‘*Unifying Geography* sees a distinguished cast of scholars addressing “big” questions about the scope, structure, distinctiveness and purpose of geographical thinking. It will prove essential reading for core courses on the theory, practice and role of geography.’
Robert Mayhew, *Institute of Geography, University of Wales, Aberystwyth*

‘This book tackles the main challenge facing Geographers today – that of Unification. The authors are to be congratulated on a wide-ranging forward-looking approach that must form the basis for modern geographical teaching and innovative research agendas.’
Sue Brooks, *Birkbeck, University of London*

It is argued that the differences in content and approach between physical and human geography, and within its subdisciplines, are often overemphasized. The result is that Geography is often seen as a diverse and dynamic subject, but also as a disorganized and fragmented one, without a focus.

Unifying Geography focuses on the plural and competing versions of unity that characterize the discipline, give it cohesion and differentiate it from related fields of knowledge. To ensure a balanced approach, almost all of the chapters are co-authored by a leading physical and a human geographer. Space, place, environment and maps are identified as the essential core components of Geography derived from its common heritage. Their importance for the future of Geography is addressed through a wide range of unifying themes. Topics covered include: fieldwork, geographical information systems, environmentalism, sustainability, globalization, landscape and culture, natural hazards, conservation and heritage, science and policy.

In its identification of unifying themes, the book provides students with a meaningful framework through which to understand the nature of the geographical discipline. *Unifying Geography* will give the discipline renewed strength and direction, thus improving its status in an increasingly interdisciplinary world.

John A. Matthews is Professor of Physical Geography and **David T. Herbert** is Professor of Human Geography at the University of Wales, Swansea.

Geography

Routledge
Taylor & Francis Group

2 Park Square, Milton Park
Abingdon, Oxon OX14 4RN

29 West 35th Street
New York NY 10001

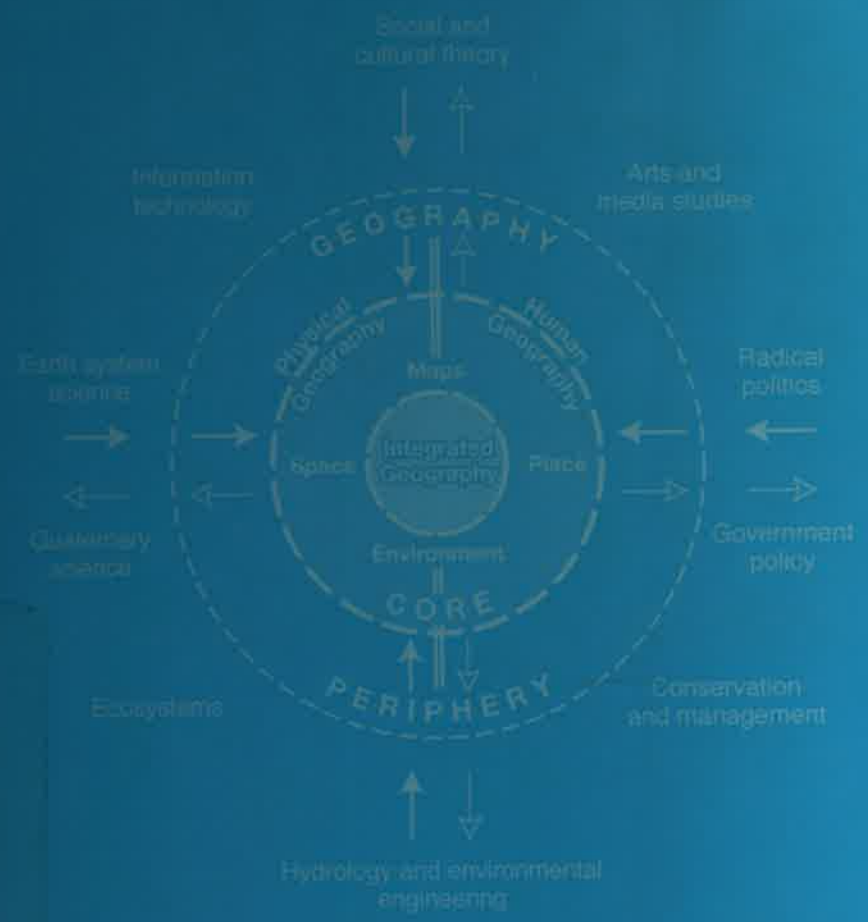
www.routledge.com
Printed in Great Britain

ISBN 0-415-30544-6

UNIFYING GEOGRAPHY

COMMON HERITAGE, SHARED FUTURE

EDITED BY JOHN A. MATTHEWS AND DAVID T. HERBERT



HUMAN VULNERABILITY, PAST CLIMATIC VARIABILITY AND SOCIETAL CHANGE

David Taylor and Anna R. Davies

NATURAL HAZARDS AND HUMAN VULNERABILITY

Coping with environmental changes as a result of the occurrence of natural hazards such as earthquakes, landslides and climatic variability is part of human existence. The ability to cope with a hazard, otherwise known as adaptive capacity, varies across environmental and socio-economic gradients and is one component of vulnerability (the others being the levels of exposure to and magnitude of hazards). Often adaptive capacity is most tested by the indirect effects of hazards, e.g. disease and shortages of food. In the case of food shortages associated with one or two years of anomalous weather conditions, successful adaptation may involve little more than being able to find adequate shelter and alternative sources of nutrition, utilize famine stores, or trading labour or other commodities for the required food staples. Under more pronounced or prolonged periods of famine, humans may resort to different and in some cases new technologies and, if opportunities exist, migrate to more suitable areas. If these coping strategies are generally unsuccessful or not possible then widespread starvation is likely to follow (D'Souza, 1988).

Building adaptive capacity is not entirely risk free, as is evident in the large losses of life and high level of economic devastation associated with the worst environmental disasters today. However, because of the complex interactions involved, understanding why adaptive capacity can, on occasion, fail requires a shift in emphasis away from natural hazard outcomes, or impacts, to causation. This in turn requires a mode of explanation that accommodates the openness (i.e. non-deterministic nature) of human–environment interactions and the presence of emergent phenomena (i.e. having different properties to those of their constituents) as products of these interactions. Such a mode of explanation and the subject matter of human vulnerability deserve consideration as core elements of a unified discipline of Geography, owing to their interdisciplinary

CLIMATE CHANGE AND HUMAN HISTORY

According to the *Annales* historian Fernand Braudel (1993: 10), the environment has provided the 'stage on which humanity's endless dramas are played out [that] partly determines their storyline and explains their nature'. Of key relevance to understanding current and anticipating future vulnerability is the extent to which this storyline has been influenced by environmental variability in the past, and the nature and range of interactions between natural hazards and human societies.

Unravelling the role of natural hazards in human history has long attracted the attention of academics from a range of disciplinary backgrounds. Most of this interest has focused on empirical studies involving climatic variability, largely because of the prospect of providing important information on the impact of future climate changes. For example, on the basis of a broad range of evidence, Winkless and Browning (1975) proposed the existence of a link between societal collapse in the past and periods of abrupt climate change arising from massive volcanic eruptions. Their work was followed by several published cases of claimed synchronous environmental (mainly climatic) and social transformations, and associated empirical evidence (e.g. Fang and Liu, 1992; Schwartz, 1992; Wright, 1993; Brown, 1994; Hoddel *et al.*, 1995; Buckland *et al.*, 1996; Van Geel *et al.*, 1996; Binford *et al.*, 1997; Hassan 1997a, b, 2002; Haberle and Chepstow-Lusty, 2000; Liu, 2000; Weiss, 2000; de Menocal 2001, Bird *et al.*, in press), and by the publication of several major texts, including Lamb (1995), Groves (1997), Fagan (2000a, b), and Davis (2001). Many of the published studies refer to sophisticated techniques of acquiring and analysing data, quantifying qualitative information, developing chronologies and establishing synchroneity between environmental and societal change parameters.

Establishing synchroneity between sets of variables is not the same as confirming a causal link, however. Nor is it alone likely to provide explanations that are resistant to deeper analysis or the inclusion of new data. Two examples highlight these weaknesses. First, many archaeologists have long accepted a climatic explanation for agrarian collapse in Andean prehistory (e.g. Shimada *et al.*, 1991). The idea has gained greater acceptability of late, as a result of increased awareness of climate variations associated with the El Niño Southern Oscillation (ENSO). Erickson (1999: 641) provides an alternative explanation: rather than a sudden climate-induced collapse following a long period of relative stability, Pre-Columbian states were 'ephemeral, rising and falling with some regularity'. Williams (2002) argues in favour of Erickson's interpretation, viewing cultural transformation in the Andes as the product of complex interactions between environment and human society. Second, recent improvements in the radiocarbon dating of palaeoclimatic evidence have led to a questioning of the orthodox explanation for the seemingly abrupt collapse of the Harappan (Indus) civilization of northern India and Pakistan – a shift towards climatically drier conditions *c.* 4450–3750 calibrated radiocarbon years ago (Singh *et al.*, 1972, 1990). Based on improved dating control, it is now believed that the climatic shift occurred earlier than previously thought (Enzel *et al.*, 1999), and that a recognizably Harappan culture continued to flourish along the Indus and its tributaries for at least another 1000 years following the onset of desiccation. A range of evidence now indicates that the eventual demise of Harappan civilization was brought about by a combination of factors, including geomorphic capture of the Sarasvati river (Valdiya, 1996), the breakdown of trade and an increased emphasis on local resources, leading to overexploitation, environmental degradation and reduced agricultural productivity (Weber, 1999).

FROM CAUSE AND EFFECT TO CAUSATION

The idea that the environment determines the features and fates of human societies, the basis of the theory of environmental determinism, became an important component of the explanatory toolkits of many geographers during the late nineteenth and early twentieth centuries. For example, Hellpach (1911), Semple (1911), Huntington (1915, 1926) and Taylor (1927, 1940) actively promoted the idea that just as the outward appearances of indigenes owed much to Darwinian processes of natural selection, in which the environment acts as both a driver of change and as a constraint on attainment, so too did characteristics such as perceived levels of innovation and economic development.

Environmental determinism has always had a climatic basis owing to the major role of climate in influencing overall environmental conditions. During the nineteenth and early twentieth centuries the theory came to underpin what Livingstone (1991: 414) terms a 'moral discourse of climate', which was founded upon and led to the reinforcement of a belief that 'salubrious climates' such as those of northern Europe 'produced superior peoples; pernicious climates' such as those of the tropics 'propagated inferior stock' (Livingstone, 1991: 426). Environmental determinism also penetrated disciplines other than Geography, notably the medical sciences. Thus distinguished figures in medicine, such as Dr Andrew Balfour, Director of the London School of Tropical Medicine (1923–1931), maintained that exposure to what were perceived to be enervating tropical climates was likely to lead to a deterioration in the physical, mental and even moral state of European colonists (Kennedy, 1990). Environmental determinism did not go unchallenged, however. Richardson (1996: 213) emphasizes that 'not all Western thinkers and policymakers accepted the ideas of environmental determinism and the social Darwinism that it embraced'. Those who questioned its explanatory appeal were in the ascendancy by the early twentieth century, with Carl Sauer (1952) arguing that human agency was a far

more potent force than had hitherto been assumed. More recently, Milton (1998) concluded that a greater appreciation of the complexity of both human culture and the environment and of the presence of cultural differences under relatively homogenous environmental conditions has further undermined the explanatory appeal of environmental determinism.

Two theories that rose to prominence during the twentieth century, partly in response to challenges to environmental determinism, are based on the assumption that 'choices are available to societies in a given environment, and that similar environments could host different human adaptations' (environmental possibilism), and that 'for a given society, one [possible adaptation] . . . is . . . probable' (environmental probabilism) (Knight, 1985: 20; and see Figure III.1).

Important weaknesses in the environmental determinism family of theories, aside from their links to positivism and reductionism, are their deficiencies in explanatory power – they are worldviews that explain everything and nothing – and indications of how a study of human–climate interactions might be conceptualized. Critically they largely ignore the purposive and reflexive characteristics of human agency. A far more powerful means of addressing the complexity of interactions between natural hazards and human societies is needed, one that incorporates both human agency and environmental processes and that conditions the shaping of society in ways that influence its vulnerability, as the following example of the onset of the Little Ice Age (LIA) and its intersection with the Great Famine in northern Europe during the early AD 1300s seeks to illustrate. A critical realist approach potentially provides a way forward in this respect. Rather that relying upon relatively simple and regular cause–effect relationships or vague notions of human–environment interactions – characteristics of the environmental determinism family of theories – critical realism provides a multilayered conceptual framework in which societal outcomes are seen as contingent, and emergent from a conjunction of a range of mechanisms and structures that are influenced by and influence both environmental and social conditions (Sayer, 1984, 2000) and go on to influence future outcomes. For critical realists therefore an understanding why something happens 'has nothing to do with the number of times we have observed it happening. Explanation depends instead on identifying causal mechanisms and how they work, and discovering if they have been activated and under what conditions' (Sayer, 2000: 14). The identification of causal mechanisms, how they work and whether and under what conditions they have been activated comprise the critical realist view of causation.

LITTLE ICE AGE CLIMATES AND THE GREAT FAMINE IN NORTHERN EUROPE, AD 1315–1322

The LIA was the most recent period of global glacier advance when temperatures were on the whole sufficiently low for glaciers to remain enlarged relative to the present. The beginning and end dates of the LIA vary from place to place, but are generally fixed at *c.* AD 1250–1300 and *c.* 1850–1890 (Grove, 2001). The timing of maximum severity also varies from place to place, with lowest minimum summer temperatures across many parts of Europe during the late AD 1500s, the 1600s and the early 1800s (Pfister, 1981).

The cause of LIA cooling is not known for certain, but variations in oceanic and atmospheric circulations are likely to have been important. Cold, dense, saline water is transported out of the polar latitudes at depth, to be replaced in the Global Ocean Conveyor (GOC) by relatively warm, surface-level currents of water (Broecker, 1991). In the North Atlantic, warm poleward-heading currents of water forming the Gulf Stream deliver heat to the Northern Hemisphere (equivalent to around 30 per cent of the direct input of solar energy according to Broecker and Denton (1990)), with its eastern arm, the North Atlantic Drift, ensuring that northern Europe is climatically relatively warm. In addition to affecting climate directly, ocean circulation is linked to atmospheric pressure patterns, and therefore indirectly to air temperature, precipitation levels and the incidence and severity of storms. In the mid-latitudes of the Northern Hemisphere, upper atmospheric flows are dominated by westerlies, which arise in response to temperature differences between high and low latitudes and that exert a strong influence on weather conditions at the Earth's surface (Edwards, 1998). Two of the major features of pressure distribution, the Icelandic Low and the Azores High, are connected in a see-saw arrangement known as the North Atlantic Oscillation (NAO) (Figure 7.1).

Rogers (1984) and Hurrell (1995, 1996) have defined indices of the NAO based on sea level pressure anomalies from recording stations located close to the areas of high and low pressure. Based on their research, a high-index pattern is characterized by an intense Iceland Low and a strong Azores High, whereas the see-saw effect is reversed during low-index conditions. The NAO index represents the strength of the mid-latitude westerlies. High-index NAO conditions are commonly associated in northern and western Europe with strong westerlies, a high incidence of storms in northern parts and mild winters, while low-index conditions are associated with incursions of cold polar winds from the north and east and therefore with much colder temperatures (Polonsky and Basharin, 2002). In extreme cases, low-index conditions cause a reversal of temperatures over Greenland and Europe (known as Greenland Above) (Fagan, 2000b).

Both the GOC and the NAO vary through time. Short-term fluctuations (days to weeks) in the NAO are thought to occur due to atmospheric processes alone. Long-term variations (months to decades of years) however appear to be intimately connected with alterations in the GOC, which itself is sensitive to perturbations caused by changes in insolation arising from variations in the Earth's orbit and, over shorter timescales, more subtle variations in solar activity, the salinity of polar waters (for example as a result of increased freshwater input from melting ice (Rahmstorf, 1994, 1995, 1997; Manabe and Stouffer, 1995)) and sea surface temperature anomalies in source areas for warm tropical waters,

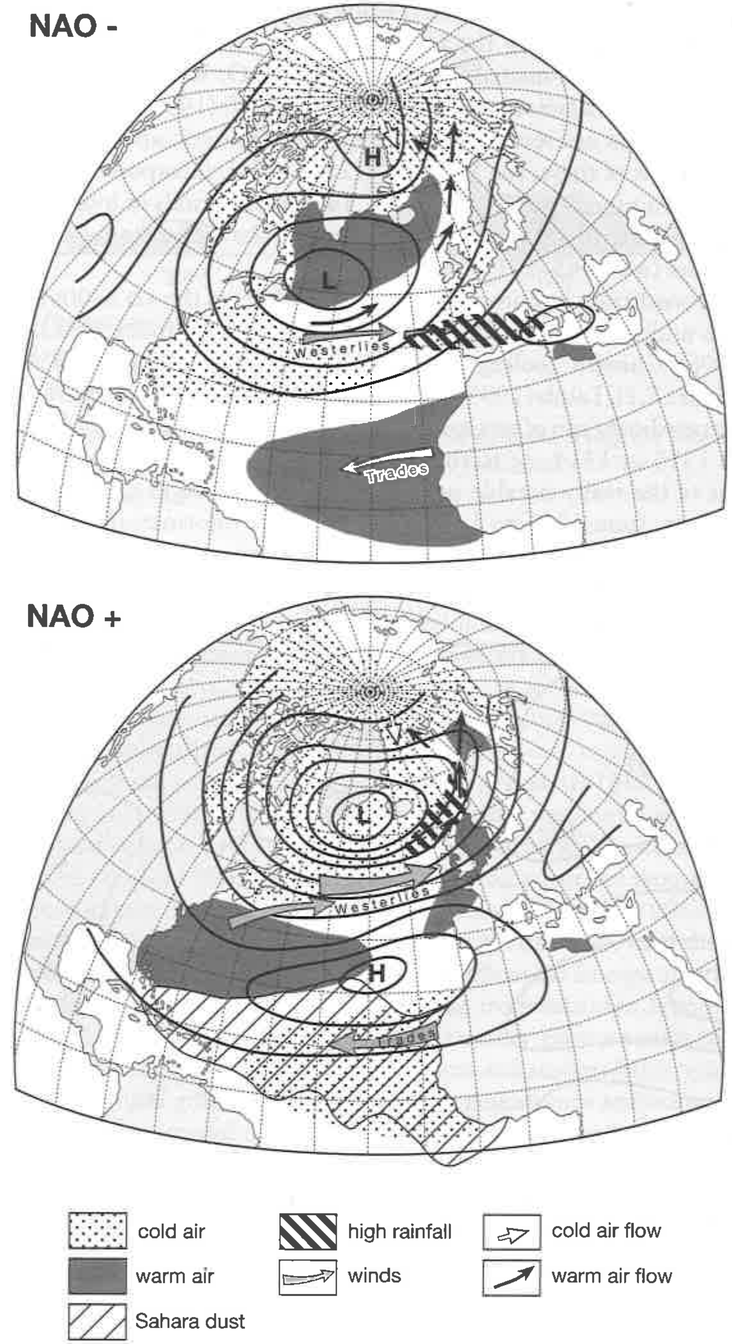


Figure 7.1 Distribution of low and high pressure cells in the North Atlantic, forming the North Atlantic Oscillation (NAO).

such as the West Pacific Warm Pool (Hendy *et al.*, 2002). A reduced GOC may have caused cooling during the LIA (Bianchi and McCave, 1999; Broecker, 2000), with any affect mediated through the NAO. Reduced solar activity may also have been a factor: according to Pfister *et al.* (1996), three periods of reduced insolation are recorded for the LIA in Antarctic and Greenland ice records; the first of these, the Wolf (AD 1280–1350), incorporates the period of the Great Famine in northern Europe. Two other periods of low insolation, recorded in Antarctic and Greenland ice cores, are the Spoerer (AD 1420–1540) and Maunder (AD 1645–1715) minima.

Climate conditions in Europe during the early part of the AD 1300s may also have been under the direct influence of a prolonged low-index NAO (Pfister *et al.*, 1996). Climatic cooling appears to have affected Europe soon after AD 1300 (Figure 7.2). Lamb (1995: 195) states that the early 1300s were marked by an 'extraordinary run of wet summers, and mostly wet springs and autumns, between 1313 or 1314 . . . to the early part of 1321 . . . [following] closely upon one of the really notable periods in the Middle Ages of mostly warm, dry summers, from 1284 to 1311'. According to information compiled by Alexandre (1987) from a large number of narrative sources, the early part of the AD 1300s in Europe was associated with some of the most severe weather in

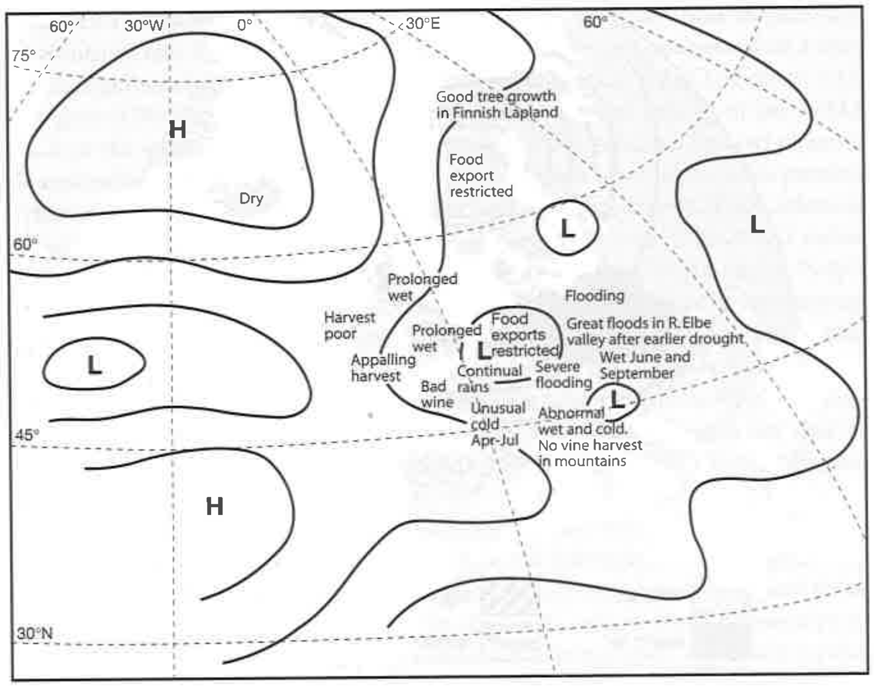


Figure 7.2 Europe in the early AD 1300s, and some of the main crises associated with the Great Famine.

Sources: based on figures in Lamb (1995) and Jordan (1996).

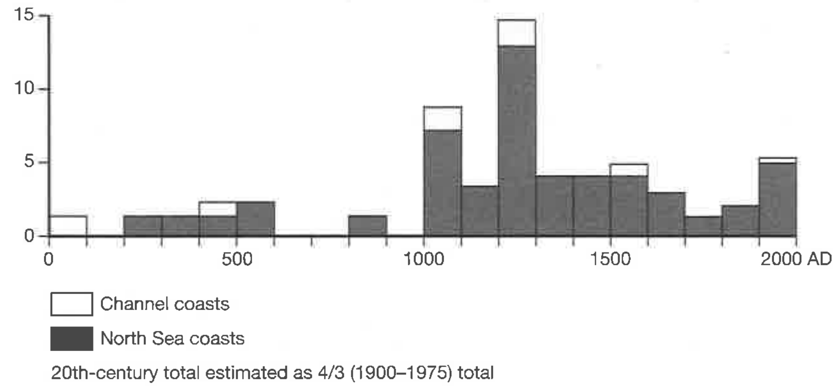


Figure 7.3 Incidence of storms and floods in coastal areas bordering the North Sea and English Channel during the period AD 0 to 2000.

Source: based on Lamb (1977, 1995).

the entire Middle Ages; winters were exceptionally cold throughout the period 1310–1330 and the summers were unusually wet between 1310 and 1320. Climate deterioration seems to have ushered in a period of synchronous dune development across northern Europe (Wilson and Braley, 1997) and devastating storms and floods were widely and frequently reported (Figure 7.3). Sand mobilized by a storm around AD 1316 may have caused abandonment of the port at Kenfig in southern Wales (Lamb, 1995).

Severe weather in northern Europe during the period AD 1310 to 1320, when anomalously cold winters alternated with unusually wet summers, overlapped with a period of acute and widely felt shortages of food, known as the Great Famine. An excess of 30 million people occupying an area of around 400,000 $miles^2$ in northern Europe may have been affected (Jordan, 1996). Extreme food shortfalls were experienced throughout the British Isles, with the possible exception of northern Scotland, and across continental Europe in a belt that extended from the Atlantic to the Baltic, and from southern Scandinavia in the north to the Alps in the south. The extremely poor weather hampered cultivation of soils already depleted of nutrients and susceptible to erosion and compaction, caused problems at harvest and during storage and transportation, and facilitated the spread of fatal diseases (or murrains) among domesticated animals.

Huge numbers of people died during the Great Famine. Echoing food crises of more recent times, many deaths are thought to have resulted from the spread of diseases such as typhus among people weakened by a reduced calorific intake and forced to cluster around the few points where food was available. Parts of heavily populated rural areas in southeastern and south-central England, for example, may have suffered a 10–15 per cent reduction in population during the years AD 1316–1318 (Jordan, 1996: 118). The death toll was also high in many towns, where dispossessed farmers and unemployed farm labourers inflated the numbers of the dead: inhabitants of Ypres may have suffered 10 per cent mortality during the summer of 1316 alone (Jordan, 1996: 146).

MULTILAYERED PERSPECTIVES

It would be easy to be seduced by apparent synchroneities between archaeological, climatic and historical evidence into concluding that the Great Famine was the result of a production crisis caused by successive years of poor weather. Such a conclusion fits easily within a perspective framed by the environmental determinism family of arguments, which prioritize the environment over human agency and positivist over realist modes of causation. However, while anomalous weather conditions held considerable importance for a minority of people living in specialized environments (Dyer, 1989), the perspective ignores the complexity of factors contributing to food insecurity. As demonstrated by recent famines, the most acute and widespread shortages of food are usually associated with a deep malaise within societal structures and political frameworks (e.g. Sen, 1981; Arnold, 1988; de Waal, 1997) in addition to the occurrence of natural hazards.

Furthermore, the adoption of a predominantly environmental perspective cannot fully account for the highly variable nature of human experiences of the famine. Minor lords and the rural and urban poor were generally the most severely effected. Others fared less badly; in England the sale of land by bankrupt lay and ecclesiastical lords allowed major landowners to consolidate their holdings and the development of a class of peasant farmers who owned the smallholdings they farmed (Dyer, 1989), while other individuals benefited by profiting from the sale of commodities, such as salt, at hugely inflated prices. Nor can the perspective provide an adequate explanation of why people in northern Europe were never again to experience food shortages of the extent or acuteness of the Great Famine (Jordan, 1996), despite the LIA continuing for another 500 years or so.

Some of the mechanisms and structures that predisposed northern European society to famine can be traced to contradictions within and interactions between a largely feudal society and the environment and were already in place by the early AD 1300s. Throughout the area affected by the Great Famine, levels of human populations had increased dramatically during the preceding hundred years or so; according to Abel (1980) the population of England had increased from around 1.5 million in the late AD 1000s to around 5 million by AD 1300, whereas that within the present borders of France had increased in roughly the same period from around 6.2 million to possibly as many as 21 million. By comparison, economic growth was comparatively sluggish, particularly during the late AD 1200s. Agricultural production, although more market oriented in less remote locations than it had been previously, was hampered by shortages of inputs in the form of capital investment and manure, with increments in output dependent upon extensification of farming rather

than intensification. An important reason for the growing crisis in agriculture was the disincentive to invest that was inherent within a feudal society (Bois, 1984) in which goods, services and cash flowed from peasants to the lords, to be spent 'on extravagant living, on the maintenance of numerous retinue, and on war' (Hilton, 1975: 177) rather than on the development and implementation of new technologies.

By the beginning of the fourteenth century competition over access to natural resources was severe, and a large proportion of the population farmed land that had recently been cleared of its forest cover (recently assarted land), or had previously been regarded as far too marginal to sustain agriculture. The productivity of long-farmed land was also in decline, because of the degradation of soils, continued mismanagement of the land and an increasing incidence of diseases of domesticated animals and plants. There is also good archaeological evidence that reductions in carcass weights of all the major domesticated animals had taken place in England by the AD 1300s, when compared to those of Roman and Anglo Saxon times, presumably because of a reduction in the availability of good pasturage (Grant, 1988). A limited infrastructure meant that it was extremely difficult to offset the impacts of these trends by shifting goods, including food, from areas of surplus to areas of high demand, a situation made worse by periodic warfare.

Inflation was also a factor. The prices of a range of commodities, including grain and salt, rose quickly during the early stages of the Great Famine, due in part to the requisitioning of supplies for armies, leaving wages in their wake. Here too the problem had its roots in earlier centuries, when population increases activated price rises above those of wages, so that by AD 1316 prices in England peaked at 150 per cent above and real wages fell to 75 per cent below their respective long-term averages (Campbell, 2000). Price hikes were a particular problem in towns where many people had no means of producing their own food and were increasingly squeezed by their weakening purchasing power. Inflation was also detrimental to many lay and ecclesiastical lords, whose incomes were largely derived from fixed rents. Jordan (1996) cites a number of cases of landowners who resorted to various means of rescheduling their debts, including annuities and the alienation of properties, or who were eventually forced to sell part or all of their properties, often at discounted prices. The collapse of income also caused some lords, especially those with small estates, to forsake direct exploitation of farmer-serfs in favour of leasing land to richer peasants. For many, financial problems were aggravated by high taxation to fund wars and planned crusades, and by the need to meet numerous demands for oblations. For example, thousands of acres of reclaimed marshland in eastern and southern England were lost to the sea as increasing royal taxation reduced the abilities of coastal communities to maintain sea defences at the very time that the frequency of storms and flooding was on the increase (Campbell, 2000).

It is perhaps surprising that seven years of anomalous weather conditions and famine in northern Europe did not lead to major and permanent societal changes, especially given that relationships between past periods of climatic change and transformations in society have been proposed for other parts of the world. The Black Death, a Europe-wide phenomenon that had its greatest impact on mortality in England between July 1348 and December 1349 and that recurred at intervals during the later part of the AD 1300s, had a far greater societal impact, bringing about a massive fall in demand for agricultural produce, disruptions to networks of trade and eventually major changes in farming (Campbell, 2000). The mobilization of available resources, including measures aimed at preventing the hoarding of food and price speculation, encouraging increased grain imports to compensate for harvest shortfalls, providing alms, mobile food kitchens and credit facilities, and the suspension of rents (Jordan, 1996), must have been critical to the prevention of more profound societal outcomes to the Great Famine. The structures of society are also likely to have played a part. For example, many people will have assumed that the prolonged catastrophe was due to a vengeful God, who was keen to mete out punishment on a sinful population (see, for example, Nicholas, 1992), and will have increased their piety and oblations accordingly. Through factors such as these elements, of northern European society, although shaken, were stirred to intervene to preserve the status quo (see, for example, Mate (1991: 89) in reference to southeast England).

Rather than a simple relationship in which anomalous weather conditions were the major determining causal factor, the Great Famine emerged from the conjunction and interaction of a complex of causal agents, one of which was a prolonged and initially unexpected deterioration in the weather around the beginning of the AD 1300s. Human agency was also critical, however, both in predisposing society to famine and in attempts to mitigate its most severe impacts. Northern Europe experienced a relatively rapid recovery in the aftermath of the Great Famine (Jordan, 1996). In hindsight, it could even be claimed that the crises of famine and plague during the AD 1300s resulted in a strengthening of European society. Dyer (1988) suggests that improved nutrition may have been one consequence, following changes in agriculture, population levels and increases in wages over prices. Reduced densities of population in some parts of England, together with the consolidation of holdings, contributed to increased capital investments, greater innovation and improved efficiencies in agriculture (Campbell, 2000). Similar developments across northern Europe presumably led to reduced vulnerability to severe food shortages, providing a possible explanation as to why food crises of the magnitude of the Great Famine did not recur during subsequent periods of anomalous weather conditions.

CONCLUSION

1. The conjunction of several environmental and social factors during the early AD 1300s increased vulnerability to major famine by predisposing extensive parts of northern Europe to severe food shortages. Some of these factors, including discrepancies between agricultural production and demand and wages and the cost of food staples, had developed over preceding centuries.
2. A number of consecutive years of anomalous weather in northern Europe during the early AD 1300s, most likely driven by natural oscillations in atmospheric and oceanic circulations, acted upon this predisposition to trigger a prolonged and in many instances an acutely felt famine.
3. Anomalous weather conditions were not the sole determinant of severe food shortages, nor did they determine collapse or even major changes in society. Moreover, subsequent periods of poor weather during the Little Ice Age did not have a similar level of impact on the availability of food.
4. Numerous attempts to link climatic variability to human history have utilized increasingly sophisticated sources of information. By comparison, little attention has focused on theoretical issues. Consequently, the environmental determinism family of theories has continued to influence attempts to explain apparently synchronous climate and societal change data.
5. Unravelling the complexity of interactions between climate change and human society demands an approach that recognizes the importance – and provides a means of establishing the characteristics – of human agency and societal structures in shaping vulnerability. Critical realism, which offers a multilayered and potentially interdisciplinary framework of study, deserves further consideration both as a means of researching vulnerability to natural hazards and as part of the theoretical foundations of a unified discipline of Geography.

References

Abel, W. (1980) *Agricultural Fluctuations in Europe: From the Thirteenth to the Twentieth Centuries*, translated by O. Ordish, London: Methuen.

Alexandre, P. (1987) *Le Climat en Europe au Moyen Age*, Paris: Ecole des Hautes Etudes en Sciences Sociales.

Arnold, D. (1988) *Famine, Social Crisis and Historical Change*, Oxford: Blackwell.

Bianchi, G.G. and McCave, I.N. (1999) 'Holocene periodicity in North Atlantic climate and deep ocean flow south of Iceland', *Nature*, 397: 515–517.

Binford, M.W., Kolata, A.L., Brenner, M., Janusek, J.W., Seddon, M.T., Abbott, M. and Curtis, J.H. (1997) 'Climate variation and the rise and fall of an Andean civilization', *Quaternary Research*, 47: 235–248.

Bird, M.I., Hope, G.S. and Taylor, D. (in press) 'Populating PEP II: the dispersal of humans and agriculture through Austral-Asia' *Quaternary International*.

Bois, G. (1984) *The Crisis of Feudalism*, Cambridge: Cambridge University Press.

Braudel, F. (1993) *A History of Civilizations*, translated by Richard Mayne, London: Penguin Books.

Broecker, W.S. (1991) 'The Great Ocean Conveyor', *Oceanography*, 4: 79–89.

Broecker, W.S. (2000) 'Was a change in thermohaline circulation responsible for the Little Ice Age?', *Proceedings of the National Academy of Sciences of the United States of America*, 97: 1339–1342.

Broecker, W.S. and Denton, H. (1990) 'What drives glacial cycles?', *Scientific American*, 262: 49–56.

Brown, N. (1994) 'Climate change and human history. Some indications from Europe, AD 400–1400', *Environmental Pollution*, 83: 37–43.

Buckland, P.C., Amorosi, T., Barlow, L.K., Mayewski, P., McGovern, T.H., Ogilvie, A.E.J. and Skidmore, P. (1996) 'Climate change and the end of Norse Greenland', *Antiquity*, 70: 88–96.

Campbell, B.M.S. (2000) *English Seigniorial Agriculture, 1250–1450*, Cambridge: Cambridge University Press.

Davis, M. (2001) *Late Victorian Holocausts: El Niño and the Making of the Third World*, London: Verso.

De Menocal, P. (2001) 'Cultural responses to climate change during the Holocene', *Science*, 292: 667–673.

De Waal, A. (1997) *Famine Crimes: Politics and the Disaster Relief Industry in Africa*, Oxford: James Currey.

D'Souza, F. (1988) 'Famine: social security and an analysis of vulnerability', in G.A. Harrison (ed.) *Famine*, Oxford: Oxford University Press, 1–56.

Dyer, C. (1988) 'Changes in diet in the Late Middle Ages: the case of harvest workers', *Agricultural History Review*, 36: 21–37.

Dyer, C. (1989) *Standards of Living in the Later Middle Ages: Social Change in England c. 1200–1520*, Cambridge: Cambridge University Press.

Edwards, R.J. (1998) 'Late Holocene relative sea-level change and climate in southern Britain', unpublished Ph.D. thesis, Department of Geography, University of Durham.

Enzel, Y., Ely, L.L., Mishra, S., Ramesh, R., Amit, R., Lazar, B., Rajaguru, S.N., Baker, V.R. and Sandler, A. (1999) 'High-resolution Holocene environmental changes in the Thar Desert, northwestern India', *Science*, 284: 125–128.

Erickson, C.L. (1999) 'Environmental determinism and agrarian "collapse", in Andean prehistory', *Antiquity*, 73: 634–642.

Fagan, B. (2000a) *Floods, Famines and Emperors. El Niño and the Fate of Civilizations*, London: Pimlico.

Fagan, B. (2000b) *The Little Ice Age. How Climate Made History 1300–1850*, New York: Basic Books.

Fang, J.-Q. and Liu, G. (1992) 'Relationship between climate change and the nomad southward migration in eastern Asia', *Climate Change*, 20: 151–169.

Grant, A. (1988) 'Animal resources', in G. Astill and A. Grant (eds) *The Countryside of Medieval England*, Oxford: Oxford University Press, 176–177.

Grove, J.M. (2001) 'The initiation of the "Little Ice Age" in regions round the North Atlantic', *Climate Change*, 48: 53–82.

Groves, R.H. (1997) *Ecology, Climate and Empire: Colonialism and Global Environmental History, 1400–1900*, Cambridge: The White Horse Press.

Haberle, S.G. and Chepstow-Lusty, A. (2000) 'Can climate influence cultural development? A view through time', *Environment and History*, 6: 349–369.

Hassan, F.A. (1997a) 'The dynamics of a riverine civilization: a geoarchaeological perspective on the Nile Valley, Egypt', *World Archaeology*, 29: 51–74.

Hassan, F.A. (1997b) 'Nile floods and political disorder in early Egypt', in H.N. Dalgrd, G. Kukla and H. Weiss (eds) *Third Millennium BC Climate Change and Old World Collapse*, Heidelberg: Springer-Verlag, 1–23 (NATO ASI Series, Volume 49).

Hassan, F.A. (2002) 'Palaeoclimate, food and culture change in Africa: an overview', in F.A. Hassan (ed.) *Droughts, Food and Culture: Ecological Change and Food Security in Africa's Later Prehistory*, Amsterdam: Kluwer, 11–26.

Hellpach, W.H. (1911) *Die Geopsychischen Erscheinungen: Wetter und Klima, und Landschatf in ihren Einfuß*, Leipzig: W. Engelmann.

Hendy, E.J., Gagan, M.K., Alibert, C.A., McCulloch, M.T., Lough, J.M. and Isdale, P.J. (2002) 'Abrupt decrease in tropical Pacific Sea surface salinity at the end of the Little Ice Age', *Science*, 295: 1511–1514.

Hilton, R.H. (1975) *The English Peasantry in the Later Middle Ages*, Oxford: Oxford University Press.

Hoddel, D.A., Curtis, J.H. and Brenner, M. (1995) 'Possible role of climate change in the collapse of Classic Maya civilization', *Nature*, 375: 391–394.

Huntington, H.E. (1915) *Civilization and Climate*, New Haven, CT: Yale University Press.

Huntington, H.E. (1926) *The Pulse of Progress*, New York: Scribner.

Hurrell, J.W. (1995) 'Decadal trends in the North Atlantic Oscillation: regional temperatures and precipitation', *Science*, 269: 676–679.

Hurrell, J.W. (1996) 'Influence of variations in extratropical wintertime tele-connections on Northern Hemisphere temperature', *Geophysical Research Letters*, 23: 665–668.

Jordan, W.C. (1996) *The Great Famine: Northern Europe in the Early Fourteenth Century*, Princeton, NJ: Princeton University Press.

Kennedy, D. (1990) 'The perils of the midday sun: climatic anxieties in the colonial tropics', in J.M. MacKenzie (ed.) *Imperialism and the Natural World*, Manchester: Manchester University Press, 118–140.

Knight, C.G. (1985) 'Geography's Worlds', in R. Abler, M. Marcus and J. Olson (eds) *Geography's Inner Worlds*, New Brunswick, NJ: Rutgers University Press, 9–26.

Lamb, H.H. (1977) *Climate: Present, Past and Future. Climate History and the Future*, London: Methuen.

Lamb, H.H. (1995) *Climate, History and the Modern World*, second edition, London: Routledge.

Liu, L. (2000) 'The development and decline of social complexity in China: some environmental and social factors', in P. Bellwood, D. Bowdery, J. Allen, E. Bacus and G. Summerhayes (eds) *Indo-Pacific Prehistory: The Melaka Papers Volume 4*, Bulletin of the Indo-Pacific Prehistory Association 20, Canberra: Australian National University, 14–34.

Livingstone, D.N. (1991) 'The moral discourse of climate: historical considerations on race, place and virtue', *Journal of Historical Geography*, 17: 413–434.

Manabe, S. and Stouffer, R.J. (1995) 'Simulation of abrupt climate change induced by freshwater input to the North Atlantic Ocean', *Nature*, 378: 165–167.

Mate, M. (1991) 'The agrarian economy of South-east England before the Black Death: depressed or buoyant?' in B. Campbell (ed.) *Before the Black Death: Studies in the Crisis of the Early Fourteenth Century*, Manchester: Manchester University Press, 79–109.

Milton, K. (1998) 'Ecologies: anthropology, culture and the environment', *International Social Science Journal*, 154: 477–496.

Nicholas, D. (1992) *Medieval Flanders*, London: Longman (cited in Jordan, 1996).

Pfister, C. (1981) 'The Little Ice Age: thermal and wetness indices', in R.I. Rotberg and T.K. Rabb (eds) *Climate and History*, Princeton, NJ: Princeton University Press, 85–116.

Pfister, C., Schwarz-Zanetti, G. and Wegmann, M. (1996) 'Winter severity in Europe: the fourteenth century', *Climatic Change*, 34: 91–108.

Polonsky, A.B. and Basharin, D.V. (2002) 'On the influence of the North Atlantic and Southern oscillations on the variability of air temperature in the Mediterranean–European region', *Izvestiya Atmospheric and Oceanic Physics*, 202(1): 119–128.

Rahmstorf, S. (1994) 'Rapid climate transitions in a coupled ocean–atmosphere model', *Nature*, 372: 82–85.

Rahmstorf, S. (1995) 'Bifurcations of the Atlantic thermohaline circulations in response to changes in the hydrological cycle', *Nature*, 378: 145–149.

Rahmstorf, S. (1997) 'Risk of sea-change in the Atlantic', *Nature*, 388: 825–826.

Richardson, B.C. (1996) 'Detrimental determinists: applied environmentalism as bureaucratic self-interest in the Fin-de-Siècle British Caribbean', *Annals of the Association of American Geographers*, 86: 213–234.

Rogers, J.C. (1984) 'The association between the North Atlantic Oscillation and the Southern Oscillation in the Northern Hemisphere', *Monthly Weather Review*, 112: 1999–2015.

Sauer, C.O. (1952) *Agricultural Origins and Dispersals*, Cambridge, MA: MIT Press.

Sayer, A. (1984) *Methods in Social Science: A Realist Approach*, London: Hutchinson.

Sayer, A. (2000) *Realism and Social Science*, London: Sage.

Schwartz, D. (1992) 'Assèchement climatique vers 3 000 BP et expansion Bantu en Afrique centrale atlantique: quelques réflexions', *Bulletin Societie de Géologie France*, 163: 353–361.

Semple, E.C. (1911) *Influences of Geographic Environment*, New York: Henry Holt and Co.

Sen, A. (1981) *Poverty and Famines: An Essay on Entitlement and Deprivation*, Oxford: Oxford University Press.

Shimada, I., Schaaf, C.B., Thompson, L.G. and Moseley-Thompson, E. (1991) 'Cultural impacts of severe droughts in the prehistoric Andes: applications of a 1,500 year ice core precipitation record', *World Archaeology*, 22: 247–270.

Singh, G., Joshi, R.D. and Singh, A.B. (1972) 'Stratigraphic and radiocarbon evidence for the age and development of Three Salt Lake deposits in Rajasthan, India', *Quaternary Research*, 2: 496–505.

Singh, G., Wasson, R.J. and Agrawal, D.P. (1990) 'Vegetational and seasonal climatic changes since the last full glacial in the Thar Desert, northwestern India', *Review of Palaeobotany and Palynology*, 64: 351–358.

Taylor, T.G. (1927) *Environment and Race: A Study of the Evolution, Migration, Settlement and Status of the Races of Man*, Oxford: Oxford University Press.

Taylor, T.G. (1940) *Australia: A Study of Warm Environments and Their Effect on British Settlement*, London: Methuen.

Valdiya, K.S. (1996) 'River piracy, Sarasvati that disappeared. Bangalore Indian Academy of Sciences,' *Resonance*, 1, 5: 19–28.

Van Geel, B., Buurman, J. and Waterbolk, H.T. (1996) 'Archaeological and palaeoecological indications of an abrupt climate change in The Netherlands and evidence for climatological teleconnections around 2650 BP', *Journal of Quaternary Science*, 11: 451–460.

Weber, S. (1999) 'Seeds of urbanism: palaeoethnobotany and the Indus Civilization', *Antiquity*, 73: 813–826.

Weiss, H. (2000) 'Beyond the Younger Dryas: collapse as adaptation to abrupt climate change in ancient west Asia and the eastern Mediterranean', in G. Bawden and R. Reycraft (eds) *Confronting Natural Disaster: Engaging the Past to Understand the Future*, Albuquerque: University of New Mexico Press, 75–98.

Williams, P.R. (2002) 'Rethinking disaster-induced collapse in the demise of the Andean highland states: Wari and Tiwanaku', *World Archaeology*, 33: 361–374.

Wilson, P. and Braley, S.M. (1997) 'Development and age structure of Holocene coastal sand dunes at Horn Head, near Dufanaghy, Co. Donegal, Ireland', *Holocene*, 7: 187–197.

Winkless, N. and Browning, I. (1975) *Climate and the Affairs of Men*, London: The Scientific Book Club.

Wright, H.E. Jr. (1993) 'Environmental determinism in Near Eastern prehistory', *Current Anthropology*, 34: 458–469.