Sustainability

Resilience lessons from ancient societies

John Haldon

What lessons can we learn from the factors that govern the resilience of human populations? A large-scale analysis examining ancient societies around the world provides a detailed look at what drives sustainability. See p.837

What makes a society resilient and sustainable in the face of environmental, political or economic challenges, and are there identifiable patterns in societies’ responses? These questions have remained largely unanswered because neither natural science nor social science has come up with an agreed set of criteria on which to base any analysis. On page 837, Riris et al.1 set out a rigorous approach that responds directly to this challenge and offers the possibility of establishing a global comparative framework through which long-term trends and responses can be identified. Evidence from the way that past societies behaved under pressure can perhaps guide today’s thinking in terms of developing sustainable strategies for addressing both contemporary and future challenges. This is an important contribution.

Identifying past resilience requires the analysis of societal responses in detail to understand the social and cultural mechanics of change, rupture and continuity. This can be achieved through established methods of historical and archaeological analysis, focused on case studies that are intended to identify and analyse the outcomes and practices that facilitated, or failed to support, resilient or sustainable adaptations. But this is an approach with a narrow focus that tends to prevent comparisons between systems over the long term. It can therefore miss deeper patterns.

To provide a broader comparative framework, researchers need to identify more-common long-term key indicators for social systemic responses to stress factors. If we can find common patterns that emerge from such comparative analysis, this offers a way to then identify potentially key correlations that might indicate specific causal associations related to the development of resilience in the evolution of social, cultural and political systems. Until now, this challenge remained to be effectively tackled.

Archaeological dating using radiocarbon (carbon-14) dates derived from evidence of past human activity (from places such as campsites or settlements) is a key source of data for fluctuations in the density and distribution of ancient populations. Drawing on published archaeological radiocarbon evidence for 16 regions across the globe (Fig. 1), the authors calibrated the carbon-14 dates using a specific statistical model to convert radiocarbon dating information to times presented in the form of calendar years before present (calendar years in relation to the year 1950).

The authors were then able to generate an analysis of this information (a meta-analysis) in which an assessment of patterns (the probability distributions) of these dates acts as an index of population dynamics. Put simply, the greater the density of dates across a given...
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period, the greater the density or longevity of the population.

By identifying regional patterns across each of the 16 groups of dating information, the authors could identify downturns (disturbances) and rates of recovery in relative levels of human activity, patterns that reflect population (demographic) changes over time and that hence serve as a way to assess degrees of resilience (the rate of recovery of a population in responding to a notable hazard). The authors could also examine the depth of the consequences of stressors, such as drought or other adverse climatic effects or natural hazards such as volcanic eruptions, for past populations. This is the first attempt of this kind to track resilience in the broadest sense of the term across such a wide sample of populations spanning 30,000 years of human history.

Resilience has been something of a buzzword in the social and ecological sciences, especially since the 1990s. The term is used in fields as diverse as ecological-systems management and archaeology, in an effort to understand how complex systems respond to stress, especially when asking: what is it crucial to be resilient to?

In ecology, for example, it has been argued that frequent natural disturbances enhance the long-term resilience of a system and that localized sub-systemic collapses or downturns are a key mechanism through which this takes place2–4. Mathematical modelling approaches can indicate how systems or parts of systems respond when they reach certain tipping points, illustrated by examples drawn from the natural world or sociological analysis. Archaeologists, anthropologists and, to a lesser extent, historians, are beginning to apply such models to their own data for prehistoric societies in particular5–6. The assumption of analogies between ecological and human systems is evident in the now generalized use of the term social-ecological system (SES) to describe societies and the ecologies with which these societies are associated. Riris and colleagues’ work reinforces this approach.

The authors’ sophisticated statistical modelling permits five key conclusions. First, the most common high-level factor in disturbances was environmental problems, with aridity being the most common type of stressor, followed by increased population mobility in spatial terms. Second, resilience was relatively high across all the dated evidence, with some 40% of the total sample returning to 90% of their pre-disturbance situation, although a complete return to pre-disturbance conditions was often inhibited by later downturns. Downturns associated with broadly socio-cultural drivers returned the highest median level of resilience. Broadly speaking, both resistance (defined as the relative effect of a disturbance in terms of the extent of limiting the population downturn) and resilience were lowest in the case of climate-driven downturns, although the statistical differences between the categories of disturbance were not significant overall. The duration of demographic downturns ranged from decadal to as much as 500 years, with few exceptions to this upper time limit.

Third, geographical location was not a major factor, although there were some outliers, such as Caribbean islands. Fourth, increased frequency or exposure to disturbances was associated with increased resistance and resilience to subsequent stressors as well as higher rates of recovery.

Fifth, the fact that herding and farming economies were correlated with both the frequency of downturns and increasing degrees of resilience reflects the increasing tendency from the early Holocene (from around 10,000 bc) onwards towards the dominance of herding and farming in contrast to hunter-gathering systems. The correlation between higher frequencies of disturbance, smaller downturns and more rapid returns to pre-disturbance population levels indicated in the radiocarbon data suggests that there is a positive feedback mechanism between vulnerability, resistance and recovery that might, in part, underlie the consistent tendency of the global human population to grow.

These are notable results if we accept that applying lessons from the past to contemporary policy and problem-solving has merit.

The authors suggest a practical approach to better understand the factors that underlie long-term, centennial-scale resilience at the deepest level, reflected in the relationship between demography and frequency of disturbance over millennia. Given the environmental effects on population stability and well-being that are evident today and predicted for the future, clarifying the mechanisms that underlie past demographic responses to the degree and frequency of stressors, such as those driven by the climate, should help to better inform policy and planning for future demographic and environmental sustainability.

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Biotechnology

Vaccine enhancer from plants synthesized in yeast

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The Chilean soapbark tree is the source of QS-21 — a valuable but hard-to-obtain vaccine additive. Yeast strains engineered to express all components of the QS-21 biosynthetic pathway provide an alternative route to this therapeutic. See p.937

Plants have long been a source of medicines, including painkillers, anti-cancer drugs, treatments for neurological disorders and even vaccine adjuvants — compounds that increase the efficacy of vaccines by enhancing the immune system’s response to a molecule that is recognized as an antigen. However, obtaining plant-derived molecules is frequently challenging. Extracting and isolating them directly from plants can result in low yields and damage to ecosystems, and synthesizing complex plant molecules chemically is difficult and often expensive. On page 937, Liu et al. provide a promising solution to this problem by synthesizing a potent plant-derived vaccine adjuvant in engineered strains of yeast (Saccharomyces cerevisiae) — an easy-to-grow microorganism.

Historically, aluminium-containing salts (often referred to as alum) were used as adjuvants for most vaccines, but in 1991, scientists discovered that an extract from the bark of the Chilean soapbark tree (Quillaja saponaria) (Fig. 1a) could serve as a useful adjuvant with minimal toxicity. This extract, made up of a mixture of two specific molecules, and termed QS-21, has subsequently been approved for use in several vaccines, including Mosquirix.