Adaptive cycles in archaeology. Indicators of change and stability in socio-economic systems.

Introduction

Change is an omnipresent, inherent feature of socio-ecological systems, in the past as much as today. Change encompasses the manifestation of emergent properties at differing rates, scales and impact onto human society and its environment (Garnsey and McGlade 2006). The adaptive cycle framework was developed in ecology and resilience studies to construct a theory of adaptive change in socio-ecological systems. In this chapter, I will evaluate the potential of adaptive cycles as a heuristic device to structure and interpret archaeological data, with the aim of understanding the nature, drivers and consequences of social change. The case study will cover archaeological proxies for socio-economic organisation and technology in Sagalassos and the surrounding micro-region (southwest Anatolia) during the Iron Age to late Hellenistic period (10th to 1st c. BCE). In this chapter, I will use archaeological indicators for the organization of labour, resource exploitation, specialization and distribution, to trace long-term patterns of stability and change in socio-economic organisation and technology, as well as human impact on the environment.

Theories of change and stability

Metaphors and models

As archaeologists, our primary goal is to understand people and societies in the past. We ask ourselves how and why change happened, or did not happen. To study change and stability in the past, we use heuristic devices to guide our thoughts, ask questions, and construct interpretations. Potential heuristics include theories, methods, metaphors, and models. Every discipline has its own set of heuristic devices to answer its research questions. These heuristics are part of a set of background theories (Turner 2007) that inform the standard “ways of doing and thinking”. Strong immersion in the background theories of a field can amplify knowledge by producing new ways of thinking. It also facilitates finding connections with complementary fields and stimulates interdisciplinary collaborations. At the same time, limiting oneself to the prevalent ways of thinking can lead to entrenchment of thoughts, reducing the potential range of questions and stifling innovative ways of answering them.

The topics and questions that constitute a given field, as well as the set of heuristic tools that are used to address them, have been described by the philosopher of science Adrian Currie as this field’s epistemic situation and epistemic resources (Currie 2018). An epistemic situation can be defined as the inherent challenges scientists face when generating data and the epistemic suitability of a given framework to capture phenomena of interest. Epistemic resources are the knowledge, capacities, evidence sources and methodological tools available to scientists to study a given epistemic situation. True interdisciplinary progress can only be made when solid embedding in the background theory of the own field is creatively combined with relevant background theories from other fields, providing epistemic resources that match a given epistemic situation.

In line with the interdisciplinary nature of this volume, this chapter focuses on the potential of interdisciplinary cross-fertilization for studying change and stability in the past. To do so, I will first look at different modes of transposing ideas and theories between disciplines. Andreas Wimmer (2006) identified four modes of cross-disciplinary concept migration: tool transfer, methodological analogy, model migration, and metaphor move.

I will focus here in particular on the latter two. Model migration entails the transfer of the theoretical propositions and empirical terms of a model into a new situation. One example is the application of general systems theory, developed by the Austrian biologist Ludwig von Bertalanffy (1901-1972) to use the properties of open systems as developed in physics to study biological systems. This type of model was later adopted and applied to a wide range of disciplines such as sociology, psychology, sustainability science, and earth sciences.

Metaphor moves are used to illustrate complex processes or models in a novel way. A metaphor can be generally defined as an illustrative device in which a term or imagery is taken from one frame of reference and used within another.[1] Metaphors work by highlighting those elements of an empirical object that are difficult to understand intuitively, and linking these to the properties of the metaphorical image. One example of a metaphor frequently used in complex systems theory is the butterfly effect. The term was popularized by the American meteorologist and mathematician Edward Lorenz (1917-2008). It uses the image of the metaphorical flap of the butterfly's wings in the tropics causing a tornado in Texas to illustrate the far-reaching effects of seemingly small causal factors in complex systems.

Both of these heuristics have their own scope and explanatory potential. A metaphor can be potentially applied to a wide range of cases but provides less detailed insight into the workings of these systems. A mathematical model, on the other hand, can only be applied to specific cases for which it is valid, but allows us to exactly trace the dynamics of those systems. Interdisciplinary research therefore requires creative combination of background theories by using the proper mode of cross-disciplinary concept migration. It is absolutely essential when transposing concepts or ideas from one discipline to the next, that we are aware of its original role as a heuristic device, and thus of its scope and explanatory potential.

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[1] A definition going all the way back to Aristotle (1457b6-9).

In this chapter, I focus on the concept of adaptive cycles. Critics of the framework have denounced its usefulness given the general nature of the dynamics it can potentially describe and its perceived tendency towards oversimplification of complex dynamics. Some have even called the adaptive cycle a ‘mere’ metaphor for system change (Gotts 2007).

Two points can be raised in response to these critics. First, while the description of the adaptive cycle as a ‘mere’ metaphor of change might have been meant in a derogatory way, this need not necessarily be a bad thing in its own right. Metaphors can be useful heuristic devices when used properly and should not be disregarded out of hand. Even though they are often dismissed as no more than ‘rhetorical window dressing’, metaphors can play an important role in innovative thinking and reveal potentially fruitful connections and novel ways of seeing that lead to new insight (Gray and Macready 2019, 129). Second, I strongly believe that the heuristic potential of the adaptive cycle concept goes beyond that of the metaphor. I will illustrate this potential in the case study of this chapter.

An interdisciplinary application of adaptive cycles entails not only transposing the outlines of the concept from one field (ecology and resilience theory) to another (archaeology), but also detailing how and why such a transposition can be performed by operationalizing the metaphor. However, we must be wary of ill-informed cross-disciplinary exchanges, particularly for the dangers of misspecification, irrelevance and misfit of concept migration (Wimmer 2006, 18). To mitigate these risks, we must first take a step back and sketch the general outlines of the original context as well as the new framework of application.

Resilience theory

Resilience theory was originally developed in psychology (Garmezy 1971) and ecology (Holling 1973). It grew as a counter narrative out of dissatisfaction with equilibrium-based models. Holling (1973, 14) defined ecological resilience as the capacity of ecological systems to absorb disturbances while retaining the same populations or state variables. In other words, the ability of systems to remain organized around the same set of processes, structures, and functions. Central to the discourse of resilience thinking is the potential of a system to mitigate disturbance or adapt to stimuli and challenges (both internal and external).

Over the last few decades, resilience thinking has attained a central position in the study of socio-ecological systems and human-environment interactions (Berkes et al. 1998; Filatova et al. 2016; Folke 2006). Resilience has also proven to be a popular concept in archaeology as we increasingly seek to participate in debates with wider contemporary relevance regarding sustainable development, long-term dynamics in coupled human-environment systems, and response options to environmental challenges (Barton et al. 2012; Redman 2005; Redman and Kinzig 2003; Schoon and van der Leeuw 2015; van der Leeuw and Redman 2002).

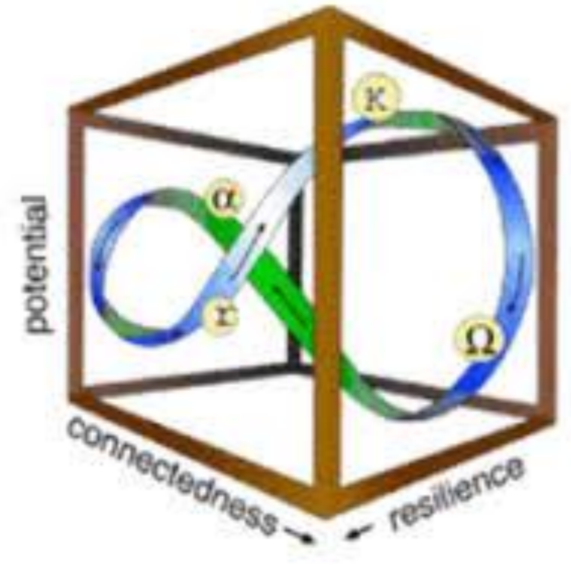


Figure 1: Adaptive cycle (Gunderson and Holling 2002).

One conceptual cornerstone of resilience theory is the adaptive cycle (Figure 1) (Gunderson and Holling 2002). Combining economics, ecology, institutional theory, and complex systems theory, it provides an integrative framework to trace change and stability in the dynamic behaviour of coupled socio-ecological systems.

The adaptive cycle describes system dynamics along three axes or dimensions: 1) potential for change, determining the range of possible options of system development though accumulated potential (in the sense of physical capital, resources, knowledge, social networks of cooperation, leadership and social trust); 2) degree of system connectedness between internal variables and processes, reflecting the rigidity of system controls; and 3) resilience, measuring vulnerability to unexpected disturbance events (Holling and Gunderson 2002, 32–33). The spatial-temporal trajectory of a system moves along these three axes through four phases: exploitation (r), conservation (K), release (Ω), and reorganization (α).

The first two phases – r and K – hail from ecology (r and K-strategists) and respectively refer to growth and conservation of the system, whereas the Ω and α phase are derived from economy and refer to the release of an increasingly integrated system and the associated loss of accumulated potential, followed by the reorganization of the system as it enters a new cycle. Dynamics in the cycle describe processes of episodic change in non-linear system dynamics. Flows move in a slow 'front' loop from r to K, inducing incremental changes and accumulation of potential (resources, capital, knowledge) within a basin of attraction, punctuated by a 'back' loop towards Ω, α, and back to r, consisting of punctuated episodes of rapid transformation that create emergent outcomes. Each part of the cycle thus results in one of two important elements of complex systems dynamics: the maximization of production and accumulation, and maximization of innovation (Holling and Gunderson 2002, 47).

It is important to note, however, that not all systems need necessarily pass through the various phases of the cycle in the exact same order (Aimers and Iannone 2013, 26–27). In some cases, an r-phase may jump directly into a reorganization phase. For example, when a given socio-ecological system cannot sustain existing levels of development or an unexpected situational event induces an impact of such a magnitude that the existing system structures cannot cope with it (*i.e.* a societal collapse event). In other instances, an α-phase may stimulate additional reorganization as the system is unable to settle on a new suitable configuration. Systems in a K-phase may also shift directly into an α-phase, thus avoiding an Ω-phase release, for example, a sudden shift to a democratic government from a totalitarian regime.

A socio-ecological system typically consists of multiple interlinked adaptive cycles. Such a hierarchical sequence of semi-autonomous, interconnected cycles has been termed a panarchy (Gunderson and Holling 2002). Each adaptive cycle represents a functionally distinct level moving at specific speeds within an integrated system. Larger cycles generally move slowly and provide the stability that permits fast-moving cycles on lower scales to pass through release and reorganization while the overall system maintains similar functions, *i.e.* stays within the same basin of attraction.

Conversely, coordinated releases at small and fast scales may, in cascading fashion, trigger releases at larger scale cycles, especially if these are at that time in the K phase characterised by low resilience. This cascade precipitates potential shifts into new basins of attraction at large scales (Walker, Salt, and Reid 2006). Widespread system shifts may occur when cycles on different levels are synchronized, either through tight interconnectedness in the K-phase or when entering the back loop of system reorganization simultaneously.

Adaptive cycles in archaeology

The adaptive cycle has been proposed as the lynchpin for integrated analyses of socio-environmental systems across different temporal and spatial scales, bridging the gaps between archaeology, the geosciences and cultural anthropology (Widlok et al. 2012). It was also put forward as a catalyst for the implementation of resilience theory in archaeology, which would allow archaeologists to be more active participants in debates on contemporary issues such as climate change and sustainability (Redman and Kinzig 2003).

The potential of adaptive cycles as a conceptual framework in archaeological research has gradually gained recognition and an increasing number of applications are published (A small selection: Aimers and Iannone 2013; Daems and Poblome 2016; Gronenborn et al. 2014; Nelson et al. 2006; Redman and Kinzig 2003; Thompson and Turck 2009; Widlok et al. 2012; Peters and Zimmermann 2017). Applications cover a range of topics such as the formation and disbandment of human groups, economic systems, settlement patterns, material production, agricultural subsistence, trade networks, population movements, and more.

A recent thematic issue of *Quaternary International* was dedicated to the topic of adaptive cycles (Grimm, Riel-Salvatore, and Bradtmöller 2017), and also included an excellent overview of applications of resilience theory and adaptive cycles in archaeology (Bradtmöller, Grimm, and Riel-Salvatore 2017). This review identified the use of four main proxies of socio-ecological systems: subsistence, demography, social organisation, and technological innovation. Each of these proxies is then studied through a number of attributes. If we take the example of social organisation, scholars have looked at forms of social control (Allcock 2017; Nelson et al. 2012; Weiberg 2012), social interaction networks (Cooper 2012), and social mobility (Peters and Zimmermann 2017; Zimmermann 2012). Identifying archaeological proxies for the dynamics of adaptive cycles is part of the operationalisation of the framework, which will be discussed in the next part.

Operationalising the adaptive cycle framework

The transposition of the adaptive cycle framework from ecology and resilience thinking to archaeology is not straightforward and caution has been advised:

> "Although animal body mass and the functions a species provides, appear to incorporate many of the most critical elements of system structuring and system resilience, it is unknown what archaeological variables reflect the core processes and functions present in human social systems, and whether the archaeological material culture available to researchers, such as pottery styles, sufficiently represents the key scaling processes structuring human societies." (Sundstrom et al. 2014, 6936)

Others have noted that the adaptive cycle model can offer a useful heuristic for understanding established archaeological patterns (Freeman, Hard, and Mauldin 2017, 85). The added value of the framework lies in its potential to conceptualise multi-scalar interactions in archaeological studies. Adaptive cycles can offer a high-level epistemological framework to coherently integrate various strands of theory to describe and understand processes, structures, and variables of complex systems. In this part, I will outline how the adaptive cycle framework can be operationalised specifically for the analysis of socio-economic systems.

Linking back to the introduction, we need to acknowledge that the application of adaptive cycles is tapping into a new set of epistemic resources for the epistemic situation of studying the past. However, given that our goal is to study past human-environment interactions, these heuristics are inherently epistemologically suitable. The rich literature of adaptive cycles in archaeology provides abundant testimony that this suitability is generally recognised.

Epistemological suitability alone does not guarantee a successful transposition. Many applications make the mistake of directly applying a new framework from one field to another without properly adjusting it to the empirical situation of the field. In many cases, this boils down to the imposition of new concepts onto existing archaeological phase models (Bradtmöller, Grimm, and Riel-Salvatore 2017). This lies at the heart of the common criticism of the adaptive cycle as "metaphor of change" rather than an empirically sound model. What is needed is a context-driven operationalisation of the epistemological tenets of adaptive cycles to match empirical archaeological data.

To exploit the full utility of the adaptive cycle as an overarching framework, disciplinary-specific theories are needed to explain causes and effects of system dynamics in specific cases (Abel, Cumming, and Anderies 2006). I will address this problem by building a multi-level theoretical framework. To properly construct this theoretical operationalisation, I will employ the concept of middle range theory (MRT). MRT was first used in archaeology by Lewis Binford (1977) to denote ways of bridging the ever-changing behavioural dynamics of human societies in the past with the static archaeological record today. The term was coined by the sociologist Robert Merton to denote a set of theories that lie between working hypotheses in day-to-day research, and the all-inclusive systematic efforts to develop a coherent theory that explains uniformities of social behaviour, organization and change (Merton 1968, 39). I will use MRT in the original sense proposed by Merton as a set of intermediate theories, bridging the high-level systemic theory of adaptive cycles with base-level archaeological proxy data. These theories need to account for change and stability in potential and connectedness as related to the resilience of the system and the four phase changes (r, K, α, Ω) of the adaptive cycle.

In this chapter, I will focus on change and stability in socio-economic systems of material culture production and distribution, covering resource exploitation, production organization, specialization, and exchange. Given this focus, the first place to look for suitable middle range theories for this case study (Figure 2) is in economic theory and innovation studies.

Phase	Process	Middle range theory	AC Parameters
r	Niche construction	Niche construction theory	Potential
r	Resource diversification	Niche construction theory	Potential
r	Division of labour	Agglomeration economies	Connectedness, Potential
r	Increasing returns to scale	Agglomeration economies	Potential
r	Economies of scale	Agglomeration economies	Potential
K	Specialisation	Agglomeration economies	Potential
K	Diminishing returns on investment	Agglomeration economies	Potential
K	Pathways of development	Path-dependency	Connectedness
Ω	Creative destruction	Creative destruction	Connectedness, Potential
α	Self-organization	Complex systems theory	Connectedness
α	Recombinatory innovation	Modular recombination	Connectedness, Potential

Figure 2: Processes to operationalize adaptive cycle dynamics derived from middle-range theories.

Suitable theories to capture dynamics in the r-phase are niche construction theory (Odling-Smee, Laland, and Feldman 2003; Riede 2019) and agglomeration economies (Bettencourt, Lobo, and Strumsky 2007; Krugman 1991; Ortman et al. 2016; West 2017). For the K-phase, I will also look at agglomeration economies, as well as path dependency (Currie et al. 2016; Ereshefsky 2014; van der Leeuw 2016). The Ω-phase will be studied through the theory of creative destruction (Schumpeter 1942) and phase transitions (Scheffer et al. 2012). Finally, the α-phase will be covered by self-organization through modular recombination (Broekel 2019; Solé and Valverde 2020; Solée et al. 2013).

The r-phase is described as a phase of rapid growth, allowing the system to quickly spread into available niches, shift into new state phases or initiate new dynamics. This phase is characterised by low connectivity between system components and quick initial accumulation of potential. It is also highly resilient because of the abundance of available resources, high level of diversity, flexibility and connectivity, resulting in a robust system configuration in the face of perturbations (Aimers and Iannone 2013, 23–24; Walker et al. 2006). Associated processes include rapid movement into uninhabited or sparsely populated landscapes, population growth, and development of new technologies and food acquisition strategies (van der Leeuw 2007, 215).

Niche construction can be basically defined as a process of modification of a system's selective environment to the degree that it changes the selection pressures acting upon that system (Riede 2019). Here, I draw this body of theory out of its original context of ecological systems, and apply it to communities and societies shaping the interaction with their environment on a socio-economic level. In the r-phase, a large amount of potential for change is present to allow societies to reshape the environment to fit their aims and purposes. Reshaping the environment need not necessarily have been a rational and conscious decision taken by the community as a whole. Rather, cumulative decisions by individuals and groups to obtain specific resources from the environment, for example clay sources, may have driven a society to optimise resource exploitation strategies across an extended stretch of time.

As societies increasingly shape their environment, they enhance the flow of energy and resources that can be used to fuel its economic goals. Specialisation processes can induce agglomeration economies, driving continued growth and development through two interrelated phenomena: economies of scale and increasing returns to scale (Arthur 1989). The former refers to sublinear (that is, increasing more slowly compared to population size) cost advantages related to scale increase, whereas the latter entails super-linear increase (that is, increasing more rapidly compared to population size) of socio-economic output (Bettencourt, Lobo, and Strumsky 2007; Bettencourt 2013). Specialisation and agglomeration economies can emerge from a range of factors, but most important are division of labour and spatial clustering of people, capital and information.

As the r-phase develops into K, system dynamics slow down and the system starts to conserve existing properties rather than explore new avenues of development. The exploitation of energy and resources from the environment is typically subjected to diminishing returns on investment. This requires putting in more energy over time to get the same return output

(Tainter 1988, 194–99). As a result, the overall resilience of the system continuously decreases in order to maintain functional integrity.

In the K-phase, potential continues to accumulate, albeit more slowly and tightly bound to existing structures rather than being freely available for innovation and system development. K-phase systems exhibit less room for innovation as internal system components become increasingly interconnected and mutually dependent within self-organized clusters of relationships. Increasing interconnectedness can sometimes result in extremely high levels of integration or hypercoherence, where an increasingly smaller number of key productive strategies start to be interdependent. At this point, extreme specialisation starts to take place, relying on efficiency and process optimization, which results in increasingly narrow avenues of development to continue multiplier effects induced by increasing returns to scale.

Agglomeration economies are key in the generation and accumulation of production surpluses needed for societies to store capital and resources as buffer for future perturbations. However, because of intensification strategies, resource availability decreases and resources tend to get ‘locked up’ over time, meaning they are more tightly controlled and more expensive, for example because of elite control mechanisms (Aimers and Iannone 2013, 23–24; Davidson 2010, 1139). In other words, the cost of ‘getting things done’ grows higher over time (Walker et al. 2006, 87). Optimizing behaviour, although theoretically desirable, can be problematic in practice because in being efficient, people, communities, and societies eliminate redundancies by focusing on a specific range of values and interests. This results in a more homogenous system in terms of functions and response diversity, which can lead to a decline in flexibility and resilience (Hegmon et al. 2008; Walker, Salt, and Reid 2006, 7–8).

The K-phase is characterised by increased connectivity between system components. This connectivity is also subject to trade-offs. The benefits of high connectivity include better flow of information and decreasing response time during disturbance events, for example by mobilizing agents for collective action. However, highly connected system components also allow disturbances to propagate throughout the entire system, whereas a less connected system might have contained disturbances within particular system components.

Increased interlocking of system components may lead to a pathway of development where a system finds it increasingly difficult to break out of a set pattern because of associated sunk costs (Arthur 1989; Janssen, Kohler, and Scheffer 2003). In such a ‘rigidity trap’, the system locked into path dependent processes becomes brittle in the face of perturbations (Hegmon et al. 2008). Institutional structures are kept in place by an interlocked system of interests, even if individual devotion to the underlying values starts to wane (Parsons 1990). This process has also been described as a gradual development of institutional mismatches or maladaptation (Currie et al. 2016; Henrich 2004; Sander van der Leeuw 2016)

A system may become too rigid or maladapted to be able to deal with an unexpected disturbance event – either internally or externally induced – and the potential bounded to the interconnected components is suddenly released and becomes lost from the organizational structure. The system now moves into the Ω-phase of release. The process of slow accumulation leading up to an event of rapid destruction has also been called a tipping point (Gladwell 2000), leading to a critical transition (Scheffer et al. 2012) through creative destruction (Schumpeter 1942). The tipping point constitutes a bifurcation point, where even a minor trigger can involve a self-propagating transition into a different system state.

A system going through a release phase, will not stay there, but will move towards the α-phase of reorganization. In this phase, connectivity is at its lowest point, allowing remaining but uncoupled system components to be re-used in novel combinations induced by the remaining system potential of the previous cycle. During this process of modular recombination (technological) innovation is at its highest (Arthur 2009). This phase matches Ilya Prigogine’s observation that when complex systems are running down to simpler forms of low levels of activity, a concentration of remaining energy into focal points can create new elaborate phenomena (Prigogine 1968). As pockets of energy and information remain available, the system reorganizes and a new cycle develops. This new system may resemble its predecessor as uncoupled system components become rearranged in a system configuration strongly resembling the previous cycle, i.e. stay in the same basin of attraction, or it may have fundamentally new functional characteristics in a system that has multiple stable states.

The middle range theories described here form a bridge between high-level adaptive cycles and dynamics of change and stability in socio-economic systems. The resulting multi-level theoretical framework increases the potential of the adaptive cycle framework to adequately capture, describe and explain multiple scales of analysis.

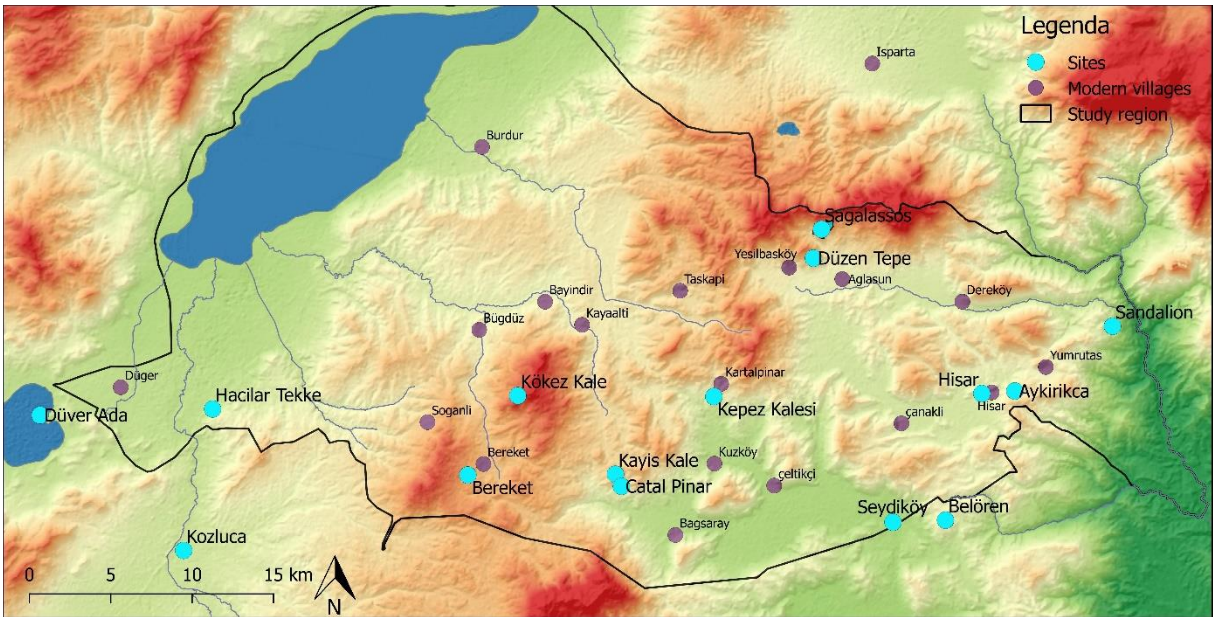
Up to this point, I have focused on general descriptions of system dynamics. It should be noted, however, that complex social systems develop on multiple scales, from micro-level human practices to macro-level polities. It is not the intention here to provide an overview of the full range of scales. Still, to understand a multi-level complex system, it is not sufficient to study one scale of analysis in isolation. The triadic structure of hierarchically-ordered scales entails that three adjacent levels need to be considered to provide a parsimonious and sufficient description of the behaviour of the middle level (Salthe 1985).

The primordial level of interest in this chapter is that of individual communities such as Sagalassos. To sufficiently capture dynamics on a community scale, I will encapsulate this level in an analysis of intra-community socio-economic practices, and inter-community interactions within the wider micro-region.

Case study: Socio-economic change and stability in the micro-region of Sagalassos

Sagalassos is most famously known as a central place in the province of Pisidia during Roman Imperial times. Its roots, however, reach farther in time, back to the late Achaemenid period (late fifth – early fourth c. BCE), when the first discernible community settled at the site (Daems and Poblome 2017; Poblome, Braekmans, Waelkens, et al. 2013). Its emergence was part of an even older trend of extensive, fortified sites located on hilltops and other elevated positions, attested in the archaeological record in the area from the ninth century BCE onwards.

Prominent hilltop sites include Kayış Kale, Kökez Kale, Kepez Kalesi, Seydiköy, Haçılar Kale and Aykırıkça (see Figure 3). Additionally, a series of small agricultural villages and hamlets have been attested in the Burdur Plain, one of the most fertile areas in the region (Kaptijn et al. 2012). These sites could be associated with Düver Yarımada, a nearby, contemporaneous site that has been interpreted as a central place and religious complex (Kahya 2015; Talloen et al. 2006). A number of smaller occupation sites have also been found in the recent Dereköy Highland survey in the eastern part of the study area (Vandam, Willett, and Poblome 2017).



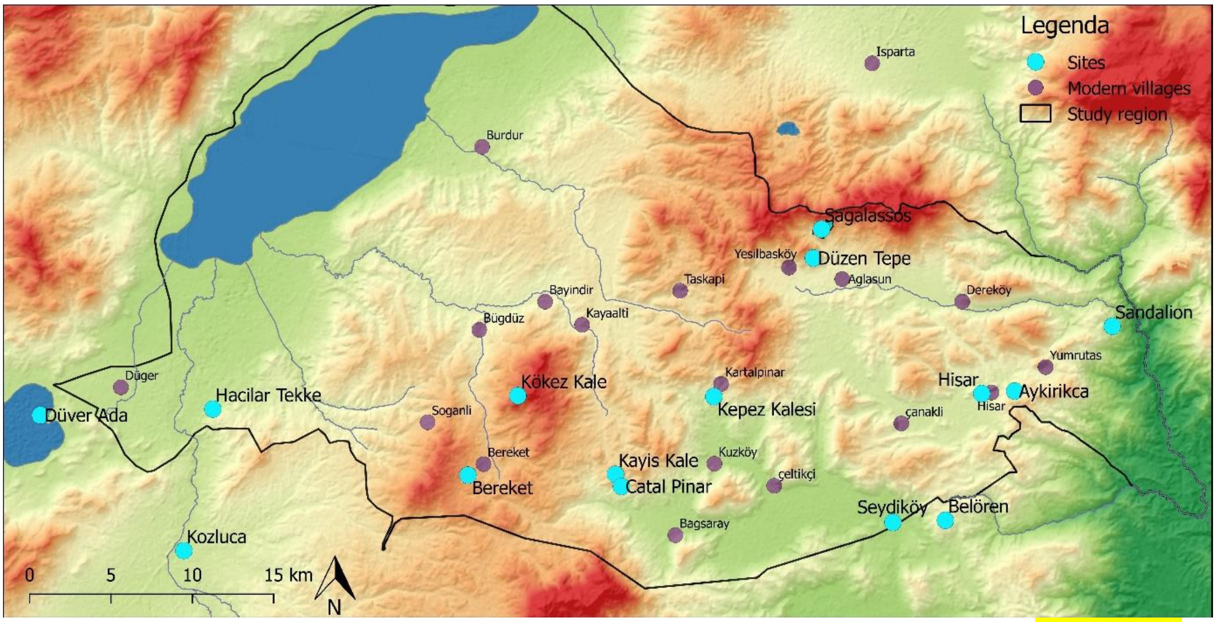


Figure 3: Map of the study area with sites and valleys mentioned in the text in blue. (placeholder: to be updated)

The hilltop sites emerging in the early Iron Age constitute the first clear archaeological evidence of human activity in the area after more than a millennium of absence during the middle and late Bronze Age (Vandam 2014). These sites can therefore quite literally be considered r-strategists creating and occupying environmental niches within the landscape.

Unfortunately, many of these sites remain understudied and are only known through collections of survey material. Detailed material studies have shown, however, that Düzen Tepe, a fortified site located on an elevated plateau overlooking the Aglasun valley – even though it was only settled from the Achaemenid period onwards – showed great similarities with these hilltop sites and could therefore be considered a proxy for community organisation in the Iron Age (Daems In preparation). Archaeological excavations and geophysical surveys conducted at Düzen Tepe, as well as extensive material studies, have suggested that this was an agricultural community with a 'locally-oriented productive landscape', focusing strongly on the immediate environment for its main subsistence, resource procurement and production processes (Cleymans, Daems, and Broothaerts In Preparation; Daems, Braekmans, and Poblome 2017; Daems and Poblome 2016; Vanhaverbeke et al. 2010).

If we extend this interpretation to the other hilltop sites, we can suggest a landscape of locally-oriented communities with a strong focus on the environmental potential of their immediate catchment area. These sizeable settlements (ranging from 1.7 to 15 ha) represented a strong tendency towards population nucleation at the time.[2]

The suggestion of locally-oriented resource exploitation is corroborated by the results of a recent study on the geochemical and petrographic composition of Iron Age pottery material.

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[2] Based on estimates by dr. Eva Kaptijn, personal communication.

Dennis Braekmans and colleagues (2017) conducted petrographic analysis of Iron Age to Hellenistic pottery using samples (n=273) taken from eleven sites, covering the major valley systems in the study area: (1) the Ağlasun valley (Düzen Tepe and Sagalassos; (2) Çeltikçi and Kuzköy valleys (Keraia, Kepez Kalesi, Aykırıkça, Hisar and Seydiköy); (3) Bereket valley (Bereket and Kökez Kale) and (4) Burdur plain (Düver Ada and Kozluca).

Thirteen petrographic groups were identified, linked to distinct provenances in the local geological substrate. Further geochemical analysis on part of this sample (n=124) and PCA of the composition identified four major ware groups based on common petrology and clay chemistry. Each of these groups could be linked to specific areas using clearly distinguishable clay sources: (A) the Burdur area (B) the Çanaklı and Ağlasun basins (C) the Çeltikçi valley (D) the central and eastern Ağlasun valley. The geochemical picture shows a clear 'compartmentalization' of the landscape, with different Iron Age communities operating within their own local environmental logic and exploiting nearby clay resources. At the same time, these communities were not isolated pockets in the landscape. Each of the thirteen petrographic groups encompassed several ware groups, occurring on multiple settlements, rather than being conclusively associated with specific sites (Figure 4).

This analysis suggests cross-valley connections in production and/or distribution systems. For example, the clays from the Ağlasun/Çanaklı basin have also been used for pottery found at Aykırıkça, Kökez Kale, Kepez Kalesi and Seydiköy. To what extent this observation can be linked to production processes taking place at one site followed by distribution to other sites, or the exploitation of similar clays by sites from different valley systems is difficult to answer at this point given the absence of clearly identified production facilities.

Petrographic groups	Sagalassos	Düzen Tepe	Hisar/Aykırıkça	Düver	Kepez Kalesi	Bereket/Kökez	Seydiköy/Belören	Hacilar	Kozluca
Calcite-sedementary	x	x	x	x	x	x	x		
Volcanic-biotite		x	x		x		x		
Volcanic-sedimentary	x	x	x	x	x	x	x	x	
Radiolarian chert						x			x
Volcanic chert	x	x	x		x	x	x		
Muscovite		x		x					
Mudstone	x	x				x	x		
Serpentine	x	x		x					
Metamorphic	x	x							
Grog-calcite	x	x	x			x	x		x
Fine-grained A		x							
Fine-grained B	x	x		x			x		
Fine-grained C	x	x			x	x			

Figure 4: Distribution of petrographic groups over sites in the research area (based on Braekmans et al. 2017).

Clear differences can be noted between the material culture from the hilltop sites in the east of the study area, compared to the Burdur Plain in the west. Pottery from the hilltop sites consisted of two main macroscopic wares: A painted buff ware and a slipped/burnished grey ware. The painted wares were decorated with a range of geometric motifs, including concentric circles, cross-hatched triangles, semicircles, fishnet patterns, bands and wave lines (Figure 5).

This type of pottery has been attested at several sites, including Hacılar Tekke, Aykırıkça, Seydiköy, Kepez Kalesi, Kayiş Kale, Kökez Kale and Çatal Pınar. The grey ware was attested among others at Kökez Kale, Kayiş Kale, Seydiköy, Kepez Kalesi.

Figure 5: A selection of Iron Age material from the study area.

Whereas similar material has also been found in the Burdur plain, other wares have been attested that seems to point towards connections with supra-regional networks. Most notably, the presence of large amounts of so-called Black-on-Red (BoR) ware and other painted wares typical for southwest Anatolia (Figure 6) can be noted (Mellaart 1955). BoR pottery at Düver Yarımada and other sites in the Burdur Plain has been attested both as imitations using local clay sources, as well as more fine-grained imports with a supra-regional provenance. While not altogether absent, this ware is far more rare elsewhere in the area, being only sparsely attested at Kökez Kale, Seydiköy, Aykırıkça and Kepez Kalesi. Moreover, clear differences in the fabrics suggest that these were exclusively local imitations.

Interestingly, one sherd found in the Burdur Plain (Figure 6, top right) has been identified as ‘Corinthian’ ware (early sixth century BCE).[3] This isolated find need not be interpreted as evidence of a direct trading link with mainland Greece or the Aegean, but is nonetheless indicative of the participation in wider networks of interaction and exchange of goods and ideas.

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[3] Personal communication with dr. Cornelis Neeft.

Figure 6: A selection of Iron Age pottery from Düver Yarımada and the Burdur Plain.

The explanation for the prominence of Düver Yarımada and the Burdur Plain may be found in their location along a series of important natural connections and avenues of communication (Poblome, Braekmans, Waelkens, et al. 2013). On the one hand, it was part of the east-west connection between the Burdur Plain and the valleys to the west, centred on modern-day Denizli. On the other hand, this east-west connection transitioned into the major north-south corridor connecting the Anatolian highlands with the Pamphylian coast, through the Burdur-Fethiye corridor. The prominent position along a large agricultural plain, would have allowed the community of Düver Yarımada to exploit sufficient resource potential to sustain a significant settlement, whereas its location on a key node within these major avenues of connectivity, might have allowed the community to tap into wider developments connecting supra-regional networks of exchange connecting the Mediterranean with the Anatolian inland. This hypothesis is corroborated by the attestation of comparably extensive amounts of Black-on-Red pottery at Panemoteichos, a settlement towards the south also located at the edge of a fertile plain along the natural thoroughfare to the Pamphylian coast (Aydal et al. 1997, 151–52).

It can be suggested that Düver Yarımada acted as some sort of a central place for the micro-region. What this meant for the relation with the hilltop sites in the east of the area is not clear. It has been suggested that these hilltop sites could perhaps be considered part of an integrated settlement system as dependencies of the principalities in the Burdur Plain area, providing strategic control over these thoroughfares (Poblome, Braekmans, Waelkens, et al. 2013). For now, this hypothesis cannot be readily tested.

To sum up, the overall picture of Iron Age communities in the study area is one of interconnected hilltop sites exploiting distinct niches within the micro-regional landscape. In addition to this internal connectivity, a more extended supra-regional connectivity has been observed at Düver, which likely acted as a central place at this time, and other sites in the Burdur Plain. The observed trend of gradually occupying different parts of the landscape fits well with an ongoing r-phase characterised by niche construction and resource diversification. The observed interconnectedness – both on a micro-regional and supra-regional level – can perhaps be considered indicative of an initiating transition towards the K-phase.

The trend of niche creation and diversification continued into the Achaemenid period, most notably seen in the emergence of Düzen Tepe and Sagalassos in the Ağlasun valley. Up to this point, community formation seems to have only taken off – be it out of concerns for security or other reasons – on elevated positions in the landscape. From the late Achaemenid and early Hellenistic period onwards, we see for the first time a shift in settlement patterns as settlement locations were increasingly shifting towards areas in lower elevations. Several smaller hamlets and farmsteads emerged across the Ağlasun valley landscape, indicating also a shift from a strongly nucleated settlement pattern towards a more dispersed population. Given that Düzen Tepe, as well as Sagalassos most likely, with an estimated population of about 1000 people (Cleymans, Daems, and Broothaerts In Preparation), were sizeable communities (15 ha) in their own right, it is possible that this dispersal was the result of population growth.

At first sight, this could be interpreted as a direct continuation of the trend towards diversification of settlement locations initiated back in Iron Age times. However, looking at evidence from the available environmental data, a different picture emerges. This data suggests that what we see is actually a reorganisation phase (α) of the settlement pattern following a release phase (Ω) of the local landscape.

If we look at the palynological data, we see a clear shift in the pollen diagrams during the Iron Age. Most notably, *Cerealia* type pollen and other secondary anthropogenic indicators (e.g. *Artemisisa campestris* L.) increase markedly, along with deciduous and evergreen oak (Vermoere 2004). This shift has been associated with the onset of the Beyşehir Occupation Phase which favoured agricultural and arboricultural production at higher altitudes (Bakker et al. 2012; Kaniewski et al. 2007).

Non-metric multidimensional scaling was applied to the 8 available pollen data sequences from three valleys (Bereket, Gravgaz and Ağlasun) across the study area to elucidate vegetation changes through time as a proxy for the overall human impact on the landscape

[BROOTHAERTS ET AL. In prep]. Results show that human impact, consisting of an increase in human indicators as well as forest taxa, markedly increased in the middle Iron Age (8th – 6th c. BCE) (Figure 7). These data seem to corroborate increased human impact through exploitation of additional environmental niches and associated resources in the landscape.

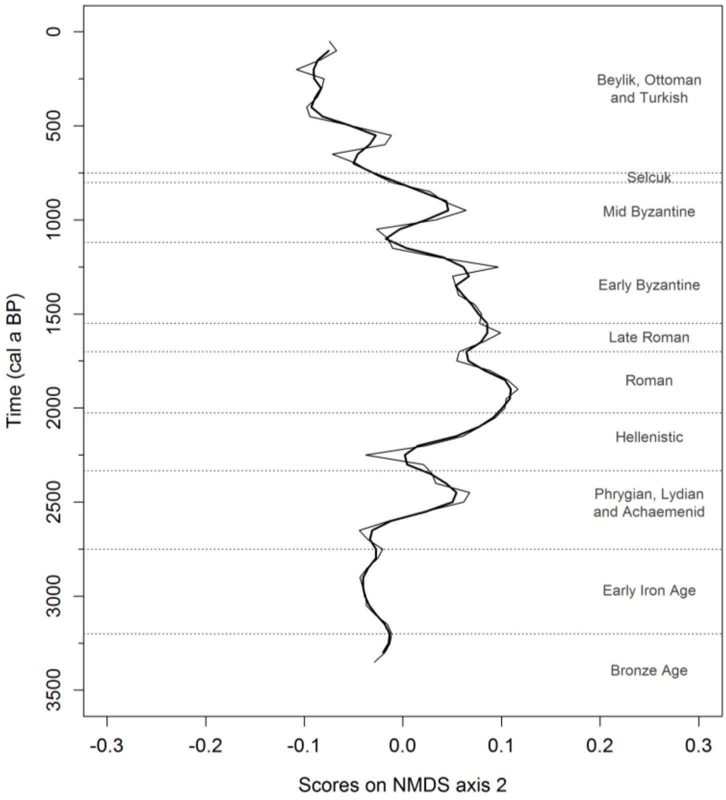

Figure 7: NMDS scores of pollen data as proxy for human impact (Broothaerts et al. In prep.).

According to a model of soil erosion developed for the Gravgaz valley, a decrease in pine forest cover induced a strong erosion phase around 700 BCE (Van Loo et al. 2017). Prior to this erosion phase, the local environment was characterised by a high resilience as soils were well developed and extension of cultivated areas was low. It is likely, however, that population concentration in nucleated hilltop sites, with a strong focus on available resources in the immediate vicinity of the site, had a major impact on their environment through significant exploitation of its energy and resources. It can be suggested that this intense exploitation initiated forest clearance leading to erosion on the higher hillslopes (Van Loo et al. 2017). This eventually led to a decrease of soil depths on the slopes, but also resulted in sediment accumulation in the valley, resulting in the creation of large fertile areas suitable for crop cultivation. The strain imposed on the landscape by the hilltop sites exceeded local resilience, inducing a release of the available potential (soil depth) and reorganization into a new stable state (sedimentation leading to more fertile circumstances in lower areas).

From the combined archaeological and environmental data it is clear that the impact of Iron Age communities on their environment created the conditions and potential for new niches in the landscape to be exploited, resulting in a more diversified settlement pattern. At the same time, these communities did not completely deplete the potential of their catchment, given that many hilltop sites continued to be inhabited until Hellenistic times. The reorganisation of local system configurations should not be considered a collapse of local environmental niches, but rather a transition into a new equilibrium with a shifting focus towards the lower valley areas.

The new adaptive cycle initiated in late Achaemenid – early Hellenistic times, was increasingly focused on the lower hillslopes and valley bottoms, being the most fertile areas in the local landscape at this point. Sagalassos was among the communities profiting most from the new opportunities, transforming from one village among many, to the primary urban centre in the area during the early Hellenistic period. It most optimally succeeded in creatively combining properties of existing system dynamics, with the potential of new opportunities. On the one hand, it originated as part of the prevalent system of hilltop sites, focused on elevated and easily defensible settlement locations. On the other hand, it retained a comparatively easy access to the lower hillslopes and the Ağlasun valley, thus being in the unique position to exploit the potential generated by the new cycle that was initiated at this time.

A significant trajectory of development occurred at Sagalassos from the late third century BCE onwards as it turned into what could be considered a polis in the sense of a politicised community centred on an urban settlement. It developed some form of political constitution and codified law system in the second half of the third century BCE (Vandorpe and Waelkens 2007), followed by the initiation of civic coinage minting between the last quarter of the third century and the first decades of the second century BCE (Van Heesch and Stroobants 2015), and the construction of monumental public architecture from 200 BCE onwards (Talloen and Poblome 2016). At the same time, a new mode of material culture production was initiated (Daems et al. 2019) and a dependent political territory was established stretching as far as the Burdur Plain (Daems and Poblome 2016; Waelkens 2004).

An increasingly economically and politically interconnected world emerged in Anatolia during the Hellenistic period, driven by the policies of the Seleucid dynasty (Aperghis 2004). I have argued elsewhere that part of the reason why Sagalassos achieved its primary position was because it tapped into the possibilities generated by these policies (Daems and Poblome 2016; Daems 2019). It succeeded in doing so by exploiting the potential of the niche it created for itself in its immediate environment, in combination with extending connectivity across a micro-regional, regional and supra-regional scale.

To illustrate this connectivity, I again turn to production and distribution of pottery material. Whereas the earliest pottery of Sagalassos was made from local clays derived from the immediate environment of the site itself, at the end of the third century it started to specifically target optimally suitable clays derived from the nearby Çanaklı valley. The extended range of exploitation for raw materials points towards the establishment of an increased catchment area needed to provide necessary energy and resources to fuel the community and its urban transformation. Additionally, through its extended political territory, Sagalassos laid claim on the fertile Burdur plain, making even more energy potential and resources available.

The increased potential coming into the city was used in part to fuel its material production. Resource specialisation and diversification allowed the community to initiate a specialised production of fine table wares. This specialisation in pottery production was (among others) made possible by increased division of labour (Daems In Press). The potters of Sagalassos also started to congregate in the southern part of the town (Poblome, et al. 2013). This spatial proximity allowed the establishment of agglomeration economies through economies of scale, increasing returns to scale and knowledge spill-overs (Lobo et al. 2013).

Agglomeration economies allowed increased production outputs to be geared not only towards the own community, but towards supplying a wider market as well. The pottery material of Sagalassos started to be exchanged on a wider spatial level, covering not only the immediate catchment area, but also gradually including neighbouring valley systems (Poblome, et al. 2013). At the same time, the appearance of amphorae from 200 BCE onwards – albeit initially in limited quantities – coming to Sagalassos from Italy, Rhodos, Kos, and Chios, indicates participation in supra-regional exchange networks (Monsieur, Daems, and Poblome 2017).

It has been stated that the organization of economic systems depends on the establishment of linkages between economic agents (Rosser 2003). As a result of increased economic connectivity such as through the expansion of trade networks, new hierarchical levels can emerge in urban systems (Garmestani, Allen, and Gunderson 2009; Rosser 1994). From the arguments presented here, it can be concluded that such a process of urban emergence occurred at Sagalassos in the Hellenistic period. Sagalassos fuelled its urban transformation by effectively transitioning from an r to a K-phase, exploiting a more diversified resource base, establishing agglomeration economies driven by division of labour, specialisation, increasing returns to scale and economies of scale. It was able to do so by optimally exploiting the available environmental potential and by increasing the interconnectedness of system components on multiple scales. This allowed the community to tap into the economic and political possibilities offered by its wider regional and supra-regional environment.

This transition towards the K-phase and the intense process of urbanisation associated with it, initiated a pathway of development that would last until the middle Byzantine period (Poblome 2014; Poblome, Talloen, and Kaptijn 2017). The continued trajectory of development at Sagalassos beyond the Hellenistic period has been described extensively elsewhere (Poblome 2014; 2015) and will not be considered here.

Conclusions

To conclude this chapter, it can be reiterated that from the Iron Age to Hellenistic period, local communities very effectively created suitable environmental niches to sustain themselves and prosper in a local context. Additionally, certain communities such as Düver Yarımada and Sagalassos succeeded in gaining prominence by extending micro-regional patterns of connectivity to a regional and supra-regional scale.

With this chapter, I aimed to show that the adaptive cycle framework can be successfully applied on archaeological case studies of socio-ecological systems in the past. Its usefulness goes beyond that of a metaphor of change and it provides a useful heuristic device that fits well with the existing epistemic resources of archaeological and interdisciplinary studies. The application of adaptive cycles in archaeology is increasingly gaining traction, but more work is still needed. The multi-level theory building presented in this chapter uses middle range theories to connect the high-level theory of the adaptive cycle to archaeological proxies. It presents a new step towards a better operationalisation of the adaptive cycle and adapting this highly promising framework as a useful heuristic for studying change and stability in human-environment interactions in the past.

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