Chapter 6
Thinking in Systems: Sustainability Cognition for Design Communities

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6.1 Sustainability: System

6.1.1 Sustainability Dilemma

Life has been on earth for about 3.8 billion years and has profoundly shaped the planet through endless rounds of evolution. Many species became extinct over time, including the extremely successful Dinosaurs, who had been the dominant terrestrial vertebrates for more than a hundred million years. In contrast, modern humans (homo sapiens) have only been around for a few hundred thousand years. Yet we must be concerned with the doom of our own species already.

"In the long term, the biosphere will handle pretty much anything we throw at it, including climate change," claims astrophysicist Adam Frank (2018) in his recent article "Earth Will Survive. We May Not." Nevertheless, "if we don't take the right kind of action soon the biosphere will simply move on without us, creating new versions of itself in the changing climate we're generating now" (para. 7–8). "Hence, when we talk about sustainability, our challenge is not to address an ethic of values, but rather an ethic of survival …The goal of sustainable development is to ensure that the human species [will survive]" (Lou, 2018, p. 346).

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In recent decades, human society has made remarkable progress in sustainability: through unprecedented levels of scientific findings, we far better understand the mechanisms of how our species affects planet Earth. "Sustainable" methods, technologies, and practices are increasingly being invented and put to application. Ever more "green" products become available in the market. Progressively, international consensus is reached among governments: in 2015, 195 countries adopted the first-ever universal, legally binding global climate deal at the Paris Climate Conference (COP21). The deal "brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects" (United Nations Framework Convention on Climate Change [UNFCCC], n.d.).

Yet, reality of human sustainability is scarcely satisfying. Our environmental impact keeps intensifying at exponential rates. New challenges appear behind relentless development and well-intentioned solutions. Every year, the Global Footprint Network computes how fast we exhaust Earth's natural resources "by comparing humanity's total yearly consumption (ecological footprint) with Earth's

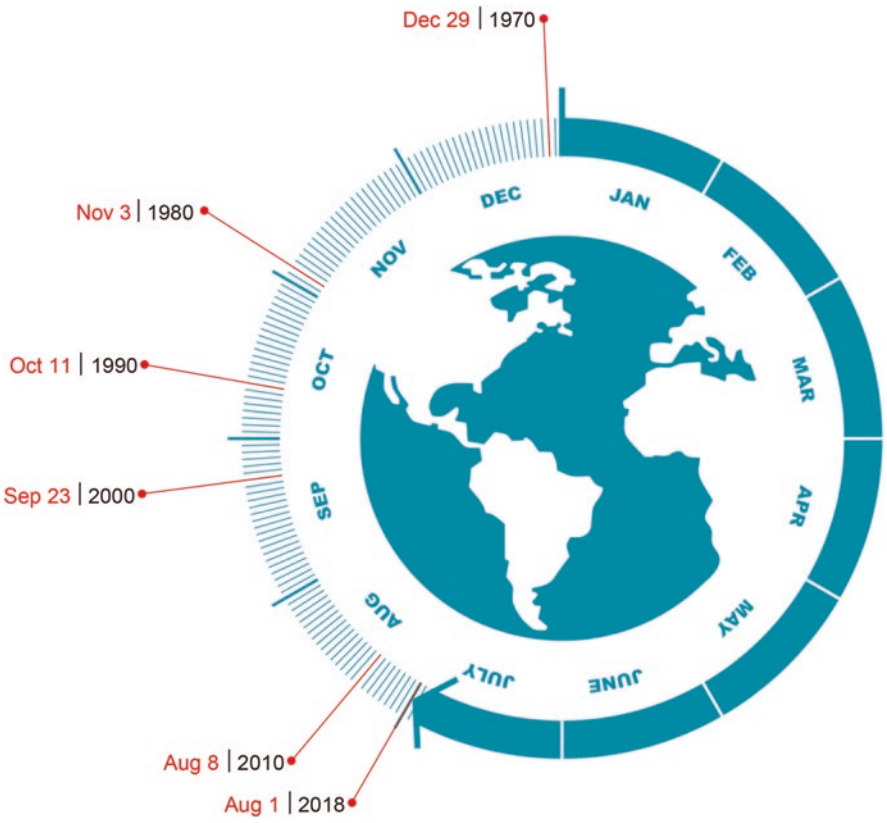

Fig. 6.1 Earth Overshoot days in 1970, 1980, 1990, 2000, 2010, 2018. Graphic by R. Tang, based on data from the Global Footprint Network, 2018

capacity to regenerate renewable natural resources in that year (biocapacity)" (Global Footprint Network, n.d., para. 1). Last year, August 1, 2018, was "the earliest date since ecological overshoot started in the early 1970s" (see Fig. 6.1). "Overusing Earth's ecosystems is one of the largest challenges facing humanity today, with climate change being a big portion of that challenge" (Global Footprint Network, 2018, para. 2 & 12).

In 2009, the concept of planetary boundaries (PB) was proposed by a group of scientists to define the environmental limits of our planet Earth, within which humanity can safely operate (Rockström et al., 2009). The findings of the following years revealed that human-induced changes are continuously and dramatically approaching these limits—even appearing beyond, already in the high-risk zone in

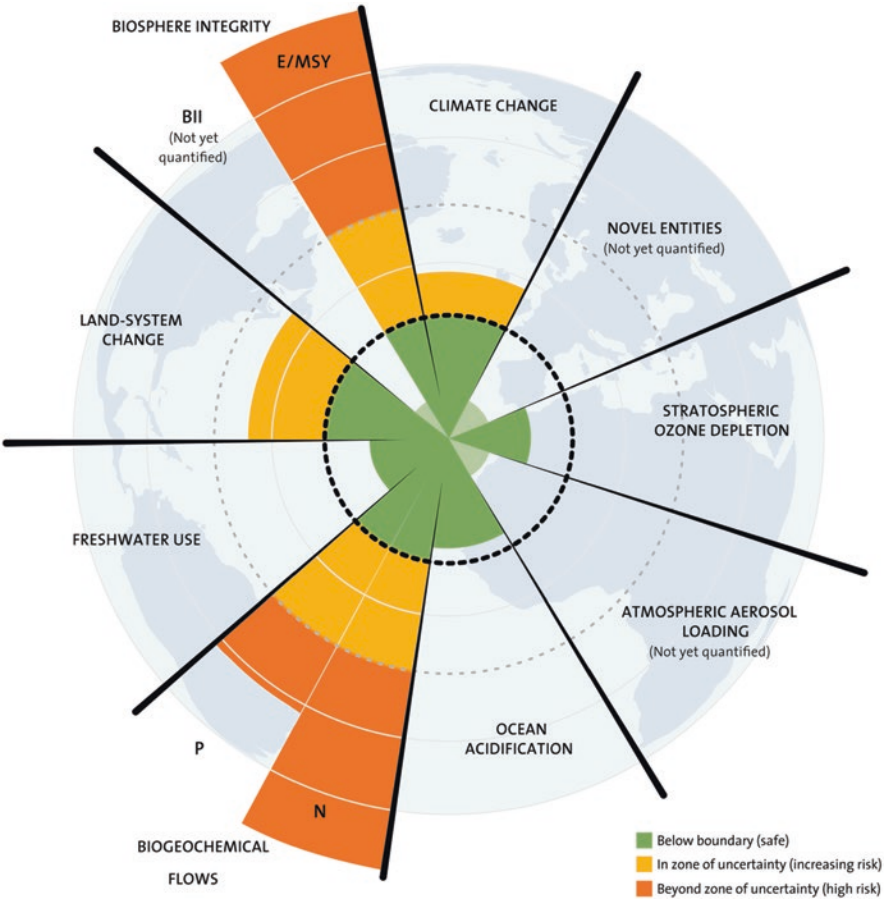

Fig. 6.2 The study on planetary boundaries in 2015. The green zone is the safe operating space, the yellow represents the zone of uncertainty (increasing risk), and the red is a high-risk zone. The planetary boundary itself lies at the intersection of the green and yellow zones. Credit: J. Lokrantz/ Azote Images based on Steffen et al., 2015. Courtesy: https://www.stockholmresilience.org/research/planetary-boundaries.html

sectors such as biochemical flows and generic diversity (Steffen et al., 2015) (see Fig. 6.2).

The consequences of devouring our ecological budget become gravely evident worldwide. We are flooded with messages about threats of global warming, toxins in everyday items, extinction of species, habitats and ecosystems, in addition to appeals from the scientific community that we must change before it's too late (Goleman, 2010). Human sustainability appears increasingly urgent, yet society's response is utterly inadequate.

If one looks closer at this dilemma, one can find that it is mainly due to the unique characteristics of true sustainability.

6.1.2 Sustainability Definition

The most commonly cited definition of "sustainable development" was defined in the report "Our Common Future" in 1987 by the General Assembly of the World Commission on Environment and Development (WCED): "[…] it meets the needs of the present without compromising the ability of future generations to meet their own needs." (United Nations, 1987, p. 16). The widely accepted sustainability concept of the "triple bottom line" is based on the consideration of social, environmental, and economic aspects. The most recent Sustainable Development Goals (SDGs) initiated by the United Nations Development Programme in 2015 (UNDP, n.d.) aim "to make sure we leave a better planet for future generations." These 17 goals are "interconnected—often the key to success on one will involve tackling issues more commonly associated with another." UNDP claims that they are "working across multiple goals" to help implantation "in some 170 countries and territories."

The key notions here are the "long-term" ("future generations"), "multifaceted, interacting issues" (triple bottom line or 17 goals) that concern every member of society ("170 countries and territories"). Such comprehensiveness, long-livedness, and interconnectedness all point to a rather complex issue with systemic characteristics.

6.1.3 Sustainability System: The Coupled Human and Natural System

According to Meadows (2008), "A system is an interconnected set of elements that is coherently organized in a way that achieves something" (p. 11). Nevertheless, "A system is more than the sum of its parts" (p. 188). Objects are networks of relationships embedded in larger systems, and many relationships in systems are nonlinear. "There are no separate systems. The world is a continuum" (p. 190).

Recently, "one major advance has been recognizing Earth as a large, coupled human and natural system, consisting of many smaller coupled systems linked through flows of information, matter, and energy and evolving through time as a set of interconnected complex adaptive systems" (Liu et al., 2015, para. 2). This "coupled human and natural system" (CHANS) represents countless integrated systems in which people interact with natural components (Liu et al., 2007).

Proof for this interconnectedness is becoming increasingly prominent in the details of our daily life. While already getting tired of the endless, depressing news on how creatures globally suffer from our inventions with plastics, we had to become familiar with the reports that tiny pieces of plastic were discovered in our table salt. Yet we did not realize how serious the problem was until researchers recently showed that 90% of commonly home-used salt brands around the world are contaminated with microplastics (Conley, 2018). This research, published in the journal *Environmental Science & Technology* in October 2018, suggests that the average adult ingests about 2000 microplastics per year due to its presence in the world's water bodies and thus in our food production processes. In the same month, microplastics were confirmed to have reached human gut as they were found in human stool in a small pilot study across 8 western countries (Wüstneck, 2018).

These findings should not come as a surprise, due to the complete interconnectedness and oneness of Earth's planetary system. We, too, live in this system. As our microplastics are now ubiquitous, permeating even remote places and species around the globe, mankind will not be spared. We tend to ignore this "inconvenient truth" (Al Gore). Yet our countless sustainability issues are interwoven with our lives in so many ways that we cannot really afford to disregard them anymore. Everything exists in a web of relationships in one way or another.

This "big picture" becomes clearer as more of the jig-saw puzzle pieces are being noticed and assembled. Overwhelming scientific evidence shows that "human activity has become the main driver of this burgeoning crisis, one that gravely threatens, well, you and me. We are collectively enmeshed in activities that inexorably endanger the ecological niche that houses human life" (Goleman, 2010, p. 9). Therefore, our every action at any moment, scale, and place, including every trade, industry, and profession and every single person on Earth, affects human sustainability or survival, respectively.

6.1.4 Sustainability Complexity

"Many key global sustainability challenges are closely intertwined (…). These challenges include air pollution, biodiversity loss, climate change, energy and food security, disease spread, species invasion, and water shortages and pollution. They are interconnected across three dimensions (organizational levels, space, and time) …" (Liu et al., 2015, para. 1). "Because they are embedded in larger systems, however, some of our "solutions" have created further problems. And some problems, those most rooted in the internal structure of complex systems, the real

messes? Have refused to go away." "No one deliberately creates those problems, no one wants them to persist, but they persist nonetheless" (Meadows, 2008, p. 4).

Thus, without holistic, systemic approaches, Earth's most urgent environmental crises will continue to persist or worsen. The systemic nature of sustainability calls for systems-based solutions which must yield "fundamental discoveries and sustainability actions that are not possible by using conventional disciplinary, reductionist, and compartmentalized approaches" (Liu et al., 2015, para. 2).

Unfortunately, starting with the Greek philosophers, humanity has developed its analytical skills much more than its synthetic ones; we are much better at breaking down an issue into its minute parts than to see the unity or connections among a multitude of aspects. Those which focus on a narrow set of features, or even a tiny fraction of sustainability, invariably create new problems elsewhere, no matter how good their intentions are. Most of the current green products or projects in the market "too often lull us to more readily ignore the way that what we now think of as 'green' is a bare beginning, a narrow slice of goodness among the myriad unfortunate impacts of all manufactured objects." "Everything made has innumerable consequences; to focus on one problem in isolation leaves all the other consequences unchanged" (Goleman, 2010, p. 26).

To date, barely any of our solutions are comprehensive enough. Despite this, however, the complexity of sustainability is only one half of the problem. The other half is the challenge of recognizing this issue at a society-wide scale. "Understanding is the first step toward finding solutions that will lead to change and redemption" (Tavris & Aronson, 2015, p. 12).

6.2 Cognition: System Thinking

6.2.1 Evolution of Thinking

According to evolutionary psychology theory, our thinking occurs in two patterns that operate differently: the reflexive and the deliberative systems (Marcus, 2008). The reflexive system perceives/assesses the world and reacts/behaves in response to it. It acts rapidly, effortlessly and essentially in the subconscious realm. It's about making snap judgments—it's what kicks in to save us (i.e., instinctive, reacting). The deliberative system, however, consciously reflects the logic of our goals and choices. It is slow, effortful, and judicious. It is about considering, planning, and making decision for the long term (i.e., devising, actually thinking).

"The two streams of thinking rely on fairly different neural substrates" in our brains (Marcus, 2008, p. 51), as they represent different products of evolution. The reflexive system depends on the evolutionary old brain systems (hindbrain), dating back as early as half a billion years ago. It controls basic functions that were as critical to a dinosaur as they are to a human. "The deliberative system, meanwhile, seems to be based primarily in the forebrain, in the prefrontal cortex," which "is a lot newer, found in only a handful of species, perhaps only humans" (p. 51).

"Evolution built the ancestral reflexive system first and evolved systems for rational deliberation second" as the progressive overlay of technologies (Marcus, 2008, p. 86). Such an evolved and organically grown product tends to be good enough but not perfect. Therefore "Even though the deliberative system is more sophisticated, the latest in evolutionary technology, it has never really gained proper control" (p. 52).

6.2.2 Hidden Impacts and Blind Spots

Our "human mind is so consistently vulnerable to error" (Marcus, 2008, p. 15) that we rarely make the best decisions. This has been shown across various fields—most famously financial markets, among others. "Over hundreds of millions of years, evolution selected strongly for creatures that lived largely in the moment ... The fact that organisms tend to value the present far more than the future" is called "future discounting" (Marcus, 2008, pp. 84–85). To act promptly rather than thinking properly was more crucial "for our ancestors, who lived almost entirely in the here and now (as virtually all non-human life forms still do)" (Marcus, 2008, p. 37). It was the obvious and indispensable natural adaptation to a threatening environment.

Today, humans live in completely different circumstances, which would require us to reflect beyond the immediate, sensible present. Our complex environments and lifestyles are supplying ever more information and require ever more input, which in turn necessitate far more attention, understanding, evaluation and planning than was required from the "hunter-gatherer." Unfortunately, "the routines of our daily lives go on completely disconnected from their adverse impacts on the world around us" (Goleman, 2010, p. 42). "We have no sensors, nor any innate brain system designed to warn us of the innumerable ways that human activity corrodes our planetary niche" (Goleman, 2010, p. 46). The reflexive system determines many of our everyday actions, although we may not be aware of it. Our so-called "fight-or-flight" (survival) mode explains why we respond primarily to immediate and biologically sensible threats and make shortsighted decisions to satisfy our direct and immediate natural needs. Future discounting is still deeply rooted in our genes, even though it seems no longer suited or necessary in our drastically modified environments.

Why we humans still can't get over the inherited tendency of future discounting can be explained by evolutionary inertia: human society has developed much faster ever since acquiring the mind, than what evolution can catch up with. Since the industrial revolution, our environments have completely been turned upside down. "By the standards of evolution, that's not a lot of time for debugging, and a long time for the accumulation of prior evolutionary inertia" (Marcus, 2008, p. 14).

This cognitive dilemma is what we humans are currently facing on our quest to avert our own extinction: we are suffering from a blind spot that is masking distant/indirect/invisible interconnections. As this is undoubtedly fatal for our existence as a species, we can no longer afford to leave these issues be hidden from us.

6.2.3 New Sensitivity: Systems Thinking

From the above discussion we find that to reach human sustainability we must enable our deliberative thinking to somehow compensate for our cognitive blind spot and overpower our reflective behavior where necessary.

"We have to acquire a new sensitivity to an unfamiliar range of threats, beyond those our nervous system's alarm radar picks up—and learn what to do about them" (Goleman, 2010, pp. 46–47). Even more so, as we live "in a world that rapidly needs to shift behaviors arising from very complex systems" (Meadows, 2008, p. Xiii). We need to reflect in a new way, a way of seeing wholes, "to see the hidden patterns that connect human activity to the larger flow of nature, to understand our true impact on it, and to learn how to do better" (Goleman, 2010, p. 44). This requires a change of mind: from seeing ourselves as different from the world, to connected to the world; from seeing problems as caused "somehow," to seeing how our own actions create these problems (Senge, 2006).

Systems thinking, which pays more attention to interdependence than independence, can contribute critically to our new sensitivity to the compensation of our cognitive blind spots. For instance, systems thinking can help us emphasize on hidden/indirect/distant impacts and relations, rather than the visible/direct/immediate ones. "It is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static snapshots" (Senge, 2006, pp. 68). "In mastering systems thinking, we give up the assumption that there must be an … individual agent responsible. … Everyone shares responsibility for problems generated by a system" (p. 78).

This new sensitivity is required both at the scale of individuals as well as society in order to produce lasting changes via many types of actors, on multiple levels and on manifold attitudes. Up until now, the environmental movement has mostly only involved groups of disconnected individuals on diverse and seemingly disconnected issues. That is not enough and is the reason why the many endeavors have not yet been successful after more than half a century of struggles. A shared sustainability awareness is a crucial missing piece in our collective efforts. Only such a shared cognition among all humans (involving every single individual of the species) will allow us to understand the complex interconnections and to become aware of the myriad hidden, indirect impacts on sustainability ubiquitous in our daily lives. This collective human culture of sustainability will be a major step towards true human sustainability.

"As our world continues to change rapidly and becoming more complex, systems thinking will help us manage, adapt, and see the wide range of choice we have before us. It is a way of thinking that gives us the freedom to identify root cause of problems and see new opportunities" (Meadows, 2008, p. 2). System thinking will help us to overcome the sustainability dilemma (that the situation is still getting worse) and potentially our cognitive dilemma (that we let it happen). Our thinking processes might be flawed by nature, but "we have a chance to make the most of the noble but imperfect minds we did evolve" (Marcus, 2008, p. 17). Education,

effective policies, big data, and artificial intelligence might be useful tools in achieving this, too, of course.

6.3 Design for Sustainability: System-based Approaches

6.3.1 Design: Basic to All Human Activity

We all live in a designed world. Everything we make, use and discard has been designed by someone, somewhere. "Design is basic to all human activity. The planning and patterning of any act towards a desired, foreseeable end constitutes the design process." (Papanek, 1991, p. 3). "In this age of mass production, when everything must be planned and designed, design has become the most powerful tool with which man shapes his tools and environment (and, by extension, society and himself)" (Papanek, 1991, p. ix). Today, design is confronted with "far greater challenges than merely satisfying individuals' needs and is operating within an ever-expanding context" (Lou, 2018, p. 349).

Unfortunately, Papanek's words from a generation ago still fully apply today: "…by creating whole new species of permanent garbage to clutter up the landscape, and by choosing materials and processes that pollute the air we breathe, designers have become a dangerous breed" (Papanek, 1991, p. ix). As society can only conveniently employ these designs as fittingly, healthily, or positively as they have been designed for, designers, as both members of society and creators of means for society, are doubly responsible.

"In many ways, the environmental crisis is a design crisis. It is a consequence of how things are made, buildings are constructed, and landscapes are used…Our present forms of agriculture, architecture, engineering, and industry are derived from design epistemologies incompatible with nature's own. It is clear that we have not given design a rich enough context. We have used design cleverly in the service of narrowly defined human interests…Such myopic design cannot fail to degrade the living world, and, by extension, our own health" (Van der Ryn & Cowan, 2007, p. 9).

Meanwhile, as every transition is a decision-making process that can be nudged by design (Lou, 2018), design appears to be predisposed to attain human sustainability.

6.3.2 Make Design Positive: Integrate Human and Natural Systems

The sustainability-conscious architects and founders of GIGA, Raefer Wallis and Ryan Dick, proposed that we ought to make design positive to the environment, and that everything we make should serve to leave the environment in a better state than

when we found it. Otherwise, the world would have been better without us. Indeed, "there is no such thing as a 'neutral' design," as Thaler & Sunstein stated in their renowned book Nudge (2009, p. 3). Every design defines interactions between Human and Natural systems, either positive or negative ones. We can make design positive to the environment through adjusting the relationship between human and nature (Lou, 2018). This creates an opportunity, where design for sustainability will drive a demand for a wave of design innovations.

Hence design must imperatively be pursued within a context of sustainability. This requires fundamental understanding of how things and nature work, recognizing the countless ways human systems interact with natural ones (Goleman, 2010). Designers must learn to think in systems so as to uncover hidden interrelationships and to thus achieve better design.

Densely populated urban scenarios of human society represent the extreme of the human system. It is where design actions are intensively ongoing and where Earth's nature has been almost completely altered. But natural processes, physical laws and chemistry cannot be muted. Multiple interactions between the coupled systems frequently take place on various scales and in various forms and affect the environment far beyond the city's boundaries. Rendering design positive to the environment in the urban context will make a significant and far-reaching contribution to saving our species and civilization.

6.3.3 Sustainability Cognition Required for the Future Designers

Nevertheless, in current design practice, it seems that dealing with sustainability aspects is often seen as tedious or the responsibility of some external expert who consults the designer. In other words, it is the work of "others," not necessarily the designer's, as designers tend to regard the sustainability topics as simply too technical, boring, incomprehensible or frustrating. Some designers might pick it up as an alternative source of inspiration, to liven up the design or to respond the trend. Very few are giving their best to render their design as sustainable as possible.

Human sustainability is an increasingly urgent challenge at global scale and with a huge impact. Training some more specialists equipped with better knowledge and newer tools is nowhere enough to achieve this sustainability. We need a different breed of designers—designers who possess a sustainability cognition, think systemically and therefore can work towards system-based approaches to this epochal problem.

For humanity's sake, sustainability must become the core of design, not merely a supplement. It must be the foundation, the vocabulary, or the guiding principle throughout any design program. Hence, it is much more beneficial, meaningful, and enduring to present and perceive sustainability as an inevitable (but benefitting) requirement of design and human life for the entire design community. We need new design communities more than new design experts (Lou, 2018).

It is indeed a great challenge to transform our current design education and practice. This challenge asks for a shared notion and a collective effort from the entire design community, as well as the overall human society as a whole—each and every one of us. Design can be a tool to inspire the whole society to extend the notion of human sustainability, thereby enabling our society to achieve sustainable societal changes on a larger scale, making it more profound and effective. Humanity needs a joint culture of sustainability to make the next step in evolution.

6.4 Conclusion

It is about "different way of seeing and thinking" and thus taking different actions (Meadows, 2008, p. 4). Obtaining a sustainability cognition will enable the entire design community to define and accept the sustainability of the human future as a starting point of its work. Learning to think in systems will empower the designers to work on multiple scales and reach a deeper level. Systems-based design approaches which tackle the coupled human and natural systems across all dimensions are necessary to address the complexity of sustainability challenges and identify effective solutions.

There is a call for systemic views on our sustainability, in design and in everyday life. Moving from analytical (breaking down) thinking towards synthetical (bringing together) thinking, human sustainability is less a topic for focused specialists than for a design community based on networked thinking. Large communities of designers as well as ordinary persons could create designs for sustainability based on democratically organized data (big data, science), technology (artificial and human intelligence), and values. Chances are, we may find such design relevant and rewarding.

References

Conley, J. (2018, October 18). 90% of Table Salt Is Contaminated With Microplastics. Retrieved March 25, 2019, from https://www.ecowatch.com/table-salt-microplastics-2613395969.html

Frank, A. (2018, June 12). Earth Will Survive. We May Not. *The New York Times*. Retrieved March 24, 2019, from https://www.nytimes.com/2018/06/12/opinion/earth-will-survive-we-may-not.html

Global Footprint Network. (2018, June 13). *Earth Overshoot Day 2018 is August 1, the earliest date since ecological overshoot started in the early 1970s*. Retrieved from https://www.footprintnetwork.org/2018/06/13/earth-overshoot-day-2018-is-august-1-the-earliest-date-since-ecological-overshoot-started-in-the-early-1970s/

Global Footprint Network. (n.d.). Past Earth Overshoot Days. *Earth Overshoot Day*. Retrieved on September 24, 2018, from https://www.overshootday.org/newsroom/past-earth-overshoot-days/

Goleman, D. (2010). *Ecological intelligence: The hidden impacts of what we buy*. Broadway Books.

Liu, J., Dietz, T., Carpenter, S. R., Alberti, M., Folke, C., Moran, E., Pelli, A. N., Deadman, P., Kratz, T., Lubchenco, J., Ostrom, E., Ouyang, Z., Provencher, W., & Charles l. Redman,

Stephen H. Schneider Taylor, W. W. (2007). Complexity of coupled human and natural systems. *Science, 317*(5844), 1513–1516. https://doi.org/10.1126/science.1144004

Liu, J., Mooney, H., Hull, V., Davis, S. J., Gaskell, J., Hertel, T., & Li, S. (2015). Systems integration for global sustainability [Structured Abstract and Abstract]. *Science, 347*(6225), 1258832. https://doi.org/10.1126/science.1258832

Lou, Y. (2018). Designing interactions to counter threats to human survival. *She Ji: The Journal of Design, Economics, and Innovation, 4*(4), 342–354. https://doi.org/10.1016/j.sheji.2018.10.001

Marcus, G. F. (2008). *Kluge: The haphazard construction of the human mind*. Houghton Mifflin.

Meadows, D. H. (2008). In D. Wright (Ed.), *Thinking in systems: A primer*. Chelsea Green Publishing.

Papanek, V. (1991). *Design for the real world: Human ecology and social change*. Thames and Hudson.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., III, Lambin, E., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H., Nykvist, B., De Wit, C. A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U., … Foley, J. (2009). Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society, 14*(2), 32. https://doi.org/10.5751/es-03180-140232

Senge, P. M. (2006). *The fifth discipline: The art and practice of the learning organization*. Random House Business Books.

Steffen, W., Richardson, K., Rockstrom, J., Cornell, S. E., Fetzer, I., Bennett, E. M., & Sorlin, S. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science, 347*(6223), 1259855–1259855. https://doi.org/10.1126/science.1259855

Tavris, C., & Aronson, E. (2015). *Mistakes were made (but not by me): Why we justify foolish beliefs, bad decisions, and hurtful acts*. Houghton Mifflin Harcourt.

Thaler, R. H., & Sunstein, C. R. (2009). *Nudge: Improving decisions about health, wealth, and happiness*. Penguin.

United Nations Framework Convention on Climate Change (UNFCCC). (n.d.). *The Paris Agreement*. Retrieved July 28, 2018, from https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

United Nations, Our Common Future: Report of the World Commission on Environment and Development (WCED). (1987). Retrieved March 24, 2019, from http://www.un-documents.net/our-common-future.pdf

United Nations Development Programme (UNDP), Sustainable Development Goals. (n.d.). Retrieved March 22, 2022, from https://www.undp.org/sustainable-development-goals

Van der Ryn, S., & Cowan, S. (2007). *Ecological design*. Island Press.

Wüstneck, B. (2018, October 23). In a first, microplastics found in human poop. Retrieved March 25, 2019, from https://www.nationalgeographic.com/environment/2018/10/news-plastics-microplastics-human-feces/