Chapter 2
The Crisis of Civilization as an Analytical Framework

2.1 The Human-Environment System as a Complex Adaptive System

The idea of a 'Crisis of Civilization' pivots around the goal of understanding human activity as a whole. It is premised on the fact that as a single biological species, human beings share common individual and social characteristics through which they interact with each other, with other species, and with the biophysical environment.

Global civilization constitutes the full mechanism of social organization by which this nexus of activities and interactions operates.

I use a 'Crisis of Civilization' framework to examine multiple, seemingly disparate global and local crises. This does not obviate the specific and distinctive dynamics of those crises, but permits examination of how these crises interrelate with one another in the context of the overarching global system of which they are part.

The theorization of human civilization as a "complex adaptive system" derives from the application of complex systems theory as developed in relation to biological systems and ecosystems (Kauffmann; Dyke; Homer-Dixon; Diamond). A rich and dense literature demonstrates that complex systems are found across the natural sciences in physics, chemistry, and biology (Ross and Arkin 2009), as well as in ecology (May et al. 2008) and economics (Farmer et al. 2012).

A system exists whenever a plurality of entities subsists in which each entity functions in some sort of relationship with the others. A *complex* system exists when the relations between these parts leads the system as a whole to display emergent properties and behavior which cannot be reduced solely to the nature of its different parts and their relationships. Those emergent properties can be codified as overarching rules that characterize the system's structure as a whole. In some cases this can be done mathematically, although this is a less useful approach when examining human societies.

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A *complex adaptive* system exists when the system as a whole is able to adapt—to generate a collective shift in its internal behavior in order to survive. Thus, while the relations between parts of a system generates the emergent structures that comprise the system as a whole, those relationships are, in turn, restrained and enabled by those wider structures. This circular relationship is integral to the system's capacity to adapt to new environmental conditions. In time this is done by evolution; more immediately this can be done by behavioral changes or species shifts.

Equally, due to the nested and interconnected nature of the components of a complex adaptive system, small perturbations in one part can have ramifying effects on other parts of the system, depending on how they are connected. This sort of internal positive feedback process means that the overall structure of a system can be greatly impacted by seemingly random occurrences—those structures can either be reinforced or undermined by these internal feedback processes.

When such internal feedback processes reach certain thresholds, or 'tipping points', they can induce fundamental re-ordering of key structures in the system as a whole—the convergence of multiple tipping points, in turn, can generate a system-wide adaptive cycle of re-structuring, a 'phase shift', through which the system undergoes a transition to a new equilibrium (Holling 2001).

The human-environment system is complex and adaptive because it represents a historically evolving civilizational form comprised of a vast interlocking array of nested sub-systems, including some from the earth's geology, resources, oceans, and atmosphere; multiple living and non-living ecosystems across these domains; and human systems, comprised of psychological, cultural and ideological fields, relations of production and associated modes of energy extraction, technological and economic systems, and political structures.

Thus, the 'Crisis of Civilization' framework is a systems approach that attempts to analyze the complex interrelationships between multiple global crises and human activities as a whole, thus understanding them not simply as discrete crises and activities in themselves, but as component factors of a wider global human-environmental system with its own emergent properties and behaviors.

This approach recognizes that each of these crises pertains to a specific sub-system in itself, with distinctive features and patterns of behavior, but equally recognizes that each of these sub-systems do not exist in isolation. Rather, their mutual interrelationship generates emergent patterns characterizing the system as a whole. Those emergent structural features, in turn, exert causal regulatory effects that shape, enable and constrain the behaviors of the sub-systems.

A systems approach thus views particular crises and associated human activities as discrete sub-systems which are, nevertheless, inherently interconnected as sub-systems in an emergent human-environmental system, captured through the concept of a world-scale human civilization. It is in this respect that the 'Crisis of Civilization' as an analytical framework is able to systemically locate multiple crises as interconnected features of a wider world-scale crisis in human civilization as an emergent macro-structure. By integrating detailed trans-disciplinary examination of crisis sub-systems with analysis of their systemic interconnections within the world-scale human-environment system, a much clearer picture of the precise drivers, dynamics and potential trajectories of these crises is possible. This permits discernment of a birds-eye perspective of overall civilizational structures and their emergent direction.

Examining human civilization as a complex adaptive system, therefore, permits multiple global crises to be understood through the lens of a range of powerful concepts with solid empirical basis in the biophysical sciences—the thresholds and tipping points of feedback processes; how interconnections between different crises can generate amplifying feedbacks with the potential to accelerate the breaching of tipping points; the extent to which different crises can be seen as properly systemic—that is, related fundamentally to the key global structures integral to the prevailing dynamic of human civilization; and how these crises relate to the system's adaptive capacity, in particular, whether they are generating a major 'phase change' in the system itself.

In particular, this allows analysis of human civilization to return to a scientific framework defined by the thermodynamics of the fossil fuel system, and the evolution and adaptation of species, bringing in critical insights from the physical and natural sciences that can inform the development of robust historical and sociological theories.

2.2 The Energy Metabolism of Human Civilization

Applications of complex systems approaches to social, environmental and economic phenomena have largely neglected the most fundamental factor in the evolution and adaptation of complex systems: energy metabolism.

Extensive research in the biological and ecological sciences demonstrates that an organism's relation to the environment is mediated fundamentally through the mode and manner by which it extracts energy from the environment, to maintain and improve its distance from thermodynamic equilibrium. Living systems extract free energy from the sun, store it, and use it. Further, they can reproduce as well as collect, process, and exchange information in order to control and direct energy and matter they receive from their environments (Terzis and Arp 2011; Hall et al. 1992).

According to the Second Law of Thermodynamics, physical systems display a tendency to dissipate energy and thus transition from states of order to increasing disorder. Therefore, physicist Erwin Schrödinger defined a living system as an embodiment of "negative entropy" as they "extract order" from their environments to survive, adapt and evolve. (Schrodinger 1944)

A living system or organism is thus defined by its ability to store energy under energy flow, before dissipation. It develops, maintains and reproduces, or renews, itself by mobilizing material and energy extracted from the environment, which is stored internally through cyclic non-dissipative processes coupled to irreversible dissipative processes. This permits the organism to survive precisely through the consumption and ordering of energy within systemic biological processes organized through genetic information protocols. The capacity to extract, store and mobilize stored energy is therefore integral to a reproducing life cycle. Eventually, of course, the energy must be irreversibly dissipated as required by the Second Law. But the increasing complexity of a living system is related directly to its capacity to extract, store and mobilize stored energy, and to thereby stave off the thermodynamic dissipation of energy. (Ho 1999)

Organisms which successfully adapt to changing or challenging environmental conditions do so through the superior processing of information about those external conditions through genetic modification, reflecting increased efficiencies in energy extraction, storage and mobilization in relationship with the environment. (Schneider and Kay 1994)

The thermodynamics of living systems applies, of course, not just to any single individual organism, but simultaneously to collections of organisms inhabiting specific environments. While human beings are the most advanced—that is, complex—biological organisms known to science, human civilization constitutes a complex adaptive system which has been able to maximize energy extraction, storage and mobilization from its environment far more efficiently and powerfully than ever before. The astonishing complexity of human civilization is related directly to its capacity to harness energy from the environment through numerous sub-systemic processes of social organization, thus maintaining increasing distance from thermodynamic equilibrium (Odum 1994).

This framework allows for a more complete empirically-grounded theorization of what the contemporary escalation of global environmental and economic crises entails for the current trajectory of human civilization. Over its historical evolution, human civilization has demonstrated a relationship with its environment involving escalating energy use and energy dissipation, with wide-ranging consequences for the stability of the global human-environment system.

Social power is an organic constitution grounded in an exploitative relationship with nature by which energy is extracted from natural resources, transformed into a commodity (through production) and eventually consumed. Energy is thus the very condition of production—but to examine the fluctuating relationship between the two requires the recognition of social power through *property*: that is, the way access to land, resources and technology to enable energy production is mediated through property rights, which in turn are related to configurations of class (Wood 1981; Aston et al. 1987; Rioux and Dufour 2008).

It is therefore necessary, in examining the energy trajectory of human civilization as a whole, to investigate inequalities in social power and class in the context of differentiated access to land, resources and technology between various human groups, and how this relates to the thermodynamics of energy as applied to human society as a complex adaptive system. This will enable us to properly grasp the processes of extraction, transformation and consumption of energy through labor, and varying relationships between society, labor, technology and natural resources, that are integral to diagnosing human civilization's current predicament (Foster et al. 2010; Hall and Klitgaard 2012).

The historical development of human civilization illustrates an accelerating trend in global net energy production driven by a series of increasingly sophisticated technological breakthroughs, each linked to fundamental shifts in the human-environment relations and corresponding socio-political and economic systems of organization. These civilizational phase-shifts toward more complex forms can be conceptualized in multiple overlapping ways.

These phase-shifts have encompassed fundamental transitions in the energy metabolism of human societies—in terms of both the types of energy extracted, and the relations of production by which this energy is extracted, stored and mobilized in society through the creation of goods and services. These energy sources include our own muscle and that of animals, as well as wood, wind, water, coal, oil, and nuclear power (LePoire et al. 2015). The relations of production accompanying these phase shifts have included the following social-property relations: hunter-gatherer, nomadic, pastoral, agrarian, feudalism, slavery, agrarian capitalism, industrial capitalism, and neoliberal finance capitalism, which is rapidly moving to a new phase of late capitalism predominated by information technology and artificial intelligence (Ahmed 2009).

It is also important to note that each new phase-shift does not necessarily constitute a clean break with previous shifts, but in the course of increasing complexity often builds on or incorporates older structures within a new, wider structural context. One useful way of understanding this process in an evolutionary fashion is through Arthur Koestler's concept of nested self-organizing hierarchical systems which successively incorporate less complex systems to create higher scales of overarching complexity (Pichler 1999).

While the latest phase shift of neoliberal finance capitalism has been able to generate an unprecedented level of wealth within the system, it has simultaneously developed an unprecedented degree of global inequality between the core—consisting of a transnational nexus of class power centred in the former G8—dominating the world's productive resources including energy, raw materials, military and information technology; and the periphery—whose countries remains largely subordinated to the global structures institutionalized by the core (Ahmed 2009; Tainter 1990).

2.3 The Physics of System Failure

Today, human civilization under late capitalism maintains its increasing distance from thermodynamic equilibrium via the throughput of vast quantities of increasingly depleted fossil fuel reserves, along with other finite and increasingly scarce resources such as metal ores, radionucleotides, rare earth elements, phosphate fertilizer, arable land, and fresh water (Nekola et al. 2013).

One indicator of the system's growing complexity today is the measure of material throughput, or economic growth—Gross Domestic Product (GDP). Under capitalist social-property relations, GDP must continuously increase through the maximization of private sector profits, simply for businesses to survive in the competitive marketplace and for the economy to maintain its ability to meet the consumption requirements of a growing population. However, as the complexity of human civilization has advanced, the continual growth in material throughput is correlated with an escalating rate of depletion of energy and raw materials, as well as an acceleration in the dissipation of energy through intensifying greenhouse gas emissions.

Robust scientific assessments now demonstrate that the continuation of those biophysical processes of environmental degradation in a business-as-usual scenario will, before the end of the twenty-first century, fundamentally undermine the biophysical basis of human civilization in its current mode of material organization and structural complexity. Further, the uncontrolled energy releases generated by these biophysical processes are manifested in climate change, extreme weather events, and natural disasters (Earth System Disruption); and drives geopolitical competition, social unrest, and violent conflict (Human System Destabilization).

These manifestations of dissipative energy release can be seen as distinctive feedback processes resulting from human civilization's accelerating exploitation of fossil fuel energy sources within the context of the biophysical limits of the environment. In turn, these two strands of systemic feedbacks—Earth System Disruption (ESD) and Human System Destabilization (HSD)—are occurring within a single, overarching human-environment system, and thus are already inherently interconnected, therefore feeding back into each other.

This mutual feedback process creates an amplifying global systemic feedback in which: (1) ESD drives HSD, which in turn generates 'security' issues perceived through the lens of 'threat' and 'risk' analysis; (2) this invites traditional securitized human responses that focus on the expansion of existing military, political and economic power to stabilize existing structures of authority and advance prevailing mechanisms of energy extraction and mobilization; (3) the entrenchment and expansion of existing structures undermines human civilization's capacity to pursue structural modifications to ameliorate, mitigate or prevent ESD, thus intensifying ESD; (4) the feedback process continues as ESD drives further HSD.

The trajectory of this amplifying global systemic feedback, carried to its logical conclusion and assuming no intervening shift, is simply the protracted, cascading collapse of human civilization in its current form toward increasingly less complex, and therefore less resource-intensive configurations, corresponding to available resources and constrained within the environmental limits imposed by accelerating climate change (Tainter 1990).

Within this amplifying global systemic feedback, one fundamental obstacle to the systemic restructuring required to avert this outcome is knowledge access, distribution, and processing. In much the same way that an integral factor in an organism's capacity to adapt to changing environmental conditions is its genetic ability to absorb environmental information and process it through genetic modification that can result in new adaptive biological configurations, human civilization must be capable of absorbing and processing accurate information about the human-environment system, and converting this into actionable knowledge, in order to be empowered to enact the key structural modifications capable of effecting a phase-shift to a more stable adaptive configuration in relation to the Earth System.

The difference here, of course, is that while evolutionary biological genetic modification is a question of random mutations, human civilization consists of a collection of conscious agents who can make deliberative decisions on the basis of the information available to them, which must be integrated into knowledge that is capable of informing adaptive behaviors. This raises the question of a pivotal system-wide structural deficiency in the knowledge processing capacity of human civilization. In short, inaccurate, misleading or partial knowledge bears a particularly central role in cognitive failures pertaining to the most powerful prevailing human political, economic and cultural structures, which is inhibiting the adaptive structural transformation urgently required to avert collapse. The most obvious locus of this global systemic information deficit is, of course, the global media system—or perhaps more accurately, the Global Media-Industrial Complex (GMIC), and related organs of communication and transnational information dissemination. The GMIC, in effect, currently operates as the information-knowledge architecture of human civilization.

The implications of this analysis are stark: scientific data demonstrates that the rapid convergence of multiple global crisis in coming years and decades is pushing a vast array of interconnected sub-systems toward a threshold of simultaneous tipping points. From a complex adaptive systems perspective, this feedback threshold signifies a global system that is on the brink, if not in the midst, of a fundamental phase-shift to a new structural configuration.

However, the evolutionary context of this process suggests that the nature and outcome of this global civilizational phase-shift will determine the ultimate fate of civilization. Rapidly changing environmental conditions and the escalating breach of biophysical limits are compelling human civilization to either adapt through fundamental structural reorganization, or face a cascading and uncontrolled series of structural regressions.

In the following sections, the theoretical architecture laid out here will be elaborated more precisely with respect to empirical data across the sub-systems of energy, mineral resources, climate, the economy, food production, and civil unrest.

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