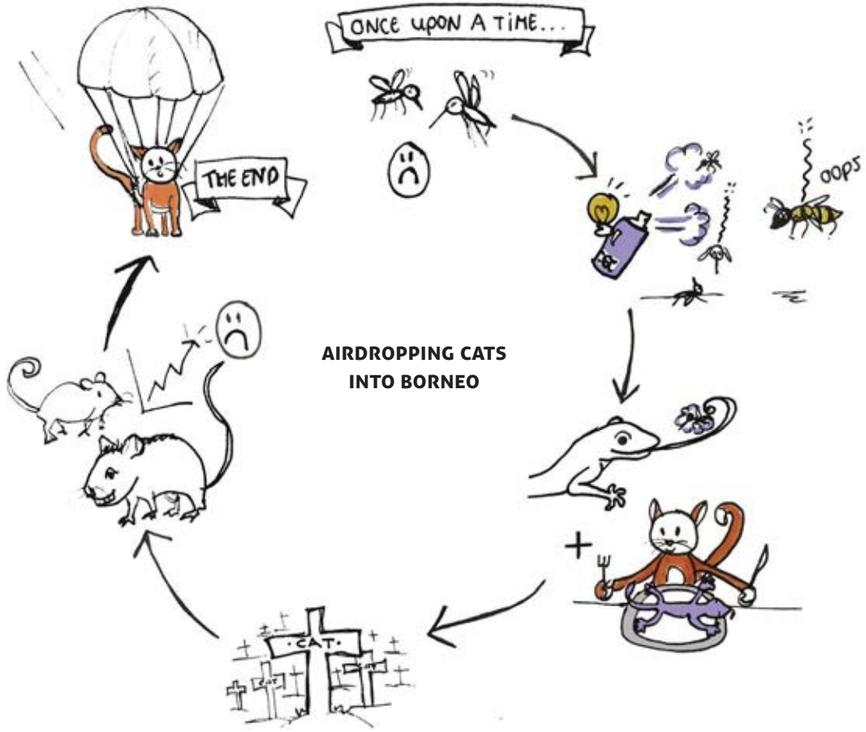
OpenNESS aims to translate the concepts of Natural Capital (NC) and Ecosystem Services (ES) into operational frameworks that provide tested, practical and tailored solutions for integrating ES into land, water and urban management and decision-making.
http://www.openness-project.eu/

NATURAL CAPITAL TOOLKIT

The Toolkit is an interactive database that helps business find the right tool to measure and value natural capital as they use the Natural Capital Protocol.
https://shift.tools/contributors/551

NATURAL CAPITAL PLANT DATABASE

The Natural Capital Plant Database is a repository of temperate climate plant information for ecological design, made by the company Natural Capital in the UK.
https://permacultureplantdata.com/



In the 1950s, in order to combat Malaria in a remote village in Borneo, DDT was sprayed in large amounts by the World Health Organization. The DDT killed the disease carrying mosquito's, but it was also ingested by gecko's. The gecko's survived the DDT, but this allowed the concentration of DDT to build up inside of them. The local cat population, that ate the gecko's, died as a consequence. After the cats died, the population of rats exploded, and the village now had a much larger problem with disease. To help resolve this, the Royal Air Force air-dropped cats in crates by parachute into the village, which re-balanced the system: Operation Cat-Drop.

This true story explains how object-oriented solutions (DDT) can have far-reaching systemic consequences. There's a great video on this online as well, with some more details. Seek 'Cats in Borneo' on Youtube.

4.16 SYSTEMS THINKING & RELATED THEORIES LIST

Systems thinking is a concept that is present and comes from a wide variety of fields over the last century. Systems thinking, systems science, systems theory and all their related fields don't have a single framework, and terms overlap and sometimes mean something different. If you're interested in deepening knowledge about systems thinking, a great starting point is to read up on these various fields first, before diving in any one specifically. This will broaden your understanding of the applicability of systems thinking, and the various terms and concepts used. Below is a list of theories and concepts that are or rely heavily on system thinking or analysis as a start. We've highlighted some of our favorites.

1. Systems Thinking (overarching, practical)
2. Systems Theory (overarching, theoretical)
3. Systems science (overarching, scientific)
4. Network science (overaching, scientific)
5. Complex Adaptive Systems (CAS) (sociological, overarching)
6. Chaos theory (mathematics, patterns in complexity)
7. Cybernetics (organized complexity, systems modeling, engineering)
8. Dynamical systems theory (mathematical, long term mechanical systems)
9. Soft systems methodology (societal transitions, complex systems thinking)
10. Systemography (systems modeling)
11. Systematics (evolutionary biology)
12. Systems psychology (psychology, overarching field)
13. Social complexity (sociological, overarching field)
14. Integral Theory (spiritual, existential)
15. Viable Systems Approach (business management, analytical)
16. Systems ecology (ecology)
17. Holistic Management (agriculture, systems thinking)
18. Permaculture (agriculture, ecosystems)

More inspiration and learning on systems thinking

If you'd like to read more, I suggest doing a 'Wikipedia trip'. Grab a beverage of choice, sit comfy behind a computer, and pick one of the theories outlined above and go to its relevant Wikipedia page. Skim it to understand the basic concepts and then go to a related article of your interest. Keep doing this until your brain is full. I've found this more useful than reading a single book on a single theory, because many concepts are shared between them, and some are better at explaining some parts than others. Many get lost in the details, while it is often more useful to know a little about a lot of them. Getting a wide vocabulary from a variety of theories will also help you explain the concepts better to others, and in turn help you with the application in you team.



Image courtesy of Gavin O'Leary, http://www.gavinoleary.com

4.17 BRAINSTORM RULES

Brainstorming can be a powerful exercise, if done well. To do it well, there's some basic rules everyone needs to stick to that we listed below.

For those not used to creative thinking, it can be hard at first, especially the 'defer judgement' part. Please remind each other of the rules when they are broken. There's nothing more devastating to a brainstorm session than 'nay-sayers', even if they are right. Brainstorming is about expanding your vision, diverging in your search for possibilities. The best ideas may come via an impossible other idea. Happy brainstorming!

1. **Defer judgement**
   Allow anyone to say anything, and build on each other's ideas. Don't say 'no' to someone's idea, instead provide an alternative.

2. **Encourage crazy ideas**
   Bad ideas may lead to great ideas, welcome even the craziest, outlandish suggestions.

3. **Go for quantity**
   Don't get stuck, keep on riffing, quantity over quality.

4. **Leave your phone off**
   Be fully engaged, close your laptop and put it away, listen to one another.

5. **Be creative**
   Use the space, paper, materials, walk around.

6. **Keep it focused on the topic and one discussion**

7. **Keep it short**
   20 minutes is the max you should be brainstorming, after which it's best to take a break or reflect on the choices, cluster ideas or do another exercise of a different nature.

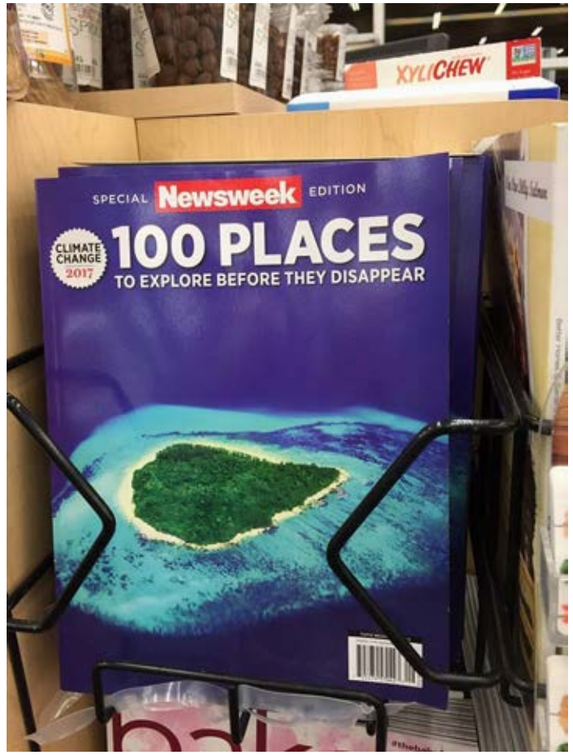
OTHER BRAINSTORM-LIKE EXERCISES

Brainstorming is a collection of ways on developing new ideas. There's a variety of exercises you can apply, many of them can be found online with a bit of searching. Ones we find useful are:

BRAIN-DUMPING
After the initial assignment has been given, let everyone write down their initial ideas on a single piece of paper and resent them to one another. Usually, people form an initial idea that may block new ideas from forming. Doing a brain-dump can help in overcoming this.

BRAIN-WRITING
Write down a sentence or an idea, and pass it to your left. Associate further on the ideas you've been given on the papers passed to you.

WORD-ASSOCIATIONS
Call out single associate words having to do with the topic, no matter how crazy, and write all these down on a flip-over. Useful for finding names, new directions and as an ice-breaker.



4.18 TWELVE SYSTEM INTERVENTION POINTS

When looking for a list of things to do to improve a system, the following list may be used for inspiration. These points have been proposed by Donatella Meadows in 1997, a great contributor to the world of classical (reductionist) systems thinking. The list therefore mostly refers to bottom-up systems design practices, and in this context provides inspiration and guidance in conjunction with other guidelines for complex systems. The list is ordered from least powerful (1) to most (12), and examples are in *cursive*.

1. **Constants, parameters, numbers (such as subsidies, taxes, standards)**
   Parameters are points of lowest leverage effects. Though they are the most clearly perceived among all leverages, they rarely change behaviors and therefore have little long-term effect.

   For example, climate parameters may not be changed easily (the amount of rain, the evapotranspiration rate, the temperature of the water), but they are the ones people think of first (they remember that in their youth, it was certainly raining more). These parameters are indeed very important. But even if changed (improvement of upper river stream to canalize incoming water), they will not change behavior much (the debit will probably not dramatically decrease).

2. **The size of buffers and other stabilizing stocks, relative to their flows**
   A buffer's ability to stabilize a system is important when the stock amount is much higher than the potential amount of inflows or outflows. In the lake, the water is the buffer: if there's a lot more of it than inflow/outflow, the system stays stable.

   For example, the inhabitants are worried the lake fish might die as a consequence of hot water release directly in the lake without any previous cooling off.

   However, the water in the lake has a large heat capacity, so it's a strong thermal buffer. Provided the release is done at low enough depth, under the thermocline, and the lake volume is big enough, the buffering capacity of the water might prevent any extinction from excess temperature.

   Buffers can improve a system, but they are often physical entities whose size is critical and can't be changed easily.

3. **Structure of material stocks and flows (such as transport network, population age structures)**
   A system's structure may have enormous effect on operations, but may be difficult or prohibitively expensive to change. Fluctuations, limitations, and bottlenecks may be easier to address.

   For example, the inhabitants are worried about their lake getting polluted, as the industry releases chemical pollutants directly in the water without any previous treatment. The system might need the used water to be diverted to a wastewater treatment plant, but this requires rebuilding the underground used water system (which could be quite expensive).

4. **Length of delays, relative to the rate of system changes**
   Information received too quickly or too late can cause over- or underreaction, even oscillations.

   For example, the city council is considering building the wastewater treatment plant. However, the plant will take 5 years to be built, and will last about 30 years. The first delay will prevent the water being cleaned up within the first 5 years, while the second delay will make it impossible to build a plant with exactly the right capacity.

5. **Strength of negative feedback loops, relative to the effect they are trying to correct against**
   A negative feedback loop slows down a process, tending to promote stability. The loop will keep the stock near the goal, thanks to parameters, accuracy and speed of information feedback, and size of correcting flows.

   For example, one way to avoid the lake getting more and more polluted might be through setting up an additional levy on the industrial plant based on measured concentrations of its effluent. Say the plant management has to pay into a water management fund, on a weekly or monthly basis, depending on the actual amount of waste found in the lake; they will, in this case, receive a direct benefit not just from reducing their waste output, but actually reducing it enough to achieve the desired effect of reducing concentrations in the lake. They cannot benefit from "doing damage more slowly" - only from actually helping. If cutting emissions, even to zero, is insufficient to allow the lake to naturally purge the waste, then they will still be on the hook for cleanup. This is similar to the US "Superfund" system, and follows the widely accepted "polluter pays" principle.

6. **Gain around driving positive feedback loops**
   A positive feedback loop speeds up a process. Meadows indicates that in most cases, it is preferable to slow down a positive loop, rather than speeding up a negative one.

   The eutrophication of a lake is a typical feedback loop that goes wild. In a eutrophic lake (which means well-nourished), lots of life can be supported (fish included).

   An increase of nutrients will lead to an increase of productivity, growth of phytoplankton first, using up as much nutrients as possible, followed by growth of zooplankton, feeding up on the first ones, and increase of fish populations. The more available nutrients there are, the more productivity is increased. As plankton organisms die, they fall to the bottom of the lake, where their matter is degraded by decomposers.

   However, this degradation uses up available oxygen, and in the presence of huge amounts of organic matter to degrade, the medium progressively becomes anoxic (there is no more oxygen available). In time, all oxygen-dependent life dies, and the lake becomes a smelly anoxic place where no life can be supported (in particular no fish).

7. **Structure of information flow (who does and does not have access to what kinds of information)**
   Information flow is neither a parameter, nor a reinforcing or slowing loop, but a loop that delivers new information. It is cheaper and easier to change information flows than it is to change structure.

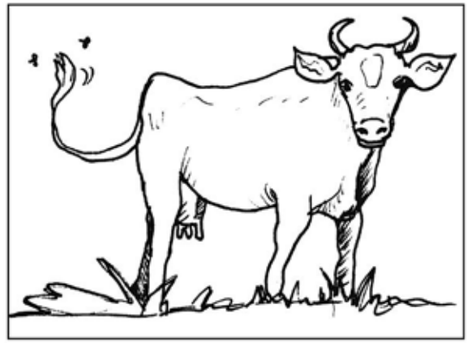
   For example, a monthly public report of water pollution level, especially nearby the industrial release, could have a lot of effect on people's opinions regarding the industry, and lead to changes in the waste water level of pollution.

8. **Rules of the system (such as incentives, punishment, constraints)**
   Pay attention to rules, and to who makes them. For example, a strengthening of the law related to chemicals release limits, or an increase of the tax amount for any water containing a given pollutant, will have a very strong effect on the lake water quality.

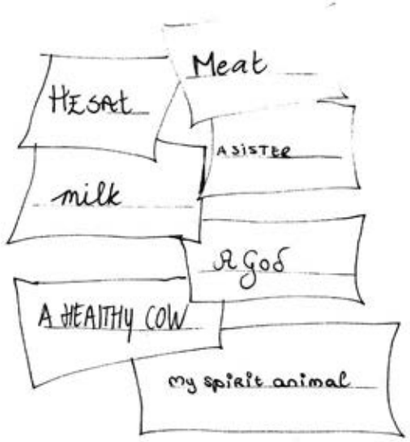
9. **Power to add, change, evolve, or self-organize system structure**
   Self-organization describes a system's ability to change itself by creating new structures, adding new negative and positive feedback loops, promoting new information flows, or making new rules.

   For example, microorganisms have the ability to not only change to fit their new polluted environment, but also to undergo an evolution that makes them able to biodegrade or bioaccumulate chemical pollutants. This capacity of part of the system to participate in its own eco-evolution is a major leverage for change.

Look at the picture below and answer the following question.



What do you see?



10. **Goal of the system**
    Changing goals changes every item listed above: parameters, feedback loops, information and self-organization.

    A city council decision might be to change the goal of the lake from making it a free facility for public and private use, to a more tourist oriented facility or a conservation area. That goal change will effect several of the above leverage points: information on water quality will become mandatory and legal punishment will be set for any illegal effluent.

11. **Mindset or paradigm that the system — its goals, structure, rules, delays, parameters — arises from**
    A societal paradigm is an idea, a shared unstated assumption, or a system of thought that is the foundation of complex social structures. Paradigms are very hard to change, but there are no limits to paradigm change. Meadows indicates paradigms might be changed by repeatedly and consistently pointing out anomalies and failures in the current paradigm to those with open minds.

    A current paradigm is "Nature is a stock of resources to be converted to human purpose". What might happen to the lake were this collective idea changed?

12. **Power to transcend paradigms**
    Transcending paradigms may go beyond challenging fundamental assumptions, into the realm of changing the values and priorities that lead to the assumptions, and being able to choose among value sets at will.

    Many today see Nature as a stock of resources to be converted to human purpose. Many Native Americans see Nature as a living god, to be loved, worshipped, and lived with. These views are incompatible, but perhaps another viewpoint could incorporate them both, along with others.

Source
http://en.wikipedia.org/wiki/Twelve_leverage_points







4.19 ETHICS IN SUSTAINABILITY

Ethics are a field of research of Philosophy that help to understand and apply concepts of right and wrong. Ethics help give a frame of reference when deciding what to do given a (difficult) choice, often related to Harmony, choices that impact others and other living things. Quite a few of these choices fall on your doorstep in working on sustainability issues, and it's good to be aware of some basic ethical frames of reference while looking at these matters. In this tool section, we look at a quick overview of what have been useful frameworks of ethics to consider when using SiD over the years, specifically in environmental ethics.

CHANGING ETHICS OVER TIME

Environmental ethics discerns roughly between three perspectives, which say a little about how societies have looked at right and wrong in relation to themselves over the centuries.

First, there is the human-centric (anthropocentric) view, in which humanity is the center and main purpose of the universe. This is the perspective that has been with us for the longest since we've formed consciousness.

The second is the metaphysical view, which uses an external value framework to help make decisions on ethics and justice, such as in many religious philosophies. Many metaphysical ethics have dominated our society's thinking for centuries.

Lastly, there is the holistic view, in which humanity sees itself as an element of an interconnected ecosystem. This last perspective is relatively new as a mainstream ethic.

All three of these perspectives are valuable when considered side by side. However, it is the last perspective, the holistic view, that in my opinion holds the most elements to understand how we can continue to live and flourish on this planet.

THREE PERSPECTIVES IN SUCCESSION

Looking at and understanding the first perspective, the anthropocentric view, helps to understand how we got stuck in our situation in the first place. Utilitarianism is one such anthropocentric ethic, which considers that what is good for the individual to be good for all. Much of the last century, especially in the western hemisphere, has been spent on glorifying "personal success" as a main mode of operation for society. This can be seen in the philosophy of one of the most influential writers of last century, Ayn Rand, who believed that if we were all heroic selfish beings, the world would become perfect on its own. Last century, appropriately dubbed 'the century of the self' by Adam Curtis in his identically-named documentary from 2002, is a witness to this. This documentary is recommended to watch for a better understanding of this perspective.

The second, metaphysical view, which uses an external framework of reference as a guide, has gathered great many insights and powerful values over the centuries from which any human can learn. For example, many religions conform to this view. However, they are not necessarily complete and balanced, and as they refer to mostly external frameworks of value, such as a deity or other unknowable entities, they are often misinterpreted and may not be able to provide answers to our questions of today.

The thirds, the holistic perspective, or the non-anthropocentric perspective, offers us a pathway in relating not just where we are going to, but also to ponder our evolution, and what we can learn from the biological and physical systems from which we spring.

A personal hero of mine, the scientist Carl Sagan, has said so beautifully: "The nitrogen in our DNA, the calcium in our teeth, the iron in our blood, the carbon in our apple pies were made in the interiors of collapsing stars. We are all made of starstuff." The holistic perspective places our lives in relation to a continuum of many things, and forces us to understand that long before and long after humanity exists on this planet, life will exist. Then, what is the value of human society to the rest of life?

Non-anthropocentric ethics is a whole field onto itself. If you find yourself facing dilemmas of social justice, environmental ethics or other fundamental matters of ethics, while using SiD or otherwise, I greatly urge you to read up on these subjects to form your own position, or consult scholars on the subject for support. One of my favorite books on the subject is a collection of the most seminal articles on a wide variety of environmental ethics, called Environmental Ethics: An Anthology by Andrew Light and Holmes Rolston III. Here, I give a brief overview of the three mainstream environmental ethics, that have helped me in understanding a bit more about this subject matter, and to apply SiD more effectively.



CONSEQUENTIALISM, DEONTOLOGY, PRAGMATISM, AND VIRTUE ETHICS

In my search for answers in the realms of Environmental Ethics some more specific insights in this are useful to share. These can be summarized in the four different perspectives of the major perspectives of environmental ethics: Consequentialism, Deontology, Pragmatism and Virtue Ethics. As with the network parameters, simply considering each one of these step by step in relation to your subject is a useful exercise in and of itself. If you face a dilemma (in a project, or even in life), consider what these four perspectives will tell you. Doing so might help you frame a clear answer, as well as understand the differing position of various stakeholders.

I find predominant use in the difference between the Consequentialist and Deontological views. I learned about these in classes at Yale University from Professor Willis Jenkins, and for his insight I am eternally grateful. Applying them in practice, I noticed they became more than just two abstract perspectives. For me, they became like the Yin and Yang of value perception in life as a whole. Both perspectives offer a valuable insight, no matter what the subject might be. They seem to represent two different parts of being, even two different parts of the brain, often debating each other, and each offering critically valuable perspectives. There is some evidence that such evaluation actually takes place in the brain. The dorsolateral prefrontal cortex, where 'reason' is mostly processed, seems to argue mostly for consequentialism, and the ventral medial prefrontal cortex, where 'emotional value' resides for deontology.

Besides these two major perspectives there are Virtue Ethics and Pragmatism. Both have their share of fascinating literature. In my primitive reading of them I see them mostly as useful support tools. Virtue ethics is a valuable case-study tool, and Pragmatism helps cut the chit-chat to be practical in moving forward, tempering too fundamentalist discussions.

You could fill a library with writings on these subjects, so I'm going to super-simplify here for the sake of brevity:

Consequentialism	Do what results in good
Deontology	Do good things
Virtue Ethics	Do what a good person would do
Pragmatism	Do what the above three agree on doing, and move on

Let's expand on that a little bit.

CONSEQUENTIALISM concerns itself with taking actions that result in a good, or the best outcome. It does not concern itself with the actions themselves, but focuses on their results or consequence. Hence the name 'consequentialism'.

DEONTOLOGY, (Deon from the Greek 'duty' or 'what is necessary') focuses on actions rather than outcomes, measured against 'what needs to be done', or some other imperative, like a set of morals. You can perhaps see that the difference between 'do a good thing' and 'do what results in good', can be diametrically opposed to one another. For example, consider the decision whether or not to feed a group of starving bisons in a nature reserve. The consequentialist perspective could be that death is part of life. The dying of the bison

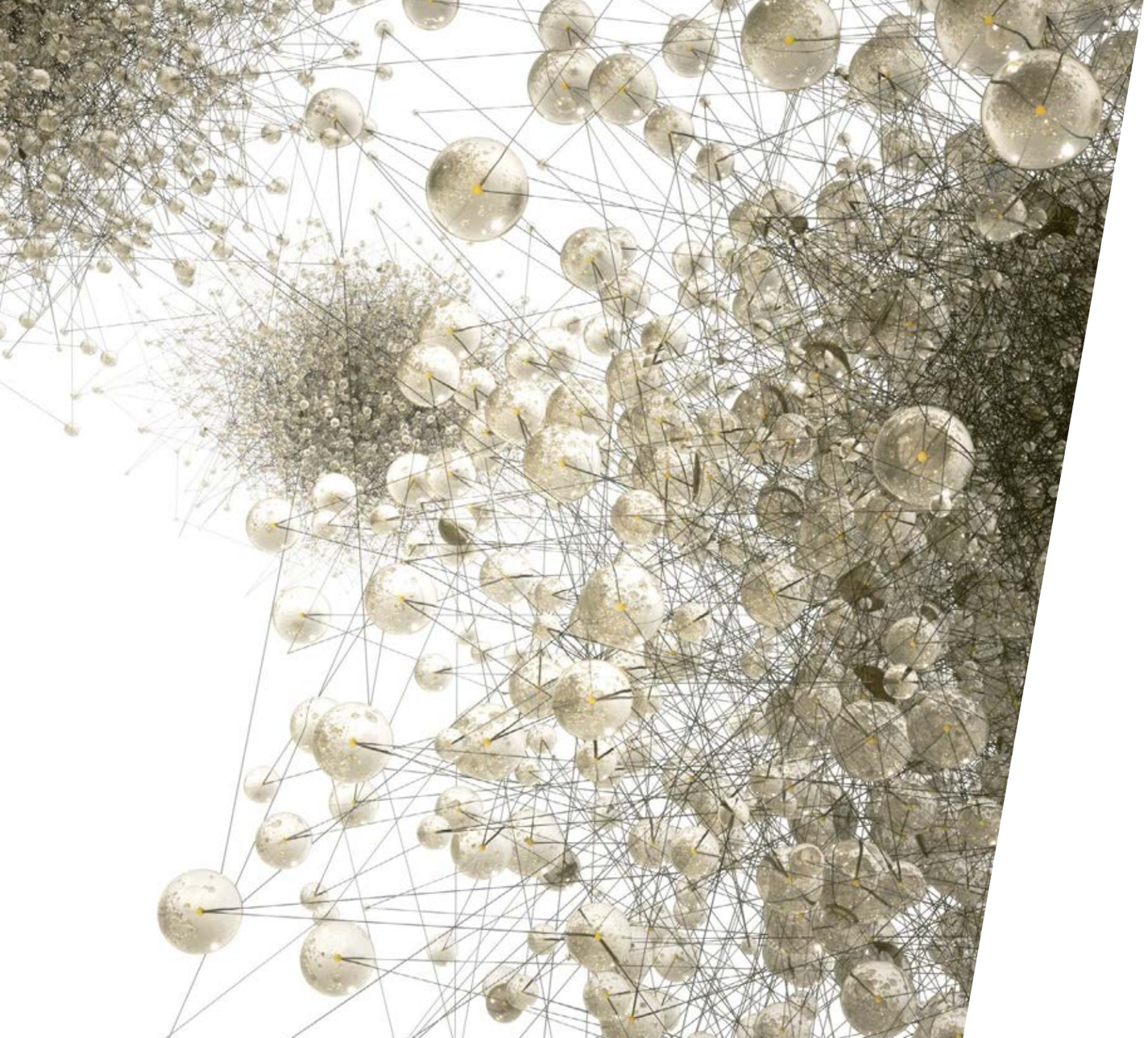


results in food for other animals, and not interfering with this system by feeding the bison is promoting the best outcome for the system as a whole. Deontology may say that those animals are suffering and not feeding them is a bad action, and therefore may advocate the feeding of the bison.

VIRTUE ETHICS refers to following the values set by an external framework, for example as set by an exemplary 'good person'. One could take Gandhi, immortalized by the famous imperative "Do what Gandhi would do". In a sense, Virtue Ethics fills in the deontological perspective with a set of morals that are predefined by something or someone else. Virtue ethics is often considered as a subset of deontology, although consequentialist motives may play a part.

PRAGMATISM acknowledges the dualism between consequentialism and deontology, and tries to find a practical way out. While pragmatism commits to the consequence of an action needing to result in the best result, as consequentialism does, it does not do so at all costs. It considers limits to the extent on which those actions may be 'bad' in nature. For example, this prevents things like severe animal suffering for the sake of the production of medicine. Some pragmatist authors also argue against some of the more elaborate philosophical frameworks such as the 'Intrinsic Value' of consequentialism or the 'least amount of suffering' accounting of deontology (include reference frames). Pragmatism seeks to find a resolution between the two standpoints that is workable, and executable. In some cases I see the pragmatic standpoint as: "Guys, let's just do what's actually practically achievable that we all agree on, and move on to the next problem".

Deontology and consequentialism always seem to exist together. Where both of them are in alignment, the practical answer is obvious: do what both say is the right thing. Looking carefully at situations where they differ, we can see echoes of some of the most vexing dilemma's humanity has had to face. These situations teach us that we are facing a fundamental human dilemma. This may help us understand the perspectives of those parties advocating for one or the other argument, and, in the pragmatist way, bring them closer together towards a resolution that is acceptable to all. For example, in the case of whether or not to feed the bison, one may decide to feed the herd only when the situation is un-naturally extreme. Or, to determine if living conditions of the Bison in the park is a human construct itself or not. If so, the suffering of the animals would be a consequence of human action in the first place, and we have a responsibility to feed them.



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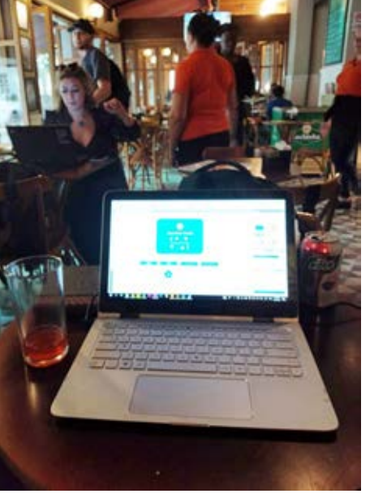
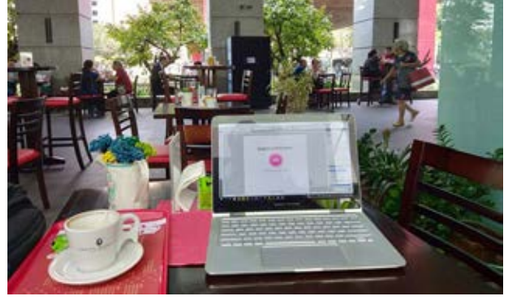
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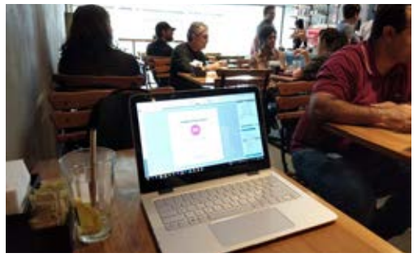
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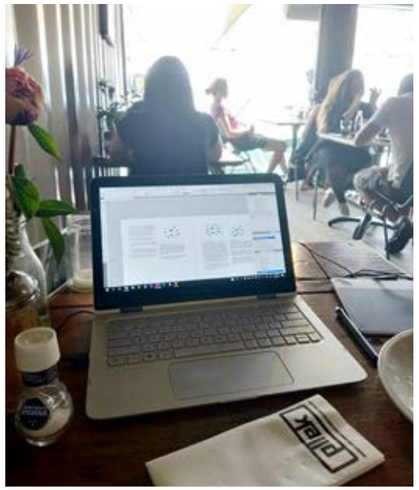
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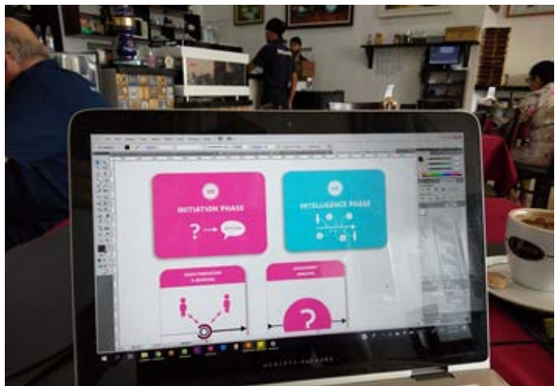
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