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How can research on past urban adaptations be made useful for sustainability science?

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Non-technical summary. Cities in the distant past – as documented by archaeologists and historians – provide an extensive record of urban successes and failures, yet this information has had little impact on the field of sustainability science. I explore two reasons for this situation. First, these scholars have often failed to synthesize their data scientifically, and, second, they have not approached the transfer of past knowledge to present research in a rigorous manner. I organize discussion of these issues around three arguments for the present value of past cities: the urban trajectory argument, the sample size argument, and the laboratory argument.

Technical summary. I explore the different ways historical and archaeological data can be deployed to contribute to research on urban sustainability science, emphasizing issues of argumentation and epistemology. I organize the discussion around three types of argument. The urban trajectory argument exploits the long time series of early cities and urban regions to examine change at a long time scale. The sample size argument views the role of early cities as adding to the known sample of settlements to increase understanding of urban similarities and differences. The laboratory argument uses data from past cities to explicitly test models derived from contemporary cities. Each argument is examined for three contrasting epistemological approaches: heuristic analogs, case studies, and quantitative studies. These approaches form a continuum leading from lesser to greater scientific rigor and from qualitative to quantitative frameworks. Much past-to-present argumentation requires inductive logic, also called reasoning by analogy. Sustainability scientists have confused this general form of argument with its weakest version, known as heuristic analogs. I stress ways to improve methods of argumentation, particularly by moving research along the continuum from weaker to stronger arguments.

Social media summary. Better methods of argument allow the past record of urban success and failure to contribute to urban sustainability science.

1. Introduction

While sustainability scientists may acknowledge the potential value of historical and archaeological data for illuminating issues of urban sustainability today, in practice few authors use such information to advance their research. The publications of historians and archaeologists, on the other hand, are full of claims for the relevance of their findings for sustainability studies. Their work, however, has had little impact. I argue that both empirical and epistemological issues are responsible for this disjunction. In 2010 I suggested one reason for this situation: although archaeologists have data on many urban issues, we have failed to analyze our data, or to use the appropriate concepts, that would permit our results to contribute to broader urban discussions (Smith, 2010b). This is still true today, but the barriers to cross-disciplinary knowledge transfer go deeper than this.

In this paper I provide a general framework that can help narrow the gap between the scientific findings of archaeology and history on the one hand, and the needs of urban sustainability science on the other. Given the scanty material record of past cities and practices, it is particularly important to use an efficient and rigorous epistemological approach in order to get the most out of the available data. I describe the research process as organized in three steps: analysis, synthesis, and knowledge transfer (Figure 1). The first two are internal to research on the past, although they usually rely in part on findings about present conditions drawn from other disciplines. The third describes the transfer of knowledge from history and/or archaeology to sustainability science. This scheme builds on concepts such as the data–information–knowledge–wisdom hierarchy in information science (Ackoff, 1989), the 'data model' concept from the philosophy of biology (Leonelli, 2019), and work in archaeological epistemology (Clarke, 1978; Huggett, 2020).

Step 1 – analysis – consists of gathering data and generating low-level inferences about the data; these are called data models by Leonelli (2019). For historians, the primary activities are archival research and historiographic methods of source analysis. In archaeology this step pertains to fieldwork, chronology-building, and the basic descriptive analysis of contexts, buildings, and artifacts. Before these first-step findings can be compared to contemporary

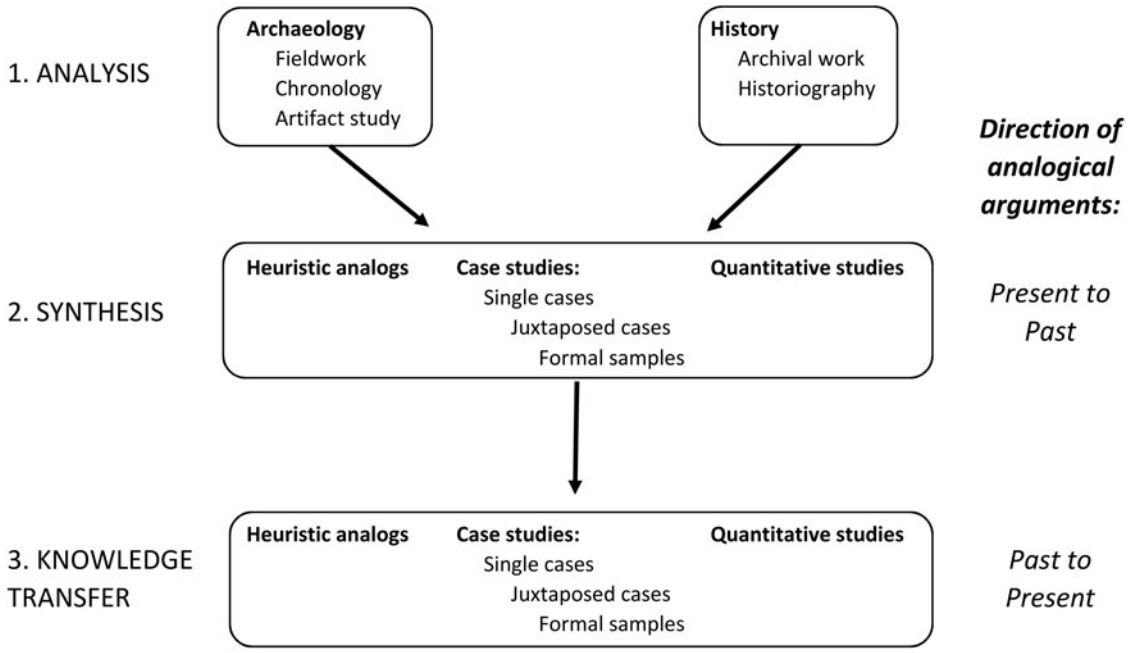

Fig. 1. Three steps in the process of research: analysis, synthesis, and knowledge transfer.

conditions, however, they need to be synthesized at a higher level. Step 2 – synthesis – uses a variety of methods and auxiliary information to generate findings relevant to one's research questions. In archaeology, and history to a lesser extent, inductive logic (in the form of argument by analogy) is crucial to the achievement of synthesis. Once the basic findings have been synthesized (step 2), then the results can be compared to contemporary conditions, and/or used in models or frameworks from sustainability science; this is step 3, knowledge transfer. This step also involves arguments by analogy, but the temporal direction of the argument is reversed. Archaeologists use analogies with contemporary societies to infer patterns in the past; knowledge transfer uses analogies with past societies to illuminate patterns in the present.

In this paper I propose three types of argument – three epistemologies – that describe the range of ways that data are used to make inferences in the second and third steps of the research process: heuristic analogs, case studies, and quantitative studies. They form a rough continuum from weak to strong arguments, and from less to more useful scientifically. I identify three varieties of the case studies approach, and these too form a continuum from weaker to stronger arguments.

Most methodological discussions of sustainability issues in history and archaeology focus almost exclusively on the first step, analysis. It is not unusual for non-historians to misuse historical data, ignoring basic methodological tenets and procedures, to create erroneous conclusions. Historians Joris Roosen and Daniel Curtis, for example, show how historical data on past plagues has been misused and misinterpreted by some scholars: 'When scholars fail to apply source criticism or do not reflect on the content of the data they use, the reliability of their results becomes highly questionable' (Roosen & Curtis, 2018, p. 103). Hansen and Hansen (2016) provide several examples from the field of economic history. My colleagues and I have made a parallel point in discussing the need for rigorous archaeological research if it is to be of use for questions of urban sustainability (Smith et al., 2021).

But even if rigorous methods are used in step 1 of the research process, a failure to employ adequate methods of synthesis and inference (step 2) can limit the value of the findings, preventing effective knowledge transfer. A recent high-profile paper on past resilience to climate change (Degroot et al., 2021) is notable for promoting rigorous historiographic methods (step 1), while failing entirely on step 2. The authors outline five case studies, based on rigorous step 1 analyses, but then proclaim a series of post-hoc assertions as their conclusions. These are offered without any testing or rationale. Post-hoc arguments like this lack testing. Instead, one gathers data, and then dreams up an explanation that fits the findings (Kerr, 1998). This is a very weak, non-scientific form of argumentation (Smith, n.d.). Several papers by John Haldon and colleagues (Haldon et al., 2020, 2021) also follow this approach. They review cases of resilience in historical societies, and end with post-hoc conclusions instead of comparative research findings based on testing. One way to improve this situation is to pay explicit attention to the nature of arguments and the role of inductive logic in past–present comparisons. Scholars need to move their research to the right in Figure 1, in the direction of more rigorous scientific methods.

2. Analogy and inductive logic in past–present comparisons

Most inferences about past human actions and conditions are based on inductive logic. We cannot observe the past directly, so we infer actions and conditions based on samples of comparative cases. The formal procedure of argumentation is often called argument by analogy. There is a large literature on analogy in archaeology, which was synthesized in an important paper by Alison Wylie (1985). Argument by analogy is an example of inductive logic. Figure 2 illustrates this process. The source cases (A, B, and C) all have attributes P, Q, and R. In archaeology these are typically ethnographic or historical cases (archaeologists used to call the method 'ethnographic analogy', even though source cases are often found in history and other disciplines).

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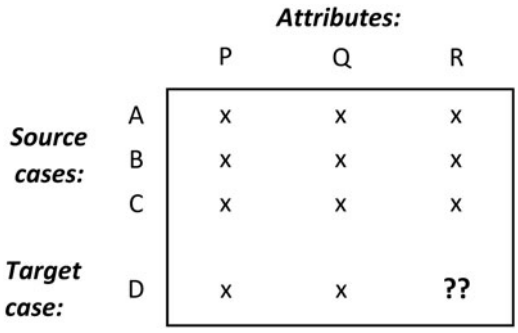

Fig. 2. Inductive logic, or, argument by analogy. Based on Copi et al. (2019, pp. 397–400).

The target case, D – within archaeology, this is usually the archaeological context one is trying to explain – has two of those attributes. Based on this similarity, one can infer that case D also has R, the third attribute. In using past data to illuminate present issues (step 3, knowledge transfer), however, the direction of inference is reversed, now going from past to present. Source cases are the completed analyses from history or archaeology, and the target case is the contemporary research context under consideration.

Analogical arguments are rarely right or wrong conclusively; rather, they vary in their strength. Logicians Irving Copi et al. (2019, pp. 397–400) list the following criteria for evaluating the strength of arguments by analogy (Wylie presents a similar version of this scheme):

(1) *The number of entities.* The larger the number of entities or cases, the stronger the argument.
(2) *The variety of the instances in the premises*. The more dissimilar the instances mentioned only in the premises of an analogical argument (i.e. among the source cases), the stronger the argument.
(3) *The number of similar respects.* The greater the number of respects in which the entity in the conclusion is similar to the entities in the premises, the more probable the conclusion.
(4) *Relevance*. Relevance is increased by causal considerations. A single highly relevant factor contributes more to the argument than a host of irrelevant similarities.
(5) *Disanalogies.* Disanalogies – points of difference between the premises and the conclusions, or between the source cases and the target case – weaken analogical arguments.
(6) *The claim that the conclusion makes.* The more modest the claim, the less burden is placed on the premises and the stronger the argument; the bolder the claim, the greater is the burden on the premises and the weaker the argument.

Some archaeologists and sustainability scientists seem to misunderstand the relationship between analogical arguments and these rules of inductive logic. In archaeology, where analogy moves from present to past, this misunderstanding takes the form of picking a single-source case – typically an entire ethnographic society – and simply assuming that most attributes in that case also characterize the target case (an archaeological site or culture). This violates of several of the six principles of inductive logic, thereby guaranteeing that the argument will be weak. For discussion of the difficulties with this kind of single-source complex analogy, see Smith (n.d.). In the transfer of knowledge from past to present in sustainability science, a similar misunderstanding takes the form of assuming that single-source complex analogies constitute the only form of argumentation by analogy. For Meyer et al. (1998), this misunderstanding leads to a rejection of the entire process or reasoning by analogy (see also, Dearing et al., 2010). Tubi et al. (2022) go even farther, using the problems with these simplistic analogs as a basis for rejecting entirely the value of past data for sustainability science today. These authors are correct that complex single-source analogies – called heuristic analogs by Meyer et al. (1998) – are a poor method of inference, but they throw away the analogical baby with the poor-analog bathwater.

3. Three epistemologies of past–present comparisons

3.1 Heuristic analogs

Many sustainability studies tapping historical lessons rely on single, complex analogs to infer present outcomes from past settings. This use of simple narratives to explain complex, contingent episodes are common in evolutionary biology, history, and archaeology; Currie (2019) refers to them as 'one-shot hypotheses'. Such analogs in history and archaeology often describe a broad and complex domain, such as an entire society. A canonical example is the collapse of ancient Maya cities, held up as a negative model to suggest practices or conditions we should avoid today (Costanza et al., 2007). In writing about how history can influence environmental policy, historian Adam Izdebski (2022, p. 9) uses the term 'storytelling' for heuristic analogs. His chapter, 'offers an interdisciplinary historian's perspective on what historical storytelling could become in the Anthropocene'.

Storytelling about complex situations – the use of heuristic analogs – is part of the humanities; it does not conform to most definitions of natural science or social science. While the humanities can play important roles in understanding issues of sustainability and climate change adaptation (Hussain & Riede, 2020), this particular form of epistemology has been criticized as inappropriate for scientific research. The term 'heuristic analogies' was first used by Meyer et al. (1998), who point out that 'they are heuristic because they are too complex or too contextually different to be formally specified' (p. 220). Dearing et al. (2010), note that, such 'analogs prove problematic for systematic assessments of current and future land systems' (p. 3). While these criticisms are valid for heuristic analogs, it appears that these and other authors (e.g. Tubi et al., 2022) err in associating *all* uses of analogy with heuristic analogs. Based on the rules of inductive arguments (Figure 2), heuristic analogs are indeed a particularly weak form of argument.

Karl Butzer (2012, p. 3632) criticizes such accounts by noting, 'Much of the current alarmist literature that claims to draw from historical experience is poorly focused, simplistic, and unhelpful'. Nevertheless, this epistemological approach has several roles in urban sustainability science today. The first derives from the nature of the humanities disciplines. Following Kagan (2009, pp. 4–5), the humanities strive to understand human reactions to events and the meanings humans impose on experience as a function of culture, historical time period, and life history. Heuristic analogs can help individuals – scientists, policy makers, the public – think through issues of urban sustainability. The power of stories to communicate complex scientific messages is well known. A second role is to provide a starting point for the

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development of research in the new domain of urban sustainability science. Heuristic analogs can help formulate more problem-oriented research, leading to more productive case-study analyses and quantitative research.

3.2 Case studies

I use the term case study to describe problem-oriented studies of one or more cities, regions, or societies, typically focusing on a particular domain such as the economy or urban planning. They differ from heuristic analogs in all six methods listed above for improving the strength of inductive arguments. While many accounts of the Classic Maya collapse consist of heuristic analogs, case-study research is also common, such as studies of the role of drought in the collapse of a specific Maya city, or a comparison of Maya calendrical dates to archaeological evidence for urban abandonment at a sample of cities.

Three levels of case-study research can be identified in the historical and social sciences: (1) single cases that are well documented and pertain to a limited domain; (2) multiple cases juxtaposed without systematic comparative analysis; and, (3) samples of cases used for comparative analysis. Movement from the first to the third level of case-study research – a priority for making past data useful to sustainability science – involves the use of larger samples, with more explicit attention to research questions and methodological issues like sampling, operationalization, and measurement. This does not mean that single-case studies, isolated or juxtaposed, cannot be useful for improving understanding of the past; indeed, most archaeological fieldwork today fits in this approach. But a movement toward the right in Figure 2 does improve the generality and scientific rigor beyond the perspective of single sites or cases.

Case-study research, in the third sense (samples for comparisons), has become a common method in the social sciences. This approach employs fewer cases than needed for statistical analysis, with greater contextual information about each (Gerring, 2017; Ragin, 2014). The goal is to draw conclusions that pertain to a wider domain than an individual case. John Gerring (2017, p. 271) argues that case-study research can be favored over statistical cross-case comparisons when new phenomena are being investigated or when a set coding system has yet to be devised. As pointed out above, sustainability-related papers led by historians increasingly pursue case-study research, but of the second type, juxtaposed cases (Degroot et al., 2021; Haldon et al., 2018, 2020). The transformation of this kind of research into full samples for comparative analysis should be a goal of historical and archaeological studies of topics like societal or urban resilience.

3.3 Quantitative analysis

Archaeological and historical research is beginning to move beyond heuristic analogs and case studies into the rigorous study of large-scale datasets to advance the scientific understanding of the past. Such datasets can support the use of statistical methods, the formulation and testing of hypotheses, and the identification of common generative processes. Quantitative data are not inherently better than case-study data about the past; detailed causal analyses of case studies are often more informative than statistical analyses of large samples of superficial data. Nevertheless, larger samples do improve inductive arguments and they often allow stronger conclusions to be drawn.

Collecting suitable archaeological and historical data is not always straightforward or easy, however. Concerted efforts need to be made by archaeologists and historians to compile datasets that are relevant to urban sustainability research and enable quantitative comparative research. Outside of sustainability research, archaeologists and historians are now beginning to draw samples of sufficient size, and code variables systematically, to engage in quantitative, statistical analyses of past social patterns and changes. At the level of cross-societal quantitative analysis, the SESHAT project is probably the premier large-scale historical data coding project (Turchin et al., 2015, 2018). In another example, archaeological research on wealth inequality now regularly employs the Gini index to measure household wealth, often in large samples (Kohler et al., 2017). The continued expansion and improvement of quantitative analyses in archaeology promises to improve the usefulness of past-to-present knowledge transfer.

4. Three types of argument

If archaeologists and historians can ask questions that are comparable to those being asked of cities today, and if they can use similar or parallel methods and concepts, then several kinds of argument can be made for the usefulness or relevance of premodern cities for research and policy work on cities today. I single out three types of argument, which I label the urban trajectory argument, the sample size argument, and the laboratory argument (Smith, 2023). Figure 3 illustrates the intersection of these argument types with the three epistemological categories discussed above. The boxes contain some examples of studies fitting the categories. While my focus is on cities and urban sustainability, I review examples pertaining to societal sustainability and adaptations more generally; the urban focus is new for archaeologists and historians and there is still only a limited literature available.

4.1 Urban trajectory argument

4.1.1 Argument

Archaeologists like to point out that one of our unique contributions to knowledge is the long-term perspective on change that the archaeological record provides (Kintigh et al., 2014; Smith, 2022). Archaeologists, historians, and geoscientists (Braudel, 1972; Butzer, 1982, 2011) developed models of time scales – the notion that different processes operate over different scales of time – long before sustainability scientists addressed the time scales of adaptation processes (Chhetri et al., 2019; Kates et al., 2012); see Figure 4. There are two basic ideas to these schemes. First, processes play out at a variety of different time scales; and, second, variables that affect human and natural systems become more or less influential at different time scales. The division of such scales into three or four categories is done for convenience, without any suggestion of rigid definitions or boundaries for the individual scales.

Nearly 30 years ago, ecological economists Robert Costanza and Bernard Patten stated, 'The basic idea of sustainability is quite straightforward: a sustainable system is one which survives or persists' (Costanza & Patten, 1995, p. 193), yet scholars of contemporary urbanism have little idea how long cities will last into the future. Archaeologists are beginning to argue that the archaeological and historical record of past settlement persistence holds potential for illuminating issues of urban sustainability today (Carballo et al., 2022; Crawford et al., 2023; Smith et al., 2021). If we can develop rigorous explanations for variation in settlement persistence – for example, why did some settlements last longer

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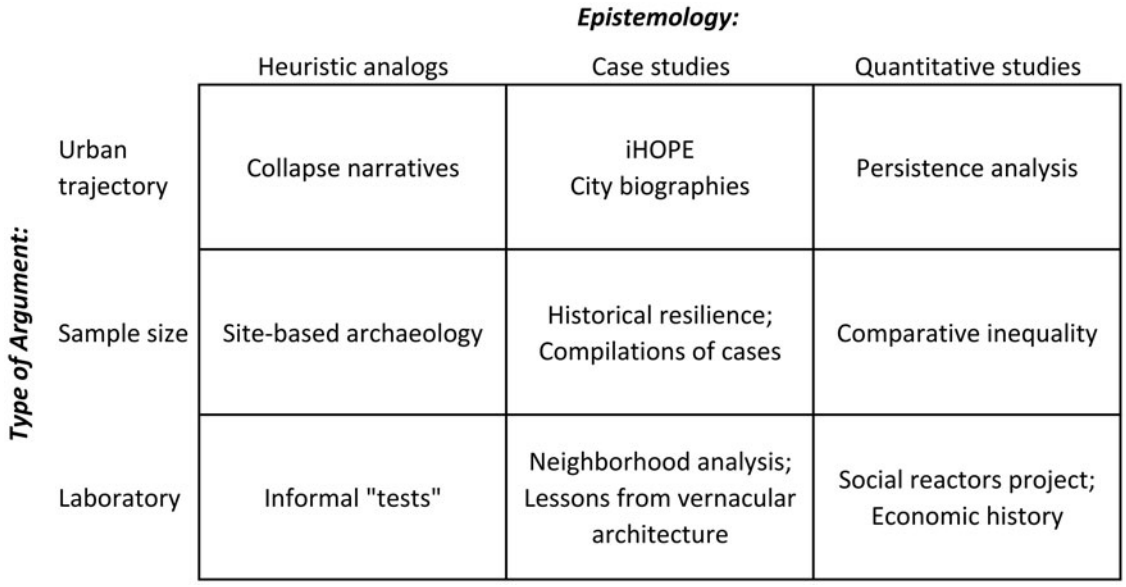

Fig. 3. Epistemologies and types of argument for bridging the gap between data on the past and research on the present.

Discipline	Author	*Time scale:* 1	2	3	4
Geomorphology	Butzer 2011	Seasonal stress	Medium-term pulse	Longer-term anomaly	Long-term environmental shift
Environmental archaeology	Butzer 1982	Adaptive adjustment	Adaptive modification		Adaptive transformation
History & social archaeology	Braudel 1972	Event	Conjuncture		Longue durée
Sustainability science	Kates et al 2012; Chhetri et al 2019	Coping adaptation	Incremental adaptation		Transformational adaptation
		(shorter)	→		(longer)

Fig. 4. Time scales in different disciplines.

than others? – then perhaps those or related factors can be singled out as potential drivers of sustainability today (Smith, 2022).

The urban trajectory argument is particularly relevant to several strains of research in sustainability science. First, the study of sustainability transformations (Kates et al., 2012; Loorbach et al., 2017), including urban sustainability transformations (Iwaniec et al., 2019), often considers the long time spans documented by archaeological and historical research. Second, regime shifts and tipping points (Lenton et al., 2022; Rocha et al., 2018) are themes in sustainability science that archaeologists are now starting to address (Lenton et al., 2021; Scheffer et al., 2021), although this work has yet to be extended to research on past cities and urban transformations. Third, a recent IPCC report touts the importance of 'taking a longer time horizon' in applying principles of climate-resilient development to cities and urban areas (IPCC, 2022, p. 42).

4.1.2 Heuristic analogs

Much of the collapse literature in archaeology and history takes the heuristic analog approach to epistemology. Stories or narratives are created about whole societies and their changes through time, culminating in a collapse event. Some studies focus on a single cultural area (Webster, 2012) while others cover a variety of cases (Cline, 2021; Diamond, 2004). In the sustainability literature, chapters in the volume, *Sustainability or Collapse* (Costanza et al., 2007) illustrate this kind of analysis.

4.1.3 Case studies

Focused case studies of urban trajectories differ from heuristic analogs by their greater precision about social and environmental processes, including a more delimited domain and a more explicit problem orientation. Archaeological research by Dan Lawrence and colleagues on trajectories of urbanization and climate change

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in Mesopotamia (Lawrence et al., 2021) is a good example of focused case studies relevant to urban sustainability today. Felix Riede's research on the effects of a past volcanic event shows the value of the first level of case-study research on a sustainability-related topic (Riede, 2019). Some of the more systematic and comparative studies of societal collapse fit here (Middleton, 2017; Tainter, 1988), although few authors have taken the step of moving their level-2 case-study analyses (juxtaposition of cases) to level 3 (more formal comparisons). One of the four major case studies used to frame the analysis in Matson et al. (2016) is the long-term trajectory of the city of London.

The iHOPE (Integrated History of People on Earth) project, which uses data from early societies to inform sustainability themes, began with discussion of heuristic analogs in the volume *Sustainability or Collapse* (Costanza et al., 2007). Project members have since published two edited volumes that fit within the level-2 case-study approach. The first (Chase & Scarborough, 2014) assembles a series of studies of Maya urban trajectories and collapse, and the second (Murphy & Crumley, 2022) presents four case studies (Highland Ethiopia, Lowland Maya, Southern Mesopotamia, and Atlantic Europe) organized around the concept of urban durability. This research would benefit from an improved operationalization of concepts and the use of more systematic comparisons.

4.1.4 Quantitative analysis

Quantitative studies of urban trajectories are becoming more common in a number of disciplines. This is part of a wider trend in economic history that is often glossed as research on persistence: the notion that past events affect present conditions (Arroyo Abad & Maurer, 2021; Nunn, 2020). While cities are sometimes used as units to measure demographic or economic development in this literature (Bleakley & Lin, 2015; Michaels & Rauch, 2018), there is little consideration of the trajectories of individual cities over time. The fact that the location of Roman roads predicts the level of economic development today does not tell us much about the trajectories of individual settlements over the past two millennia. The long-term trajectories of past cities and settlements – their rise and fall, founding and abandonment – can provide evidence relevant to urban adaptations to climate change today (Smith et al., 2021). While quantitative research on this question using archaeological and historical data is only just beginning (Carballo et al., 2022; Crawford et al., 2023), the effects of past climate change on early settlements is now being studied with good samples and quantitative methods (Hambrecht et al., 2018).

4.2 Sample size argument

4.2.1 Argument

The sample size argument states that scholars, planners, and officials can benefit from the addition of premodern cities to the roster of cities today to create a larger sample for various goals. Social-science research on urbanism today has traditionally favored cities in the developed nations. The increasing attention to urbanism in the developing world has two important implications for sustainability: first, the new focus addresses contexts where the social effects of climate change will be the most severe and most extensive (IPCC, 2022). Second, the analysis of cities in the global south allows cities and urban processes to be addressed more broadly than is possible from cities in the developed nations alone (Bryan et al., 2020; Randolph & Storper, 2022). The sample size argument for past cities can be seen as an extension of this idea. The addition of past cities, as well as cities in the global south, to the sample of cities available for analysis, increases the chances that scholars or planners might identify a practice or pattern that will be useful in understanding or designing cities today (Keith et al., 2020).

4.2.2 Heuristic analogs

Many archaeological and historical descriptions of premodern cities end with a vague claim for relevance to contemporary concerns, including sustainability issues (e.g. Chase & Chase, 2016). As pointed out by Meyer et al. (1998), however, such relevance is hard to act upon for single complex cases; see also Smith (2021).

4.2.3 Case studies

The spate of recent studies of societal resilience, based on historical cases, fall into the second level of case-study research: the cases are assembled and juxtaposed, but without any cross-case analysis beyond rough post-hoc generalizations (Haldon et al., 2018, 2020, 2021; Izdebski et al., 2018; van Bavel et al., 2020). In archaeology, this trend is exemplified by studies such as Scarborough and Isendahl (2020) and Murphy and Crumley (2022). Even economists – accustomed to pursuing quantitative analyses of large samples – are forced to use the second level of case-study research in their attempts to link up ancient and modern urban resilience because of the lack of available systematic data (Glaeser, 2022). Some useful urban studies include Barthel and Isendahl (2013) and Ur (2015).

One role of case studies in the sample size argument is to correct errors that derive from parochial views of the urban world based on limited areas or time periods – usually Western Europe and/or the United States. Such errors include the claim that all cities have defensive walls, or streets, or the assertion that urban sprawl occurs around all cities in all periods, and even the claim that cities must be permanent settlements; see discussion in Smith (2023). Archaeologists and historians can assemble numerous cases that show the limitations of these European-centered generalizations. In addition, many level-2 compilations of case studies – analyzed in a more focused and controlled manner than heuristic analogs – provide food for thought, if little in the way of systematic analysis or comparison (e.g. Fisher & Creekmore, 2014; Smith, 2019; Woolf, 2020).

4.2.4 Quantitative analysis

Large samples of early cities, suitable for quantitative analysis, rarely contain much detail about individual cases. For this reason, they rarely advance the sample size argument.

4.3 Laboratory argument

4.3.1 Argument

The laboratory argument is stated by Curtis et al. (2016) as follows: 'The historical record is one "laboratory" in which hypotheses developed by sociologists, economists, and even natural scientists can be explicitly tested' (Curtis et al., 2016, p. 751). The phrase 'explicitly tested' is crucial here; I exclude vague statements to the effect that the archaeological record is a laboratory of completed experiments (Murphy & Crumley, 2022, p. 2), and concentrate on the testing of quantitative models. If early cities show the same patterns as contemporary cities, then a particular

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model or theory achieves a much greater level of generality, and the argument for past–present similarities is strengthened. The laboratory argument can be seen as a special case of the sample size argument; I separate it because of the scientific value of research using the laboratory argument.

A successful 'laboratory' test of this nature does not imply that premodern cities are the same as cities today; rather, it means that there are some domains in which all or many cities share key features (e.g. neighborhoods) or properties (e.g. scaling regularities). The fact that these domains tend to involve settings and processes in which social interactions lead to energized crowding shows the importance of social interactions for urban processes, both today and in the distant past (Lobo et al., 2020; Smith, 2023; Storper, 2013). Alternatively, many models of cities today are not appropriate for the ancient world because they rely on industrial technology (e.g. smart cities), the capitalist economy (e.g. the urban growth machine), or the legal institutions of modern nation-states (e.g. regulation through zoning laws). Some writers claim that the gulf between ancient and modern societies is so vast that it is foolhardy to try to establish clear continuities (Tubi et al., 2022), but a more productive attitude is to suggest that the proof is in the pudding: this is an empirical question for testing, not a matter for grand pronouncements. Although topics like neighborhoods or city size are important for urban sustainability, the laboratory argument itself lacks close parallels within sustainability science.

4.3.2 Heuristic analogs

This category describes cases where concepts and theories from research on contemporary society are applied informally to complex ancient contexts, and evaluated using subjective methods. Demarest and Victor (2022), for example, apply theories from management and institutional theory to the Maya collapse and report parallels to society today. The lack of operationalization and quantification limits the value of such studies, although they may be useful in devising more formal or rigorous analyses of archaeological or historical data.

4.3.3 Case studies

This category includes various systematic qualitative, or semi-quantitative, studies using early cities to draw conclusions relevant to contemporary concerns. One example is the prevalence and importance of urban neighborhoods. In the contemporary world, urban neighborhoods are both important to residents, and scientifically crucial for understanding urban organization (Sampson, 2012). Is this just a feature of cities today, or does it signal something more general, perhaps a universal role for neighborhoods in urban settlements? Research by historians (Garrioch & Peel, 2006) and archaeologists (Arnauld et al., 2012; Smith, 2010a) revealed the prevalence and social importance of neighborhoods in cities throughout the past. Indeed, neighborhoods seem to be one of the very few urban universals.

A second example is the use of architectural and urban principles from traditional and past societies, particularly concerning housing and urban layout, to draw inferences for urban design today (Alexander, 1979; Hakim, 2014; Rapoport, 1990). These architects and planners argue that vernacular housing and settlements offer positive guidelines that planners can use today to improve the livability of cities and neighborhoods. Some of these principles have been incorporated explicitly into the planning movement known as the 'new urbanism' (Talen, 2019).

4.3.4 Quantitative analysis

The quantitative testing of models from contemporary cities and urban societies, using data on past cities, is farthest advanced in two areas: studies of urban growth and decline by economic historians (Michaels & Rauch, 2018; Nunn, 2020) and research on settlement scaling. The social reactors project (https://www.colorado.edu/socialreactors/) was formed explicitly to test the social reactors model of urban scaling (Bettencourt, 2013) against archaeological and historical data. Quantitative empirical regularities identified for systems of cities today were found to hold for a variety of early cases (Lobo et al., 2020; Ortman et al., 2020), permitting the inference that the same or similar social and economic dynamics generated the empirical patterns in both contemporary and ancient urban systems. The implications for this finding for urban sustainability have yet to be established, though.

Closer to the concerns of urban sustainability research, Peter Peregrine (2020) has used statistical methods to model archaeological and historical data on social responses to climate change. At the level of individual regions and cities, Klassen et al. (2022) investigate spatial equilibrium, a fundamental model in urban economics, at ancient Angkor in relation to food production, showing that the basic spatial constraints on urban movement and activity are quite similar in the past and the present.

5. Discussion

Past cities had to respond to challenges both environmental – for example, climate, volcanic – and social – for example, political conquests, institutional shifts – if they were to survive and flourish. The ways they did this, and their successes and failures, provide a record of urban adaptations around the world over thousands of years. This information can potentially illuminate key aspects of urban sustainability science today, including urban climate-change adaptations. In spite of published claims for the relevance of archaeological and historical data for sustainability science (Kintigh et al., 2014; Rockman, 2012; Sabloff, 2008), these efforts have had little impact to date. This paper is designed to help rectify this situation. The three arguments outlined above – the urban trajectory argument, the sample size argument, and the laboratory argument – encompass some of the ways that data from past cities and societies can contribute to advancing the field of urban sustainability science. Many of my examples are from studies not specifically addressing cities and urbanism, mainly because of the paucity of published research in this area.

The epistemology of past–present comparisons has not been sufficiently emphasized in the published literature, and this has had negative effects on the possibilities of knowledge transfer. Although sustainability scientists first identified the problems with using heuristic analogs as explanations for past sustainability-related processes (Meyer et al., 1998), they erred in confusing this very weak form of explanation with the more powerful and general approach of argument by analogy. When historians presented the step-1 results of their analysis of societal resilience (Degroot et al., 2021), their failure to engage in synthesis or quantitative comparisons (step 2) limited the value of their findings. Epistemological issues are important. Studies that attempt to use past data to illuminate the present can be arranged into a sequence of types that I label heuristic analogs, case-study research, and quantitative studies.

If archaeologists and historians want to produce data that are useful for sustainability scientists today, they will have to improve both their methods and their epistemology. If sustainability

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scientists want to use data from past urban contexts (step 3 in Figure 1), they need to understand the nature of the data and research processes that generated findings in steps 1 and 2. For successful knowledge transfer from past to present, heuristic analogs are useful only in a narrow sense. Case-study research produces much stronger results. I identified three levels of sample size and rigor within case-study research; analyses of single cases (level 1); juxtapositions of multiple cases (level 2); and systematic comparisons and analyses using standard social-science methods (Gerring, 2012, 2017) (level 3). The quantitative analysis of adequate and representative samples is the gold standard in producing scientifically rigorous and useful results from archaeological and historical data. This approach is now flourishing in archaeology (Klassen et al., 2022; Kohler et al., 2017; Ortman et al., 2020; Turchin et al., 2018), but most of the work lies outside of the realm of urban sustainability issues. This approach needs to be applied to sustainability issues. Weak arguments and vague claims of relevance are not helpful, except perhaps as stages in a trajectory that moves toward more rigorous arguments using quantitative data.

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