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A Social-Ecological Approach to Architecture and Planning

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ABSTRACT

Sustainable design has failed to fundamentally transform the performance of the built environment in the most critical indicator: social-ecological impact. Design has focused on making systems more efficient, instead of redesigning the system to continually enhance natural processes and center the welfare of the people who live, work, and experience the built environment. Buildings, neighborhoods, and infrastructure must be reimagined using a social, ecological, and technological systems approach connecting the social needs of the community within the constraints of biophysical systems. We present an approach in the evolution of sustainable design, one that builds on green design and regenerative design, but advances a social-ecological design methodology - one that is sensitive to scale, adopts a systems approach, is future-oriented, and centers social needs in design.

Keywords: *Regenerative, Social-Ecological Systems, Design, Planning, Ecosystem Services*

INTRODUCTION

To respond to the challenges of a dynamic world characterized by climate change, resource crises, and widening economic inequalities, architecture must be redefined using a social-ecological systems approach that grounds social needs for food, water, energy, and health within the biophysical capacity of the surrounding environment at relevant scales. Thus far, sustainable building design has focused on making existing systems more efficient or "green" instead of designing them to integrate with and enhance the social-ecological system or landscape within which they are embedded. This is the difference between green design and social-ecological design, a fundamentally new approach that is required of architecture across scales (building to neighbourhood to city) to achieve sustainable and resilient urban development in a dynamic world.

The architecture and built environment community have addressed sustainable urban development with incremental "green" guidelines that make buildings marginally better than standard practice. Dr Ray Cole from the University of British Columbia states: "green design is directed at reducing degenerative impacts… this is insufficient for an ecologically sustainable future and is an insufficient aspiration to motivate design professionals and their clients."(Cole, 2015) This is not transformative enough to be truly 'sustainable'—that is, to create a pattern of development that supports human health and well-being with renewable resources.. Social-ecological design aims to create site developments that enhance the potential of a place to support sustainable, equitable, and healthy human communities by incorporating benefits provided by local ecosystems, and understanding the social needs in that place.

Sustainable design has been focused on reductive approaches of efficiency and mitigation that have not challenged the traditional assumption of an unlimited supply of materials, energy, and water that can flow through the system to support life. John Tillman Lyle calls these systems: "one way throughput systems." (Lyle, 1994). Lyle outlined an approach to system design that focused on mimicking the function of a living system or a “regenerative system.” He proposed a closed loop system leveraging resource and energy storage and the regeneration and recycling of outputs. (**Figure 1**)

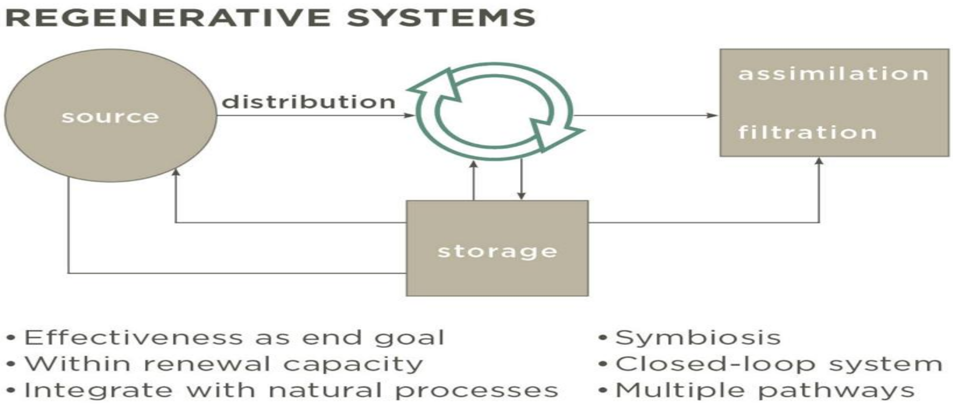

Figure1. *John Tilman Lyle: Regenerative Design for Sustainable Development. 1994.*

The social-ecological approach to design that we describe in this paper draws heavily on principles of regenerative design.

We advocate for a social-ecological view of the role of design that does not separate design, development, and architecture from an idealized nature, but integrates buildings and neighbourhoods with living systems in time and space. The process involves not only designing systems of resource flows to be self-renewing, but also understanding a new way of “social, ecological, and technological systems thinking” for design.

In their 2012 article, Bill Reed and Pamela Mang, outlined four key premises to guide regenerative design and site development: (1) understand the potential of the place, (2) define the goals for the capacity to be developed, (3) “partner” with the place, and (4) co-evolution (Mang and Reed, 2012). Expanding on the work of Mang and Reed, our team developed a social-ecological process for design that aligns with updated thinking in architecture, design, ecology and environmental science.

The social-ecological approach to design begins by exploring the needs of a community, and elicits a desired future state of the site as a goal to work towards. In this future state, the built environment improves human well-being by addressing basic social needs and enhances the provision of ecosystem services to help meet those needs, within the environmental limits set by the surrounding landscape. Social-ecological design asks architects to create buildings that are not just “less bad”, but beneficial to the social and ecological landscapes they inhabit. Taking into account multiple temporal and physical scales, design should integrate people and place. This kind of approach to design is a non-linear process, since needs and outcomes need to be constantly re-assessed and iteratively improved or managed. It requires interdisciplinary engagement between architects, ecologists, engineers, community members and other stakeholders, and a shift in architectural vocabulary. In the following sections, we describe the social-ecological design approach in more detail.

Background

One of the core principles of a social-ecological systems approach is that society is embedded within, and wholly dependent upon, the biosphere. People and nature are intertwined and shape each other in complex ways across local to global scales (Berkes et al. 2000; Folke et al. 2016). Ecosystems provide many benefits to humans that are co-produced by nature and society, such as clean water, food, flood control, temperature regulation, and mental health. These “ecosystem services” are the contributions of nature to people’s well-being and quality of life (MA 2005, IPBES 2016). Ecosystem services are often undervalued, and the costs of degrading nature’s ability to provide ecosystem services are underestimated, if realized at all (Daily et al. 2009). Drivers or stressors (such as climate change, pollution, and habitat degradation) affect ecological structures and processes that drive the provision of ecosystem services. Changes in ecosystem services affect human well-being through impacts on food production, water supply and quality, recreational opportunities, cultural identity, or other benefits.

In the past, ecosystem services have typically been assessed at the landscape scale, mostly in rural environments. However, recent advances in ecosystem service science have led to more fine-scale assessments that are applicable in the urban context, taking into account the provision of ecosystem services by green infrastructure such as street trees, urban parks, community gardens, coastal habitats etc. (Keeler et al. 2018). There is growing interest in ecosystem services in the urban planning communities, particularly in the context of climate change and the potential of nature in cities to mitigate negative climate impacts through strategies such as "ecosystem-based adaptation" (Geneletti & Zardo 2016). There is little overlap in ecosystem service research and the built environment, particularly at the scale of individual buildings or sites. Many questions emerge when considering the relationship of buildings to their environments using ecosystem services. How do ecosystem services translate to the built environment? Which ecosystem services can be performed or partly substituted by technology and the built environment? What is the ecological significance of the services that buildings can provide? How does the provision of ecosystem services by a building or site relate to other negative ecological impacts associated with the built environment?

In the framework of regenerative urban design, Maibritt Pedersen Zari at Victoria University in New Zealand has researched the questions above and recommended particular ecosystem services for their suitability for the built environment. (Pedersen Zari, 2012, 2015, 2018.) Her research determined buildings can contribute to climate regulation and the purification of air, provide habitat, cycle nutrients, as well as provide fresh water, fuel and food.

An ecosystem service approach to regenerative urban design is closely related to its physical site, in terms of ecology, climate, and culture. Zari illustrated the use of an Ecosystem Service Analysis (ESA) approach to evaluate built environments at an urban scale and help to devise regeneration-oriented goals for their re-development. The research focused on New Zealand's capital city of Wellington and aimed to determine "measurable rates of ecosystem service provision that exist (or existed) on a site". Zari's work creates a foundation for our work with the aligned focus on ecosystem service measures and the desire to add rigor to the holistic thinking of regenerative design. However, this approach does not explicitly link ecological conditions and design goals with the self-determined social needs of the community, and instead prioritizes the regeneration of "pre-development" ecological conditions that existed at a site. It also de-emphasizes the role that design can play in providing cultural ecosystem services, which is a category of often intangible services that contribute to well-being aspects such as physical and mental health, recreation, spiritual and cultural practices, scenic beauty, social cohesion, and sense of place (Daniel et al. 2012). In contrast, we take the position that previous, "natural" conditions are often no longer relevant within the context of rapidly changing, constantly evolving social-ecological systems in the Anthropocene, and that design should instead focus on achieving future conditions that improve social-ecological outcomes for the community, including culturally and socially important outcomes that are difficult to measure. In a social-ecological design approach, connecting site development to ecosystem services is guided by the goal of minimizing environmental externalities (or negative impacts) and enhancing the co-production of ecosystem services that contribute to human well-being in a holistic and forward-looking manner.

Socio-Ecological Systems as a Basis of Design

Sustainable design focuses on ecological systems as the basis of design. However, the fundamental goal of the built environment is to provide for human well being: homes, clean air and water, food, energy, sanitation, jobs and happiness. This is where design should start: the social foundations of the place and community. The key design challenge for the next century is to transform the built environment to not only provide for the social needs of the community, but also to fulfill those needs within the limits of ecological systems by taking an integral approach to social, ecological and technological systems.

Environmental Ceilings

Significant social, cultural, technological, and environmental change is occurring. In the last thirty years, global temperatures are the warmest in the last 1400 years (IPCC, 2014), biodiversity has dropped by 58% (WWF, 2016) and nearly 50 countries are experiencing water stress or scarcity. Many factors are contributing to these changes in our society's institutions and processes.

As Stephen J. Jackson (2014) puts it: "The worlds we inhabit—natural, social, and technological have real limits and fragility. The euro-centered world that has dominated the culture of the last two hundred years is in the process of coming apart, perhaps to be replaced by new and better stories or perhaps not." To remain relevant and provide value in a time of flux, the field of architecture must change its structure of practice.

Technology and population growth have ensured that humanity impacts and affects all the planet's life-supporting systems, and while climate change may be humanity's most urgent problem today, it is not the full extent of the challenge. In 2005, the Millennium Ecosystem Assessment found that 60% of the world's ecosystem services were degraded or used unsustainably (MA 2005). Human activity is disrupting the self-regulation of planetary life-supporting cycles like those of carbon, water, biogeochemical flows, and others (Steffen et al. 2015). Many argue that humans have altered Earth system processes to such an extent that we have entered the Anthropocene - a new geologic time period (Crutzen 2002). These examples illustrate that the natural environment has limits within which human development must occur.

A worldview that separates humanity and nature is flawed. As Bill McKibben (2006) writes: "This is a historical moment entirely different from any other, filled with implications for our philosophy, our theology, our sense of self. We are no longer able to think of ourselves as a species tossed about by larger forces, now we are those larger forces…the end of nature." While scientists are connecting human activity to life-supporting ecosystems at local to global scales, the architecture and building community are still using green building guidelines like LEED in the United States, BREEAM in the United Kingdom and others that are founded on the principle that efficiency is the remedy to ecological overshoot. Instead, the design process should assess specific limits of a place and the potential to affect life-supporting cycles.

Social Foundations

Human health and well-being is the ultimate goal of development of buildings, neighborhoods, and cities. Yet one quarter of the world's population still lacks electricity (Gronewold, 2009), one third do not have access to improved sanitation (CDC, 2018), and one third are malnourished (UN, 2016.) Architecture and design can help address these problems, but must do so within a larger contextual framework. The United Nations Sustainable Development Goals (SDGs) provide an overview of priorities for international development, and essentially define a desired future for people and the planet. Embedded within the SDGs is the idea that there are certain basic needs that should not be compromised, such as the need for food, water, sanitation, education, equality, and freedom. Building on the idea of social needs that should be met, within the context of environmental limits, Kate Raworth developed a concept for sustainable development that combines eleven social foundations with nine planetary boundaries to create the "doughnut of social and planetary boundaries" (Figure 2) (Raworth, 2012, 2018).

Figure2. *The Donut by Kate Raworth. (2012)*

This approach creates a safe and just space for humanity that provides all of the resources (food, water, healthcare, energy, etc.) to fulfill human rights and needs within the limits of the planet's critical life supporting systems (Raworth, 2012). This concept of a safe and just space for humanity aligns with the principles of social-ecological design, which aims to improve human well-being by enhancing ecosystem services and minimizing environmental externalities. As David Wahl writes: " I firmly believe that the multiple crises we are facing are symptoms of our pathological habit of understanding and experiencing ourselves as separate from nature." (Wahl, 2016) The design process needs to embrace that it is also a culture and capacity-building effort between the design team, the community, and the social-ecological systems that intersect in the place of the design.

An Emerging Social-Ecological Design Theory

Social-Ecological Design Theory

Social-Ecological Design Theory builds on the shift from the traditional sustainable design approach that is grounded in a reductionist approach. Regenerative design begins to embrace a more systemic approach and seeks to create more transformative goals for design instead of the incremental goals negotiated by green design. While some elements of social-ecological design are forecasted by regenerative design theorists such as using ecosystem services as a metric (Zari, 2012, 2015, 2018.) and the necessity of involving stakeholders in the design process to build capacity (Regenesis Group, 2016), more shifts in thinking are required. Three key theoretical shifts are required to evolve Regenerative Design Theory into a truly Social-Ecological Theory of Design.

First, focus on the future potential of systems within the complexity of changes occuring in the Anthropocene and cast off romantic "pre-development" notions of nature separate from people. Second, begin with a focus on the social needs of a healthy thriving community and then consider the ecological limits and technological challenges of design. Third, use an ecosystem service measure to assess design that enhances the benefits provided by local ecosystems, in pursuit of more livable, sustainable, and equitable communities. Table 1 outlines a comparison of the differences between current sustainability models (Green), Whole systems sustainability (Regenerative) and Social, ecological and technological sustainability (Integral) design. These differences in design theory necessitate a transformation in the design process outlined in Figure 3.

Table1. *A Comparison of Sustainable Design Approaches adapted from Hes and Du Plessis, 2015.*

	Current sustainability models (Green)	Whole Systems Sustainability	Social, Ecological and Technological Sustainability
Goals	Meet socially negotiated goals/conditions of sustainability across three spheres of development (society, economy, environment).	(Restore and) Maintain resilience and integrity of local and global social-ecological systems.	Integrate social, ecological, and technological systems to provide for human well-being.
Strategies	Command and control, manage, measure fixed/static.	Cooperate, participate, adapt, learn, understand, flexible, dynamic.	… and coevolve, equity, engage, capacity building
Measure	Progress to incremental goals	Distance from thresholds	Ecosystem services and human well-being
Approach	Reductionist - Solve individual, tightly scoped problems and add solutions to solve large problems.	Holistic - Understand the big picture to solve problems of relationship and emergence.	Integral and iterative - Acknowledge the complexity of social, ecological and technological systems and their relationships. Foster complex adaptive systems thinking.
View of Nature (with reference to Mace 2014)	Nature despite people	Nature for people. Biomimicry. Pre-development conditions. "Master" patterns.	People and nature. Acknowledgment of the Anthropocene. Landscape ecology. Future potential.
Equity	?	?	Involve a diversity of stakeholders, including extant

			and ecological communities in social, ecological and technological system management to building capacity and resilience.

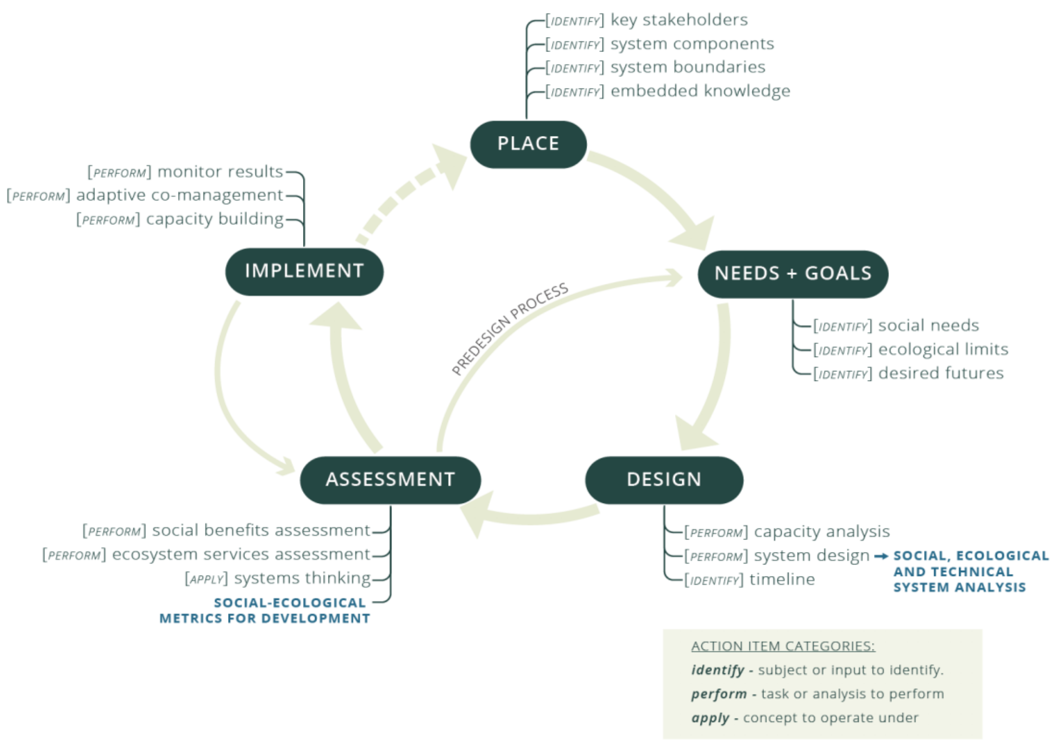

Figure3. *A Social-ecological Design Process*

A Social-ecological design process is inspired by theory on complex adaptive systems and resilience. Social-ecological systems, like all complex adaptive systems, are characterized by dynamic and emergent interactions across nested scales of time and place (Gunderson & Holling 2002; Liu et al. 2007; Levin et al. 2013). A particular development site is part of a bigger system, and is itself made up of multiple interacting subsystems. Resilience is the capacity of a social-ecological system to adapt or transform in the face of change, while continuing to support human well-being (Biggs et al. 2015; Folke et al. 2016). The mindset required of the designer is therefore "conscious participation in complex systems… sensitivity to temporal and spatial scale-linking dynamics." (Wahl, 2016). The goal of design is not a fictitious moment of sustainability, but the creation of emerging pathways of systemic resilience that provides for social needs, while enhancing the health of all living systems in a place. The process is iterative and has five aspects: place, needs and goals, scenario design, assessment and implementation.

Place

The social-ecological planning process begins with the "place" or the unique network of relationships between living systems that form the social-ecological "whole". It is the result of patterns of relationships that occur at multiple physical and temporal scales. This phase of design starts with identifying key stakeholders within the interacting social-ecological system. Social components such as values, customs, networks, institutions, local knowledge, and existing infrastructure are identified alongside ecological components including wildlife habitat, vegetation, climate, soil conditions, geology, water, energy flows and geochemical cycles. System boundaries are identified, which can vary in scale from the building, to the site, neighbourhood, city, watershed, or an entire region. These boundaries are based on biophysical, political, and other factors. The process of identifying stakeholders, system components, and boundaries across scales is an important part of place-based research, and draws upon established methodologies such as social-ecological inventories and resilience assessments (Balvanera et al. 2017; RA 2010; Quinlan et al. 2015; Schultz et al. 2007). The main goal of this phase is to identify "the evolutionary dynamics of the place in order to identify the potential for realizing greater health and viability as a result of human presence…" (Mang and Reed, 2012)

Needs and Goals

The main goal of development is to provide for the social foundation of the community living not only in the area affected by the development, but also in the surrounding areas. Kate Raworth defines the social foundation of a community as the "basics of life on which no one should be left falling short. These twelve basics include sufficient food; clean water and decent sanitation; access to energy and clean cooking facilities; access to education and to healthcare; decent housing; a minimum income and decent work; and access to networks of information and to networks of social support." (Raworth, 2018) However, these societal needs must be achieved within the environmental limits or capacity of a place. Raworth uses the concept of planetary boundaries (Steffen et al. 2015) to define the biophysical limits of development, including variables for climate change, ocean acidification, ozone, chemical pollution, freshwater, biodiversity and air pollution. While these boundaries were first described at the global scale, they have since been down-scaled to be applied in contexts such as national (Cole et al. 2014) and city-level assessments (Hoornweg et al. 2016). Each of the biophysical boundaries has a different scale of process and function, with varying thresholds beyond which irreversible changes may occur. (Figure 4) For example, carbon dioxide emissions accumulate globally and have a global scale threshold, while chemical pollution may be impactful at more local/regional levels within ecosystems.

Fig. 4. Categories of planetary boundaries.

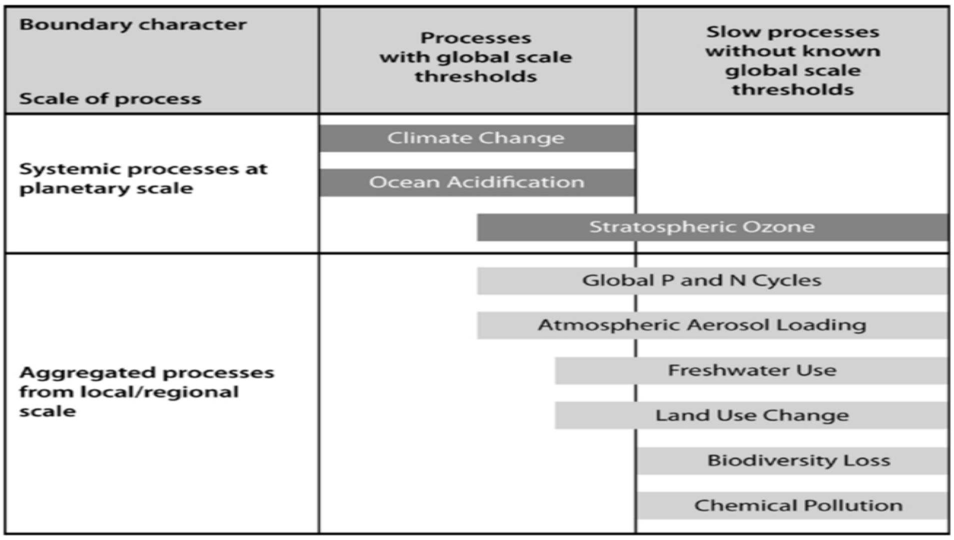

Figure4. *WWF, 2016*

Knowledge of the social needs, environmental limits, and social-ecological relationships are embedded within a place. The challenge for the design team is to work with the community of people in the place of the development to understand these ever-changing and evolving relationships, build adaptive capacity, and create goals for the future.

The design team must facilitate the creation of a vision for a sustainable future by all the stakeholders in a place to be successful. Designs never reach 'destination sustainability'. Instead, communities should prepare for the long – and at points surprising – learning journey. David Wahl describes this as inhabiting the world as both a pilgrim and an apprentice: "To walk the path into an uncertain future we would do well to cultivate the attitude of a pilgrim – with respect for all of life... We would also do well to cultivate the attitude of an apprentice – acknowledging that nature in all its forms – whether through our fellow human beings or through the multitude of fellow species on this planet – has so much to teach us. As pilgrims and apprentices we have to be willing to question and, at times, give up what we know and who we are for what we could become. (Wahl, 2016) Seeing the design process as the beginning steps in a journey means that it is not linear, but iterative. Teams will move through the steps from Needs + Goals to Scenarios to

Assessment and back to Needs many times in the Pre-Design Process.

Creating Design Scenarios

Design is where theory and practice are integrated. The developments that a culture plans and builds are a reflection of its worldview. After the place-based needs and goals are identified, scenarios are created to present whole integrated designs of the site or building in question. These scenarios translate the identified needs and goals into different, alternative designs across all of the subsystems of the place. (Graves and McLennan 2013) and (Zari, 2012, 2015, 2018) have detailed methodologies for integrating social-ecological system analysis into the design process. In the design process for a Living Community master plan for University in Burnaby, BC, a series of "petal" diagrams were created to map the patterns and capacity of systems related to the Living Community Challenge imperatives relative to water, energy, food and civic structures. (Graves and McLennan, 2013).

During the development of the scenarios, design will inherently involve system design. A social-ecological approach to system design seeks to provide for the social needs of a community while enhancing ecological foundations at all scales. This approach integrates social, ecological and technical systems in a design philosophy grounded in the following key principles:

- Social, ecological and technical systems are complex and continually changing in space and time.
- There are no fixed boundaries between these systems and they should be integrated in design.
- A multi-scalar approach to setting the limits of system design should be taken
- Qualities of a system are just as important and sometimes more important than quantifying flows.

Figure 5 provides a template for system designers to integrate social-ecological goals into the particular systems (energy, water, materials etc.) of a place. The template organizes system flows into four stages: source, use, reuse and outflow. Sources are preferred to come from conversion from natural cycles (captured rainwater, solar radiation, wind, etc.) or stored sources (cisterns, batteries, thermal envelope etc.) before reverting to reclaimed or non-renewable sources. Uses are structured to have the potential for reuse whenever possible. Flows and systems are designed to use and reuse in multiple loops before resources flow out of the system. Outflows are designed to store resources for future use if possible. If not, out flows should be designed to recharge or enhance the water cycle on a site. This serves to see outflows as sources for future processes instead of waste and therefore reduce pollution and extraction impacts on ecological systems. In addition, system redesign should verify the ability of each system to function within the renewal limits of the place.

It is very important to note that these systems are constantly changing in space and time. System design needs to accommodate these ever changing complex systems.

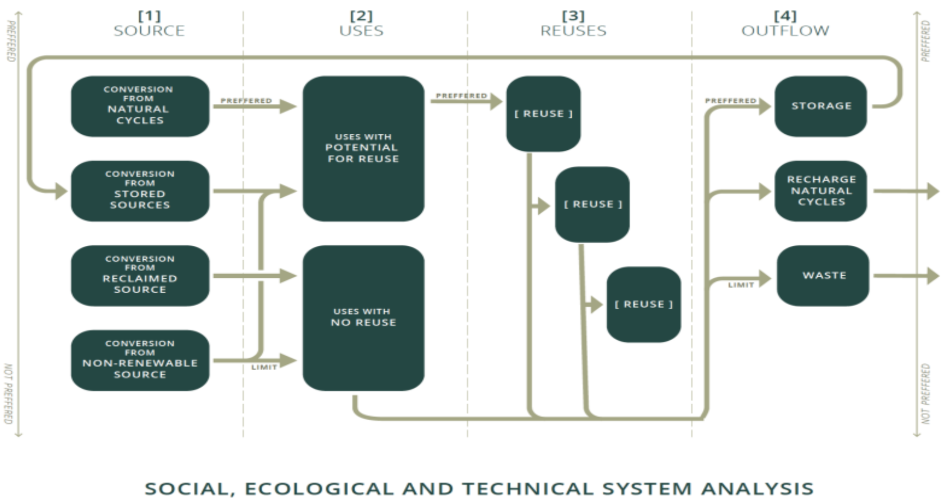

Figure5. *Social, Ecological and Technical System Analysis Template*

Assessment

In the assessment phase, different design scenarios are evaluated against the social needs, environmental limits, and social-ecological goals that have been identified for the development site - ideally in close collaboration with the community.

There are many ways in which social and ecological benefits of a building or site development may be assessed. Communities may develop their own list of relevant well-being metrics, specific to their context. Or they may rely upon existing standards and measures for well-being, such as the SDGs or life-satisfaction metrics (Graham et al. 2018). On the ecological end of the spectrum of benefits, there exist numerous frameworks for assessing ecosystem services, but most rely on the same common elements of identifying ecological structures and processes that produce benefits for people, quantifying those benefits, and assigning a value to them. The value of an ecosystem service may be expressed in economic terms, but it may also be expressed as a non-monetary contribution to human well-being (Pascual et al. 2017).

Within the framework of regenerative design, Zari developed a process for Ecosystem Service Analysis (ESA), with the aim of determining measurable regeneration goals in the urban context. In her approach, the pre-development condition of the local ecosystem is used as a baseline for comparison, against which any new development is assessed. To some degree, the goal of a regenerative design is therefore to emulate that historical baseline as closely as possible. In contrast, the social-ecological approach to design is oriented towards a future vision that has been co-produced by the design team, community, and other stakeholders. This means that the provision of benefits by on-site ecological systems is assessed against the social-ecological goals that have been set for the development. Figure 6 shows a selection of metrics that can be used in such a future-oriented social-ecological assessment of development benefits.

Since a design is situated within a greater social-ecological system, these metrics may need to be considered at different scales. For example, a development may include a vegetable garden that produces food (an ecosystem service) and therefore contributes to meeting the basic social need for food in that community, but this is a locally-confined benefit. On the other hand, trees and vegetation on the site may sequester and store carbon as they grow, which is an ecosystem service with global benefits. Similarly, the extent to which a development improves water quantity and quality depends on its location within the watershed, and any benefits may only accrue to downstream communities.

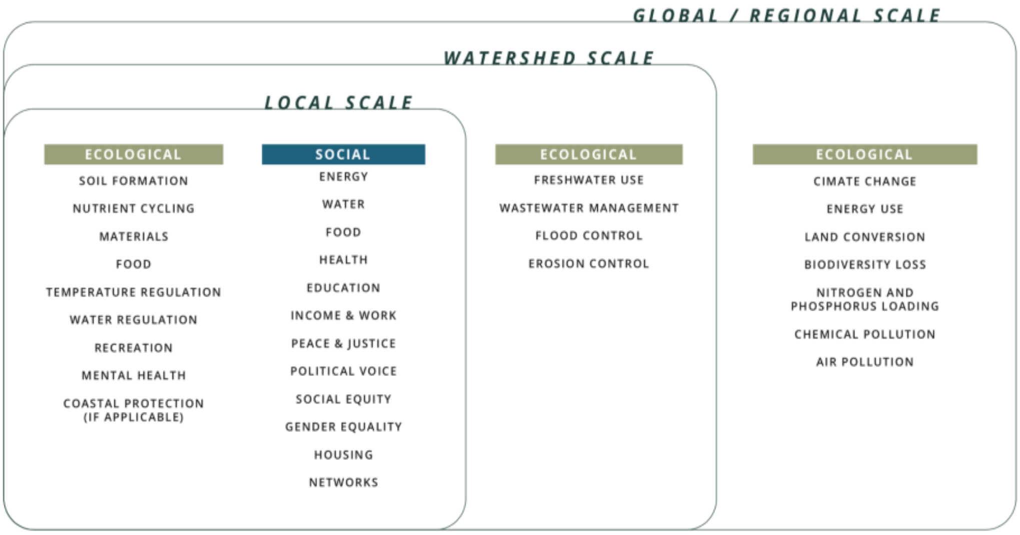

Figure6. *Social-Ecological Metrics for Development*

In a social-ecological approach, different design scenarios are therefore evaluated against the desired future state using a variety of ecosystem service and social well-being indicators. The metrics are merely a suggested starting point. When assessing scenarios for their social-ecological benefits, it is critical to remember the insight of William Bruce Cameron: “It would be nice if all of the data which sociologists require could be enumerated because then we could run them through IBM machines and draw charts as the economists do. However, not everything that can be counted counts, and not everything that counts can be counted." (Cameron, 1963) Social-ecological design must accept that design and development occur within a milieu of complex systems in space and time. Therefore, things are always changing, and the needs, limits, and goals of the development should constantly be re-evaluated. Social-ecological design is an iterative and adaptive process, which allows for adjustments to be made, thus enhancing the resilience of the development (see also next section on "Implementation").

Implementation

As a development moves into the implementation phase, it is critical to understand that there is no "end" to the process. When the construction is finished, this is just the beginning of new social-ecological relationships. Therefore, adaptive cycles are required to respond to changes and improve over time (Armitage et al. 2009; Fabricius & Currie 2015). Adaptive co-management practice should integrate building of capacity in the community as a part of the design process. As David Orr states:

"This building of eco-literacy (capacity) builds the potential for the creation of a "culture of coevolution around the project." (Urban Sustainability Learning Group, 1996 in Mang, Reed, 2012) How can the human community be sensitive, creative and aware of the social-ecological systems they occupy? This knowledge can be shared and enhanced over time to improve future operations and developments.

Future Research

The research presented here provides steps forward in refining how current practice can have a pathway to more transformative social-ecological design. Future research is needed to test the process on projects of various scales in diverse places and communities. Additional work will refine the metrics of social-ecological design and patterns of system redesign. Advancing a social-ecological design methodology - one that is sensitive to scale, adopts a systems approach, is future-oriented, and centers social needs in design has transformative potential.

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