Katrin Pfeifer · Niki Pfeifer
Editors

Forces of Nature and Cultural Responses

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ISBN 978-94-007-4999-3 ISBN 978-94-007-5000-5 (eBook)
DOI 10.1007/978-94-007-5000-5
Springer Dordrecht Heidelberg New York London

Library of Congress Control Number: 2012953107

This volume is dedicated to
J. Donald Hughes
on the occasion to celebrate his 80th birthday.

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Key Publications

- Blampied, N. M.: Single-case research designs and the scientist-practitioner ideal in applied psychology. In G. Madden (Ed.). Handbook of Behavior Analysis, Vol 1. Washington, DC: American Psychological Association, 2012, 177–197.
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Key Publications

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Key Publications

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Key Publications

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Key Publications

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Key Publications

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- Kemp, S.: Medieval psychology. Westport, Conn.: Greenwood, 1990.

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Key Publications

- Keul, A. G.: Zur Akzeptanz des Passivhauses im Massenwohnbau. Evaluation (POE) acht österreichischer Siedlungen und Vergleich mit konventionellen Bauten. Umweltpsychologie 14(1) 2010, 66–88. (Paper on the acceptance of passive housing estates.)
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Key Publications

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Key Publications

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Key Publications

- Pfeifer, N.: On argument strength. In F. Zenker (Ed.), Bayesian Argumentation. Berlin, Heidelberg: Synthese Library (Springer), in press.
- Pfeifer, N.: Experiments on Aristotle's Thesis: Towards an experimental philosophy of conditionals. The Monist, 95(2) 2012, 223–240.
- Hauer, K. and Pfeifer, N.: Reporting on historical severe storms: Two examples of Utrecht (1674) and Abtenau (1796). Atmospheric Research 100(4) 2011, 580–585.

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Key Publications

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- Raeburn, B. B.: Stars of David and sons of Sicily: Constellations beyond the canon in early New Orleans jazz. Jazz Perspectives 3(2) 2009, 123–152.
- Raeburn, B. B.: They're tryin' to wash us away': New Orleans musicians surviving Katrina, The Journal of American History 94(3) 2007, 812–819.

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Key Publications

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- Whiteford, L. M. and Trotter, R. T.: Anthropological ethics for research and practice. Long Grove, Illinois: Waveland Press, 2008.
- Whiteford, L. M. and Whiteford, S. (Eds.): Globalization, water and health: Resources in times of scarcity. Santa Fe, New Mexico: School of American Research Press, 2005.

Acknowledgments to Reviewers

The editors express their sincere gratitude to the following reviewers who generously contributed their time, expertise and efforts during two or even three reviewing rounds for the substantial benefit of the included chapters:

- Gregory S. Aldrete (University of Wisconsin-Green Bay, USA)
- Ari Belasen (Southern Illinois University Edwardsville, USA)
- Bob Bolin (Arizona State University, USA)
- Vladimir L. Bychkov (Russian Academy of Science, Russia)
- Eduardo A. Cavallo (Inter-American Development Bank, USA)
- Makena Coffman (University of Hawaii at Manoa, USA)
- Robert K. Doe (Tornado and Storm Research Organisation (TORRO), UK)
- Peter van Doorn (Tornado and Storm Research Organisation (TORRO), UK)
- J. Donald Hughes (University of Denver, USA)
- Eric C. Jones (UNC-Greensboro, USA)
- Alexander G. Keul (University of Salzburg, Austria)
- Carry van Lieshout (King's College London, UK)
- Myles McCallum (Saint Mary's University, Canada)
- Floyd McCoy (University of Hawaii-Windward, USA)
- Douglas Paton (University of Tasmania, Australia)
- Lawrence N. Powell (Tulane University, USA)
- Bruce I. Sacerdote (Dartmouth College, USA)
- David N. Sattler (Western Washington University, USA)
- Mark Stenhoff (author of *Ball lightning: An unsolved problem in atmospheric physics*, Kluwer Academic/Plenum Publishers)
- Victoria Sword-Daniels (University College London, UK; University of Canterbury, New Zealand)
- Graham A. Tobin (University of South Florida, USA)
- Jonathan Webb (Tornado and Storm Research Organisation (TORRO), UK)
- Linda Whiteford (University of South Florida, USA)
- Thomas Wilson (University of Canterbury, New Zealand)

Moreover, the editors express their sincere gratitude to the following reviewers of contributions to *Forces of Nature and Cultural Responses*. Although these contributions were finally not included in the volume, the editors nevertheless wish to acknowledge sincerely *all* reviewers.

- Gregory S. Aldrete (University of Wisconsin-Green Bay, USA)
- Gregory Button (University of Tennessee, Knoxville, USA)
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The editors hope that no reviewer of contributions to *Forces of Nature and Cultural Responses* is left out in the above lists.

Contents

Chapter 1
Forces of Nature and Cultural Responses: An Introduction

Niki Pfeifer and Katrin Pfeifer

If the past is not usable, then history is an enterprise in vain.

J. Donald Hughes[1]

Investigations of the impact of forces of nature on humans and cultural responses have become popular in recent years (see, e.g., Alexander 2002; Torrence and Grattan 2002; Wisner et al. 2004; Perry and Quarantelli 2005; Rodriguez et al. 2007; Mauch and Pfister 2009; Bobrowsky 2012). This volume investigates relationships between forces of nature and human culture (broadly construed) in a multidisciplinary context bridging science and the humanities. Forces of nature include various extreme natural phenomena like lightnings, earthquakes, tsunamis, volcanic eruptions, plagues, hurricanes, and floods. Forces of nature may culminate in disasters if living beings are severely threatened, harmed, or even killed and everyday life is seriously interrupted. *The International Federation of Red Cross and Red Crescent Societies* defines "disaster" as a "sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or

[1] Interview with Hughes (2010, p. 308).

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K. Pfeifer and N. Pfeifer (eds.), *Forces of Nature and Cultural Responses*,
DOI 10.1007/978-94-007-5000-5_1,

society's ability to cope using its own resources".[2] Causal analyses, management and prevention strategies, social networks, economic aids, and political acts are just a few of various cultural responses to forces of nature. People, peoples, and states deal and dealt with forces of nature throughout history.

The aim of this volume is to provide an overview of selected issues in disaster research bringing together overviews and case studies of forces of nature and cultural responses from Ancient Times until nowadays. This volume investigates not only "classical" forces of nature but also controversial ones like ball lightning. Moreover, the volume includes not so obvious but interesting and important impacts of forces of nature on human culture, for example, the impact of earthquakes on academic performance and hurricane Katrina's impact on the current jazz scene in New Orleans.

A key feature of current disaster research is its high interdisciplinary, which is also reflected in this volume and even within the coauthorships of some of the chapters. We bring together scholars of disaster research from various disciplines, including environmental history, ancient history, environmental anthropology, psychology, meteorology, historical geography, and a jazz expert. Each chapter is as self-contained as possible, and the reader is invited to go back and forth, led by her/his scientific interests.

This volume is structured into four sections:

- Section 1 investigates theories and case studies of ball lightning phenomena.
- Section 2 includes a psychological study on the impact of earthquakes on academic performance, a study on tsunami vulnerability and recovery strategies in Thailand, and a study on the social and economic aftermaths of a tsunami and a hurricane in Hawaii.
- Section 3 consists of a chapter on volcanic eruptions and plagues as well as cultural responses in Ancient Times and a study on contemporary vulnerability and resilience under chronic volcanic eruptions.
- Section 4 investigates the impact of hurricane Katrina on the current jazz scene in New Orleans and cultural responses to floods in The Netherlands in Early Modern Times.

In the first section, Robert K. Doe introduces and critically discusses ball lightning research from various angles. He reports historical and contemporary cases of ball lighting phenomena, human interactions, current theories, and models of ball lightning and discusses laboratory experiments that aim to produce such phenomena. Finally, Doe surveys various skeptical arguments against the existence of ball lightning. Doe concludes his chapter by observing that some significant progress has been made in the understanding of ball lighting phenomena, that they exist, but that they are also scientifically hard to deal with.

[2] http://www.ifrc.org/en/what-we-do/disaster-management/about-disasters/what-is-a-disaster/ (retrieved on May 24, 2012).

Doe's chapter serves as an introduction to the second chapter of Section 1 by Alexander G. Keul. Keul discusses various epistemological problems in ball lightning research associated to the classification, reports, analysis of residues, and laboratory simulations of ball lightning phenomena. He analyzes the psychological level of witnesses, scientists, the media, and the public. Perceptions, scientific accounts, and how ball lightning phenomena are treated in the media as well as in the public are diverse forms of cultural responses to ball lightning phenomena. Moreover, Keul's chapter includes an analysis of the Montafon photograph, the Zwoenitz video of ball lightning phenomena, and international ball lightning statistics. Keul concludes his chapter by mentioning obstacles and chances for future ball lightning research.

Section 2 investigates earthquakes, tsunamis, and hurricanes. Simon Kemp, William S. Helton, Jessica J. Richardson, Neville M. Blampied, and Michael Grimshaw report two psychological studies on the impact of the 2011 earthquake in Christchurch, New Zealand—which affected the University of Canterbury—on academic performance. Kemp et al. observed that students showed higher levels of depression, anxiety, and stress compared with earthquake-unaffected controls. Interestingly, the overall grade performance was better than the performance in the comparable period before the earthquake occurred. The authors discuss different psychological impacts of the earthquake and conclude that people exposed to a natural disaster are quite resilient and have the potential to regain healthy functioning after such an event.

The second chapter in Section 2 by Khanin Hutanuwatr, Bob Bolin, and David Pijawka provides an analysis of the recovery dynamics and the role of community-based organizations of a representative village which was affected by the 2004 Indian Ocean Tsunami. This case study discusses results from more than 100 in-depth interviews performed during extensive fieldwork in the time period between 2005 and 2009. The chapter concludes by discussing implications for vulnerability reduction in coastal regions.

The third chapter in Section 2 by John Lynham and Ilan Noy investigates long-term socioeconomic consequences of coastal disasters in Hawaii. Specifically, the authors describe the macroeconomy and the aftermaths in the affected regions of the 1960 tsunami and the hurricane Iniki, which hit Hawaii in 1992. The chapter is concluded by comparisons with other disasters. Considering the vulnerability of coastal regions to tropical storms, floods, and earthquake-generated tsunamis, the authors point to distressing prospects for further future long-term economic consequences.

Section 3 investigates volcanic eruptions and plagues. In the first chapter of this section, J. Donald Hughes surveys various kinds of natural disasters in Ancient Times and focuses on two case studies. Based on eyewitness accounts and archaeological and scientific studies, the author analyzes the 430 BCE plague that raged over Athens and the volcanic eruption of Mount Vesuvius, which devastated Pompeii in 79 CE. Hughes observes that ancient cultural responses to forces of nature were to a great extent uninformed, chaotic, and inadequate.

In the second chapter of Section 3, Graham A. Tobin and Linda M. Whiteford identify provisioning capacity as a critical component of vulnerability and resilience under chronic volcanic eruptions. Based on extensive fieldwork in Ecuador, the authors report various qualitative and quantitative data investigating perception, damage, mitigation, health issues, behavioral changes, housing, environmental impacts, and economic consequences of the highly active volcano Mount Tungurahua since 1999.

Section 4 investigates cultural response to hurricanes and floods. Bruce Boyd Raeburn reconstructs the development of the New Orleans jazz scene in the aftermath of hurricane Katrina. While Katrina was not the first hurricane that hit New Orleans, it was characterized with intensely increased media coverage compared with previous disasters. Raeburn's chapter is a case study of how jam sessions help to mentally deal with natural disasters: new possibilities and the whole emotional spectrum ranging from sorrow to joy are key features of the jazz culture.

The last chapter of the volume, written by Adriaan M.J. de Kraker, compares two flooding disasters that raged over The Netherlands in 1682 and in 1715. The key finding consists in the observation that people dealt more efficiently with the 1715 flooding compared with the flooding in 1682. Damage assessment, improvements in dike building, and revised legislation improved the situation in the aftermath of the flooding disaster of 1715. This indicates that a great deal was learned from previous flooding events.

How do and how did people perceive, manage, and respond to natural disasters? How are the causes of natural disasters explained in history, and how are they explained today? These are the guiding questions which constitute the common theme throughout the volume. The chapters provide answers from diverse disciplines and methodological points of views. Taken together, the chapters illustrate the high complexity of the relations between forces of nature and cultural responses.

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Section 1
Ball Lightning

Chapter 2
Ball Lightning: An Elusive Force of Nature

Robert K. Doe

Abstract Ball Lightning (BL) is a metastable, rare phenomenon and one of the most unusual and controversial. Reports have been numerous and varied, and have fascinated and perplexed researchers for centuries. Ball lightning has proved impossible to predict and is extremely difficult to document in the natural environment. Laboratory attempts at simulation have been challenging. However, much discussion has been detailed in the literature and countless laboratory experiments presented. Ball lightning has been witnessed indoors, outdoors, and from the skies by aviation professionals and passengers. Critics claim the phenomenon does not exist. It has been discounted as hallucinations, misidentification, and folklore. This chapter examines theory and development, along with historical and contemporary discussion of the phenomenon.

Keywords Ball lightning • Plasma physics • Electrical discharges • Atmospheric electricity • Ball lightning interactions

2.1 Introduction

One of the aims of this collected works is to examine relationships between specific natural forces and culture, thereby bringing together facets of earth sciences and historical geography. If there is one subject that fits these disciplines well, it is the history and science of ball lightning. Ball lightning (BL) is a fascinating preternatural phenomenon, fascinating because it remains a scientific enigma. Despite thousands of sightings and scientific publications on the subject, ball

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K. Pfeifer and N. Pfeifer (eds.), *Forces of Nature and Cultural Responses*,
DOI 10.1007/978-94-007-5000-5_2,

lightning remains in a highly debatable arena. So what exactly is ball lightning? This is a difficult question to answer concisely as there is no widely accepted theory or consensus as to what ball lightning is.

Ball lightning is often interpreted as an atmospheric electrical phenomenon, more often observed during or shortly after electrical storms, but not necessarily a direct consequence of such. It is not deemed a subset of linear lightning. It is self-contained, luminous, independent, and commonly globe-shaped. Its size varies, and reports suggest sizes between a few centimeters to as large as many meters in diameter. It appears spontaneously and lasts only seconds. On dissipation, it can explode or disintegrate either with noise or without noise (some observers have described a "crackling" sound). Some observers have reported heat, whereas others have reported none. Odors have been described, some resembling ozone, nitrogen oxide, or sulfur, and colors have been described as ranging from red to yellow and blue to white. This is a phenomenon of many variables.

Observations on ball lightning have been global, and research has been international. Numerous event databases have been composed and statistical analyses performed, particularly in the USA (McNally 1961, 1966), United Kingdom (Tornado and Storm Research Organization (Meaden 1973, 1976, 1985, 1990)), Russia (Bychkov et al. 1993), Austria (Keul and Stummer 2002), Germany (Keul et al. 2006) and Japan (Ohtsuki and Ofuruton 1987), to name a few. While there is some consensus in the results of these international data, for example, that of size, shape, color, and lifetime, there are also some conflicts, particularly when it comes to formation theory. Research by McNally (1966) obtained interesting results after the author surveyed, via a questionnaire, 1.962 Oak Ridge National Laboratory employees, 5.6% of whom reported that they had seen ball lightning. When the results were analyzed, it was deduced that ball lightning:

> "...can move along wires, float in air, jump back from earth, rotate and roll, move straightly, or stay motionless. A spherical form is the dominant one. Its size can range from 2 cm to 2 m, and the most probable size is 24 cm ... The predominant color group is red–orange–yellow (57.5%), with white color observed in 28.8% of the cases, and 13.7% of the cases falls under the color range green to violet. The duration of existence of BL [ball lightning] ranges from parts of the second to 2 min; the average time is about 3 s. It usually disappears quickly (often with an explosion)." (McNally 1966)

Ohtsuki and Ofuruton (1987) compared >2.000 observations in Japan with databases from Europe and the USA. They found only 3% of cases were observed during thunderstorms in comparison to some 95% in Europe which were observed in thunderstorm conditions. Both databases demonstrated a peak occurrence in August, and there was some correlation between the distribution of observations and the distribution of thunder. It should be noted that the spatial distribution of observations can also be linked to population density. There has been much research on seasonal lightning in Japan (Takeuti et al. 1973). Regional and seasonal variations are discussed in detail by Rakov and Uman (2003) with particular reference to winter lightning discharges in the coastal area of the Sea of Japan. Rakov and Uman (2003) discuss many unique regional winter features (e.g. lightning flashes lower than in summer storms, lightning strikes to tall structures is greater), which

suggests Japan has a complex regional and seasonal lightning climatology. Much research continues in this area (Ishii et al. 2011; Shindo et al. 2011) in an effort to better understand these variations.

Observations of ball lightning can be found back as far as the sixteenth century (Gloucestershire, U.K. in 1556 (Stenhoff 1999)), and there has been an enormous wealth of reports and literature on the subject since. It would be impossible to review and summarize them all; however, contained herewith is a brief review of selected key literature. One of the earliest, authoritative, and scientifically oriented texts on ball lightning was by Brand (1923), *Der Kugelblitz*. Interestingly, Brand started his book with a quote from Arago (1838): "The problem with ball lightning. There is only one instance," writes F. Arago in his classical treatise – "*Sur le tonnerre*" – "in which the physicist cannot accomplish what nature can effect with so much ease: he cannot produce lightning in the form of a ball; in fact, he cannot produce ball-shaped accumulations of matter which move slowly yet strike like *lightning*." These words are apt today.

Considering the early forms of communication and dissemination before the comparative ease of the "digital age," what Brand attempted must be admired. He collected and analyzed European ball lightning reports, presenting what was a very detailed assessment, which included diurnal trends. A lower incidence was suggested during morning thunderstorms (0000–1200 UTC) than during afternoon thunderstorms (1200–0000 UTC). The annual trend of ball lightning incidence correlated with that of thunderstorm incidence in Central Europe; however, the relative incidence for ball lightning was seen to be lower in May and June and higher in December to March. He analyzed the shape of ball lightning from 178 cases, with descriptions ranging from egg-shaped, oval-shaped, oblong, oval fireball, a tongue of fire, balloon shape, lamp shade, heart, diamond, star, incandescent lamp, amphora, curved cucumber, a round flame, rod-like, pillar-shaped, balls of flames, and clumps of fire. The sizes are discussed in detail and reported as being from the size of a pea up to 27 m in diameter! Rotation and color were also analyzed, with the majority of balls being reported as white, bluish white, blue, green yellow, red–yellow, red as well as a mix of color. One of the more interesting analyses was that of odor, which was frequently described as sulfurous. Reports of ball lightning odor are fascinating with some mentioning the combined smell of "sulfur and garlic" (which Brand (1923) noted as reminiscent of ozone), nitrous oxide, and often gunpowder (similar to the smell of burnt sulfur). However, it is also discussed that no odor can also be experienced. Brand also included many selected case study reports between the years 1665 and 1919, with the majority of discussion on nineteenth-century events.

There are a number of seminal texts on ball lightning which provide useful background for researchers in the field. The title by Singer (1971) called *The Nature of Ball Lightning* presented insightful chapters, particularly on storm lightning and the problems associated with researching ball lightning, ball lightning in the pre-scientific era (and the problems of misidentification with meteors and complex conventional lightning paths (Holzer and Workman 1939)), photographs, characteristics, theories, and experiments along with key observations. Some of the

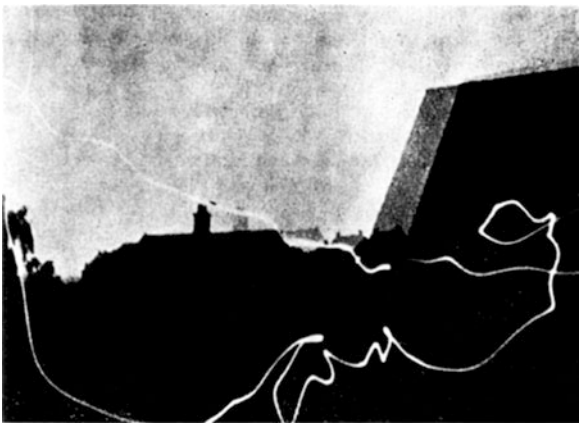

Fig. 2.1 A ball lightning photograph? Image adjusted with contrast enhancement, which shows camera movement (Photograph by M. Bird and discussed by Petersen (1952, 1954). Adapted from and with kind permission of Springer Science + Business Media: Singer (1980), Springer-Verlag, Heidelberg)

early observations are still highly debated, and Singer (1971) made reference to what *could* be the first reported case in the works of St. Gregory of Tours dating from the sixth century AD (Bougon 1902): "A fireball of blinding brightness appeared over a procession of religious and civil dignitaries of Tours during the dedication of a chapel. The sight was so terrifying that all the people in the procession threw themselves to the ground."

Singer (1971) reported an additional event from 793 AD during a heavy storm and "fire dragons" being observed in addition to intense lightning (Algeo and Pyles 1966). In the chapter *Photographs of Ball Lightning*, one of the most debated images of ball lightning to date is discussed (Fig. 2.1). This photograph has been discussed by Muller-Hillebrand (1963), Singer (1971), Barry (1980), and Stenhoff (1999). The photographer and eyewitnesses claimed the image was ball lightning, but critics claimed it was camera motion and a street light effect. Barry (1980) stated: "Based upon the evidence available, the identification of the photograph must remain questionable but cannot be termed erroneous at this time." Stenhoff (1999) also made reference to camera motion, noting that, "... background images are duplicated, indicating camera motion." Figure 2.1 has been adapted to include enhanced contrast. The building image and chimney are clearly duplicated in the image, indicating some camera movement. The witnesses claim that street lights were not lit at the time. After 68 years and much discussion, questions still remain about this image.

The text by Barry (1980) defined the difference between bead lightning (a string of luminous lightning segments) and ball lightning, and his work followed in a similar style to that of Singer's. This is a very detailed book with thorough chapters on deduced ball lightning characteristics, photographs, and laboratory experiments. The book was one of the first to dedicate a chapter to skepticism associated to ball lightning, which is particularly relevant when evaluating photographic evidence. Stenhoff (1999) published what could be described as a thorough treatise on the subject, which included the history of ball lightning and observations and defining characteristics of the phenomenon. Like Barry (1980), it presented a critical

analysis, and the chapter "Phenomena that may be mistaken for ball lightning" is important in assessing the pitfalls of misinterpretation and examines a wide range of conditions from corona discharges to insect swarms! Of particular interest to ball lightning researchers will be the assessment chapters which examine electrical, thermal and mechanical risks, death and injury, risk to buildings, aircraft and trees. Stenhoff (1999) listed >2.000 references on the subject. This demonstrates the vast amount of available literature. Volumes by Rakov and Uman (2003) and Bychkov et al. (2010) present a general review of investigations and included discussion on observation data, experimental modeling, and theoretical approaches. Rakov and Uman (2003) present a useful overview of ball lightning with over 200 references on the subject, selected case studies from around the world, discussion of statistics and theories, and laboratory simulation, along with the bead lightning, volcanic lightning, earthquake lightning, and nuclear lightning.

2.2 Case Studies

Research into ball lightning takes three primary approaches: observations, theory, and laboratory experiments. Were a researcher to collect all known observations of ball lightning, this would be an immense volume. The number of observational reports for ball lightning is in the thousands. Rakov and Uman (2003) summarized just nine studies which recorded >4.000 observations (Brand (1923) 215 reports; Humphreys (1936) 280; McNally (1961, 1966) 498; Barry (1967) 400; Rayle (1966) 112; Charman (1979) 68; Egely (1989) 380; Bychkov et al. (1993) 2.500; Hubert, (1996) 253). However, it should be noted that duplication between databases is not always taken into account in these figures.

When investigating ball lightning, principle questions should be asked relating to the time, locale, corroboration, key characteristics, and prevailing weather conditions (Table 2.1).

Analyzing ball lightning observations is not an easy task, particularly with reports from historical literature (especially in times when atmospheric science was not so well understood). One of the earliest reports of possible ball lightning dates from the seventeenth century and occurred at Widecombe-in-the-Moor, Devon, UK, on 21 October 1638. The event allegedly resulted in the loss of four lives. Figure 2.2 presents extracts written (in old English) shortly after the event and details an important early source of what was probably lightning, ball lightning, and maybe even tornado activity.

The event was clearly a devastating thunderstorm and lightning strike, but accounts from the congregation present anecdotal evidence of a large separate fireball entering the church (Fig. 2.3). The fireball was described as approximately 8 ft (2.4 m) in diameter, with a "foul sulphurous odour." In addition to the fatalities, 60 people were severely injured and some were described as having their bodies burnt, but clothes untouched. The storm had other severe meteorological impacts in nearby Brixham, Devon, UK, where hailstones as big as "turkey eggs" and weighing "6–7 ounces" (circa. 0.18 kg) were reported. An analysis of the primary source in

Table 2.1 Preliminary questions on observation of ball lightning

Location and witness data	
Date, time and location	Witnesses details
Key characteristics	
Size	Shape
Color	Duration
Luminosity	Motion
Heat	Sound
Changes (in size or shape)	Smell
Formation	Decay (silent or explosive)
Weather conditions	
Storm conditions present/not present	
Connection with lightning or lightning flash	

A more detailed questionnaire adapted from the work of Rayle (1966) can be found in Appendix A of Stenhoff (1999)

VPon Sunday the 21. of *October* last, In the Parish Church of *Withycombe* in *Devonshire* neare *Dartmoores*, there fell in time of Divine Service a strange darkenesse, increasing more and more, so that the people there assembled could not see to reade in any booke, and suddenly in a fearefull and lamentable manner, a mighty thundering was heard, the ratling whereof did answer much like unto the sound and report of many great Cannons, and terrible strange lightening therewith, greatly amazing and astonishing those that heard and saw it, the darkenesse increasing yet more, till they could not (in the interim) see one another; the extraordinarie lightning came into the Church so flaming, that the whole Church was presently filled with fire and smoke, the smell whereof was very loathsome, much like unto the sent of brimstone, some said they saw at first a great ball of fire come in at the window and passe thorough the Church, which so much affrighted the whole Congregation that the most part of them fell downe into their seates, and some upon their knees, some on their faces, and some one upon another, with a great cry of burning and scalding, they all giving up themselves for dead.

Fig. 2.2 Extract (in old English) from: Anon (1638a) Printed by G.M. for R Harford, London 1638 (A copy of this text is held in the Henry E. Huntington Library and Art Gallery (STC 25607, ESTC S119945, call number 22303))

conjunction with additional sources (Anon 1638b; Taylor 1638; Rowe 1905) was presented by Pfeifer and Pfeifer (2011) who discussed interpretation along with societal and cultural responses from this extreme weather event.

The first meeting of scientists investigating atmospheric electricity and ball lightning was in 1753 (Bychkov et al. 2010) and there are numerous ball lightning reports from the eighteenth century. The following is translated from Brand (1923): *July 1744. Knifvings Gut. Sestier.* "*De la foudre, de ses formes et de ses effets.*" *1, 119, Paris 1866*:

Fig. 2.3 The woodcut engraving depicts a lightning strike and separate 'fireball' which struck the church and congregation during service. [Original text in old English]: 'A most prodigious & fearefull storme of winde lightning & thunder, mightily defacing Withcomb-church in Deuon, burneing and slayeing diverse men and women all this in service-time, on the Lords day Octob: 21-1638.' Image originally published in Vicars (1643). A reproduction of the original is in The British Library (see also: http://en.wikipedia.org/wiki/File:Great_Storm_Widecombe_woodcut.gif)

"On a day of the month of July 1744 a menacing cloud appeared over Knifvings Farm; the thunder came nearer and nearer. A farmer's wife was busy cooking at the kitchen fireplace, when suddenly a lightning bolt struck and she witnessed a fireball about the size of a fist coming out of the chimney. The fireball passed between her feet without causing her any bodily harm and continued along its path without igniting or knocking over the spinning wheel and several other objects standing on the kitchen floor. Terrified, the farmer's wife dashed to the door; just as she was about to open the door the fireball came leaping towards

Fig. 2.4 Ball lightning – "Globe of fire descending into a room" in "The aerial world," by Dr. G. Hartwig, London, 1875 [1886 Longman Greens Edition]. Library Call Number QC863.4 H33 1886. Image ID: libr0524, Reproduced courtesy: Treasures of the NOAA Library Collection. National Oceanic and Atmospheric Administration/Department of Commerce, USA

> her, passed right by her feet, then entered a room, which had an exit to the outside, traversed it, crossed the threshold and then entered the farmyard. After crossing the yard, it passed through the door of a shed, ascended toward the adjacent wall and then climbed up its outer side. Upon arriving at the edge of the straw roof it exploded and disappeared with such a dreadful bang that the farmer's wife fainted. The shed caught fire and burned down completely. The clergyman Tiburtius documented this report in the presence of the farmer's wife, her husband and the maid." (Brand 1923)

A similar account is depicted in Fig. 2.4 which shows the potential for physical interaction.

2.3 Interactions

Human-physical interactions with ball lightning are very rare. When they do occur, the reports need careful assessment and validation. Cherrington et al. (2002) reported what could have been one such case. The medical investigation,

Lightning-Induced Injury on an Airplane: Coronal Discharge and Ball Lightning, is seminal. The case related to a flight attendant seated at the rear of an aircraft (which had been delayed due to thunderstorms) during take-off from Chicago, USA. The following is an extract from the Cherrington et al. (2002) case study:

> "Twelve minutes into the flight, while still ascending, he [flight attendant] began to feel a tingling throughout his body. Within a few seconds, there was a bright flash and loud boom. From the window on his left, he saw lightning strike the plane. Immediately after, another flight attendant, seated in the front and facing aft, saw a golden ball of light enveloping the patient for a brief moment. She then saw electrical sparkles emanating from his body ... The odor of ozone was noted in the airplane ..."

The "golden ball of light" enveloping the flight attendant could have been corona discharge. Unfortunately, the flight attendant reported mild confusion, headache, nausea, tinnitus, and numbness to the left upper extremity, followed by insomnia and forgetfulness in later days (Cherrington et al. 2002). Lightning strikes to aircraft are common. But it is extremely rare for the effects of such to impact inside the aircraft. Singer (1971) discussed a number of ball lightning interactions with aircraft. Stenhoff (1999) also discussed how linear lightning can interact with an airplane in-flight by moving from the nose to the tail. Bychkov et al. (2010) wrote the following:

> [ball lightning can] ... explode outside near the aircraft's fuselage or propeller, and can melt a metal and surround the molten place with soot. Furthermore, BL [ball lightning] can get into a hermetic cabin of an all-metal aircraft. It often moves by a straight line along a passage to the tail part of the saloon at a height of about 75 cm over a floor ... [... and velocity of 1–2 m/s].

The study of ball lightning interactions with aircraft presents more credible observational data as reports come from crew, pilots, passengers, and occasionally multiple witnesses. Reporting from pilots can be classed as that of professional witnesses based on their level of meteorological training and knowledge of other phenomena such as St. Elmo's Fire and corona discharge. Crews occasionally report what is thought to be ball lightning in corroboration with passengers. More often, witnesses wish to remain anonymous. The reporting of such meteorological data from the aviation industry is therefore mixed. There are very few established incident reporting channels, unless injury or damage occurs (leading to official investigation), and therefore most cases are often passed on as "air-travel lore."

Stenhoff (1999), Grigor'ev et al. (1992) and Rakov and Uman (2003) all recount the following pilot's account from 1960:

> I was at the controls of a KC-97 USAF tanker, heavily loaded with JP-4 fuel for offload to B-47 bombers. En route to the refueling rendezvous (Elko, Nevada) we were in the clouds at 18 000 ft. There was light precipitation, temperature was above freezing and there was no turbulence. I recall that St. Elmo's fire was dancing around the edges of the aircraft front windows. The crew was experienced in all phases of all-weather operation and not concerned or apprehensive about any portion of the mission to be accomplished. As I was concentrating on the panel (no outside visual references were visible) a ball of yellow-white color approximately 18 inches in diameter emerged through the windshield's centre

> panes and passed at a rate about that of a fast run between my left seat and the co-pilot's right seat, down the cabin passageway past the navigator and engineer. ... After approximately 3 seconds of amazingly quiet reaction by the four crew members in the flight compartment, the boom operator sitting in the rear of the aircraft called on the interphone in an excited voice describing a ball of fire that came rolling through the aft cargo compartment abeam the wings, then danced out over the right wings and rolled off into the night and clouds! No noise accompanied the arrival or departure of the phenomenon.

A more recent example was published by the Air Accidents Investigation Branch (AAIB) (1997) (Bulletin No: 9/98 Ref: EW/G97/10/24). It involved a Fokker F28 Mark 0100, G-UKFK, shortly after takeoff from Schiphol Airport, The Netherlands:

> "Whilst in IMC [Instrument Meteorological Conditions – weather conditions that require pilots to fly by reference to instruments], it [the aircraft] encountered precipitation in the form of small hailstones; the weather radar was in use and showed no hard core closer than 5nm. The aircraft then received a lightning strike. The cabin crew observed what they described as fire-balls in the cabin, originating at the front and appearing to exit in the region of the overwing emergency doors. The Captain observed the master caution lights operating and warnings of EL 1 and EL 2 appearing on the MFDU, indicating that hydraulic pressure had fallen in both right and left systems of the elevator hydraulic control unit."

The reporting of ball lightning by the aviation industry clearly presents useful, technically descriptive and often corroborative reports. In an effort to improve verification and analysis of aviation data, Doe et al. (2009) developed an international dataset of 87 probable ball lightning aircraft case histories from 1938 to 2007. Thirty-seven Russian military and civil aviation ball lightning reports were provided by Bychkov (Aviation ball lightning in Russia, 17 June 2009, personal communication). The statistics showed an April to August maximum. At ball lightning impact, 15 aircraft were climbing, 7 descending; most were at cruising altitude. Forty-eight percent reported ball lightning outside the aircraft, 43% inside, and 8% both in and outside. No damage was reported in 39% cases, 45% caused minor damage and 13% major damage; three events reported military aircraft loss. Three objects caused minor injury, one major crew injury. Mean size was described as 25 cm, sometimes over 1 m, color 30% in the yellow–red, 10% in the blue–green spectral region, 8% white, duration around 10 s, sometimes over 1 min. Thirty-eight percent of incidents ended with an explosion of the object. Thunderstorm conditions were reported by 29% of the observers; 10% said there was no thunderstorm. Some cases reported an initial cloud-aircraft lightning flash, in other cases originating without a lightning flash (which is of particular interest to ball lightning theorists). Approximately 50% of incidents occurred inside the airframe, some causing minor damage. It should be stated that ball lightning constitutes no major air traffic risk, but routine incident/accident reporting and damage/injury investigation are advised to aid further scientific knowledge in this field.

2.4 Theories and Models

Stanley Singer, when president of the *International Committee on Ball Lightning*, commented that ball lightning models disagreed fundamentally in their primary source of energy, which included: vortex motion, atmospheric chemistry, charged aerogel or polymers, magnetic plasma loops, external microwaves, and even nuclear power (Dijkhuis 1998). Indeed, the Committee advised against producing statistics based on poor observations, suppressing the important features recorded in the few reliable reports by qualified observers.

A review of various models of ball lightning was presented by Donoso et al. (2006). This included a discussion on chemical, optical, free-force, plasma and topological models, along with physical models like Kapitza's Model (electromagnetic high-frequency localized discharges (see also Kapitza (1955)). Other theories include: electromagnetic standing waves within a ball of plasma (Watson 1960), cosmic rays of antimatters (Ashby and Whitehead 1971), superconducting plasma vortices (Dijkhuis 1980), a plasma continuum model (Silberg 1981), a combustion model (Fischer 1981), eddy current in lightning plasma (Shelton 1989), microwave interference (Ohtsuki and Ofuruton 1991), plasma surrounded by hydrated ions (Turner 1994), electromagnetic knots (Ranada and Trueba 1996), corona discharge generated by dissipating electrical ground currents (Lowke 1996), a geodesic dome construction from helical and scaling vortex loops in discharge plasma sheared by a dielectric wall (Dijkhuis 1998), the dynamic capacitor model (Nikitin 1999), oxidation of nanoparticles (Abrahamson and Dinniss 2000), polymer composites (Bychkov 2002), the effect of the self-purifying of plasma from heavy particles (Alanakyan 2002), earthquakes and volcanoes (Durand and Wilson 2006), symmetry breaking of the hydrodynamic vortex ring (Tar 2006), light bubbles (Torchigin and Torchigin 2007), microwave heating of carbons (Menendez et al. 2010), solid positively charged core (Muldrew 2010), linear lightning impact on Earth components with creation of a reservoir-strong oxide cover filled with metal powder (Bychkov 2010), and electro-frozen dipole oriented water molecules confining an electric charge (Tennakone 2011). Further model theories are categorized by Rakov and Uman (2003) who list by internal and external energy sources, and detailed discussion is provided by Bychkov et al. (2010) (see also the chapter by Keul (2013) in this volume).

Amirov and Bychkov (1996) researched the influence of thunderstorm conditions on the physical properties of ball lightning. Their methodology was simple: ball lightning events from a database of 1.077 events (Amirov et al. 1995) were ranked by diameter, along with weather conditions in relation to humidity, correlating to the charge state of the atmosphere. Thunderstorm conditions were then ranked in relation to the electric field of the atmospheric ground layer. After statistical analysis, their results showed that the lifetime and diameter of ball lightning decreased under conditions of increasing humidity and increasing electric field.

Grigor'ev et al. (1992) presented 43 eyewitness case studies of ball lightning entering a room through glass windows and also electrical devices. The interaction with glass is an interesting research direction, particularly in connection with extraneous gas and plasma ball lightning discussions. James and Meaden (1997) reported a ball lightning (glass) interaction following a lightning strike to a low-flying USAF jet on the 17 June 1996 in Tewkesbury, UK. An eyewitness stated:

> "Two forks of lightning came from the clouds in front of the plane, converged on it and gripped it. The tail end of the plane became illuminated . . . " At this moment, the jet was passing a factory where a worker saw a "blue–white ball" move along the factory roof. Then, " . . . It entered the factory through an up-and-over door and was seen as a 'pulsating light' or a 'fiery sphere the size of a tennis ball'. Once inside the building it moved very rapidly for two seconds, following the course of the overhead girders without touching them and lighting up each girder 'blue, white and orange' as it raced along. It produced what one witness described as 'unbelievable sparks'. Intensely bright, the object illuminated the whole printing works and was seen by about 40 people. After thus racing around the interior of the building for two seconds, the 'fireball' hit a window which glowed orange, and the ball disappeared with a bang . . . " (James and Meaden 1997)

An incident, with similar characteristics occurred on 25 February 2005 at Guernsey, The Channel Islands, UK, and was reported in *This is Guernsey* (Anon 2005):

> A pensioner had the shock of his life when ball lightning shot through his front window . . . seen at the same time as a Flybe aircraft was struck twice in mid-air. So-called lightning balls penetrated at least four homes in the north of the island . . . Mr Falla was about to go to bed when the loudest clap of thunder he had ever heard went off. A split second later, a lightning ball entered his lounge through the window and closed curtains and the television broke . . . "It made a hissing noise and I would say it went dead centre into the back of the TV." Mr Falla examined that the set, which he expected to be warm, but could find nothing obviously wrong. As he opened the curtains to look outside, he heard an aircraft, which he believes was the Flybe Dash 8 that had been forced to abort its flight to Exeter. "I pulled the curtains back to see, but the glass was fine. 'The thing that amazed was that the ball came through the window without causing any damage. The thing I don't know is where it really went.' The ball was a yellow/white colour and about the size of a football."

Questions remain as to how ball lightning can penetrate glass without a trace. Torchigin and Torchigin (2005) stated that: " . . . a process of penetration through a window glass clears ball lightning from extraneous gases because no gases can penetrate through glass but the conventional air at the opposite side of the glass is available for compression by an intense light." Tsintsadze (2008) suggested that ball lightning is a weakly ionized gas, in which the electromagnetic radiation can be accumulated through the Bose-Einstein condensation and/or the photon trapping in the plasma density well. The authors derived a set of equations to describe the stability of ball lightning [BL] which theorized that, " . . . BL moving along any uncharged surface remains stable, even when the shape of BL changes, and it can penetrate into any split, hole, chimney, etc. However, if the surface is charged, on which the BL moves, then the surface of BL is also charged. In this case, the

surface of BL becomes unstable. Eventually the instability leads to explosion of BL and release of energy of the trapped photons and/or the Bose-Einstein condensate" (Tsintsadze 2008).

2.5 Laboratory Experiments

There have been many laboratory and field experiments in an effort to simulate ball lightning. Barry (1968) described a laboratory experiment in which a "ball of fire" was created that possessed many properties of natural ball lightning, including existence for a finite time without an external energy source. Ofuruton and Ohtsuki (1990) conducted experiments producing ball lightning with a discharge in flammable gas and/or aerosol (Fig. 2.5). They determined a ball lifetime of 0.3 s in 2% methane and more importantly noted: " . . . humidity, distribution of temperature, and place of the electrodes are important factors for producing ball lightning."

Grigoryan (1996) discussed ball lightning formation and artificial generation with reference to what is known as the Stakhanov cluster hypothesis, where ball-lightning is conceived as a localized collection of ions surrounded by shells composed of polar molecules (of water and other compounds produced in air). For example, there are ion clusters that can exist without recombination over a long period of time (many seconds, tens of seconds, and several minutes) (see Stakhanov 1996). Grigoryan (1996) stated:

> "...ball-lightning can in principle be produced artificially. This can be arranged by producing a moisture-laden atmosphere with a variable concentration of vapor and water drops within a volume insulated by firm walls (it is desirable to have transparent sections in them). In this medium, a powerful linear explosion with controlled energy should be fired, for example, by passing pulse electric current through a thin linear conductor (the well-known scheme of an exploding wire). If Stakhanov's cluster hypothesis is correct, ball-lightning will be generated under appropriate parameters in this experiment."

Fig. 2.5 A laboratory experiment to generate ball lightning using Methane (2%)-air mixture (discharge voltage 8 kV), 0.099 s after discharge (Image adapted from: Ofuruton and Ohtsuki 1990; Reproduced with kind permission: *Il Nuovo Cimento C* and Y. Ohtsuki)

In 2002, Russian scientists Egorov and Stepanov simulated a ball lightning type object in the laboratory after claiming: "... there is still no conclusive evidence that ball lightning, i.e., an airborne, long-lived, isolated, and luminous formation, has been reliably reproduced in a laboratory." But they hypothesized the general conditions required for the development and transferred this to experiments in their laboratory of Nuclear Physics in Russia:

> Water vapor possesses a number of unique properties: it is lighter than air, does not support combustion, and inhibits the oxidation of inflammable substances, but at the same time, it is capable of interacting with heated carbon or iron with the formation of molecular hydrogen. An extremely inhomogeneous distribution of electron density across an H_2O molecule induces large effective charges on the hydrogen and oxygen atoms. Dipole water molecules attach to free ions and envelope aerosol particles. The binding energy of the first H_2O molecule to the H^+ ion is 7.18 eV, for the second, 1.6 eV, and for the fifth, 0.51 eV. The binding energy of water dipoles to other ions, both positive and negative, is of about the same magnitude. (Egorov and Stepanov 2002)

Their results were visually striking. They created long-lived plasmoids, effectively analogues of ball lightning, using a colloidal graphite, acetone, and water. The plasmoids were between 10 and 18 cm with a lilac-colored centre surrounded by a diffused yellow color. Egorov and Stepanov (2008) then presented an experimental setup for generation of a ball lightning. They produced floating glowing plasmoids (12–20 cm in diameter and lasting circa. 1 s). With >3.000 simulations, these possessed an electrical charge and a central kernel containing a variety of hydrated ions and aerosol. More recent experiments include Hill et al. (2010) who attempted to create ball lightning by directing lightning, triggered from thunderclouds using the rocket-and-wire technique, through a variety of materials. Despite the complexity of artificial ball lightning simulation, sterling attempts have been performed and documented. It is these attempts which take us a step closer to understanding the complexity and dynamics of ball lightning.

2.6 Skepticism

It would be true to say that, without any detailed solid evidence or reliable scientific monitoring and subsequent analysis obtained from the natural environment, ball lightning has its skeptics. In fact, some scientists completely dismiss the concept. This is understandable, particularly where unreliable reporting and misinterpretation have contributed to skeptical views (especially where ordinary lightning is the cause, or meteors have been wrongly interpreted as ball lightning). Hughes (2010) discussed a connection between meteors and ball lightning. A green fireball, with multiple witnesses and photographic evidence, was witnessed in Queensland, Australia, in May 2006. But in addition to this green fireball, "... a green light rolling down the slope of a ridge very soon after the passage of a bright 'parent' object" was observed (meteors are thought to create a green fireball effect due

to the velocity and producing ionized oxygen (Halliday 1960)). Hughes (2010) hypothesized the possibility of an ionosphere-to-ground conductive path in an effort to make a connection between an aerial fireball and ball lightning on the ground.

Stenhoff (1999) discussed skepticism to ball lightning and interestingly noted that Michael Faraday was not skeptical of the existence of ball lightning, but doubted it had "... anything to do with the discharge of ordinary electricity" or was related to lightning or atmospheric electricity (Faraday 1839). During the early 1970s, a number of researchers suggested ball lightning was a result after-images produced by lightning flashes on the retina (Argyle 1971; Charman 1971; Berger 1973). This was nothing new, as in 1888 Lord Kelvin in his presidential address to the British Association for the Advancement of Science (BAAS), suggested that ball lightning was indeed an optical illusion (Thompson and Kelvin 1888; Singer 1980). Brand (1923) made reference to Arago (1838) who wrote:

> "Without going into a long-winded discussion on this subject, I would merely like to remark that in my opinion the slowly moving fiery balls, such as were mentioned, for example, by Babinet, and such as Hapouèle, witnessed from a dung pit as they first moved horizontally and then obliquely upwards, etc., do not exist in reality, and are nothing else but subjective optical phenomena, such as after-images left on the retina of the eye owing to the *'blinding' effect* of the preceding lightning."

Torchigin and Torchigin (2005) published detailed research on the physical nature of ball lightning and argued that ball lightning is not an electrical phenomenon but is instead an optical phenomenon where only an intense light and compressed air interact. Indeed, trying to justify the physical and chemical processes of ball lightning with the laws of physics is not an easy task. The authors noted that:

> "... its [ball lightning] main characteristics are well-known. These characteristics include several properties which, taken together, appear inconsistent with the accepted laws of physics. As a consequence, a number of eminent physicists, including Kelvin, have refused to accept that it is anything more than an optical illusion. Faraday treated the evidence more objectively but still refused to believe that it is an electrical phenomenon."

Interestingly, Egorov and Stepanov (2008) in their laboratory simulations allowed spectators, and it was claimed that those who witnessed the phenomenon reported physiological effects in the form of after-images: "In some observers, plasma flashes caused a spot on the retina, which persisted for 10 s and moved in space following head turns." Cooray and Cooray (2008) postulated that some ball lightning observations could even be optical hallucinations caused by epileptic seizures. They compared eyewitness reports of ball lightning and the symptoms of seizures of the occipital lobe and argued that a person experiencing such a seizure for the first time may believe that they have witnessed a ball lightning event:

> "Since many of the ball lightning reports are associated with nearby lightning strikes, the possibility that the rapidly changing magnetic field of a close lightning strike could trigger an epileptic seizure ... The results show that the time derivative of the magnetic field in the vicinity of an intense lightning flash is strong enough to stimulate neurons in the brain. This strengthens the possibility of inducing seizures in the occipital lobe of a person located in the vicinity of lightning strikes." (Cooray and Cooray 2008)

In a similar approach, researchers at the University of Innsbruck suggested ball lightning could be a hallucination induced by magnetic stimulation of the brain's visual cortex or the eye's retina (Than 2010). However, explaining ball lightning as an electromagnetic brain effect caused by ordinary lightning was discussed by Keul et al. (2008). They stated that: "A critical assessment of this alleged effect has to link the physical properties of lightning and its EM [electromagnetic] field with the neurophysiology of EM-induced hallucinations, so-called magnetophosphenes." They concluded that the electromagnetic fields of close lightning flashes, because of their spatial configuration and magnetic induction, were unlikely to produce magnetophosphenes, thereby refuting an electromagnetic/ball lightning brain effect hypothesis.

2.7 Conclusion

This brief review has highlighted that some significant progress has been made in our attempt to understand ball lightning, particularly in the last 100 years. Yet the phenomenon still remains difficult to record in the natural environment despite improved technology. However, with the advent of advanced digital cameras (including camera-phone photography with the ease for internet dissemination), video recorders, digital surveillance cameras, and greater number of meteorological recording and monitoring stations using perpetual digital technology (as well from the storm chaser community), the chances of recording ball lightning are much improved. The study of ball lightning often relies on observation analysis, then piecing together the possible causal mechanisms to determine a valid hypothesis. But as Rakov and Uman (2003) aptly write; "Despite the lack of scientific documentation, the properties of ball lightning are relatively well known from statistical analysis of observers' reports spanning a period of three centuries." The large number of international historical and contemporary observations have provided a wide variety of data for analysis. Opportune photographs have presented valuable examples, but these need very careful validation. For the scientist, these data, along with laboratory experiments and model development, are a step toward answering the many unsolved questions. For the cultural and historical geographer, over three centuries of reporting presents a wealth of research potential. There is no doubt that a phenomenon exists, but it is also one of the most scientifically intractable.

Acknowledgments The author would like to acknowledge Prof. Vladimir Bychkov and Asst. Prof. Alexander Keul for their research assistance. Gratitude goes to NOAA and Prof. Ofuruton and Prof. Ohtsuki for image reproductions.

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Chapter 3
The Ball Lightning Controversy: Empirical Case Studies

Alexander G. Keul

Abstract The term Ball Lightning (BL) has been used since Arago (1837) for an unexplained class of metastable luminous phenomena in atmospheric electricity. BL seemingly appears at random in time and space, and lasts only for seconds, vanishing with or without traces. BL causes epistemological problems in case classification, analysis of residue, and laboratory simulation. After about 400 years of BL report history and over 150 years of scientific efforts, most of the incoming material is still anecdotal, and theoretical discussions still outnumber critically assessed field investigations. BL also has a psychological level with different mental models, lay theories, and working paradigms creating a difficult pattern for witnesses, scientists, the media, and the public. The author – meteorologist and psychologist, involved in BL case studies since 1974 – explains the near-forensic examination of witness reports and alleged evidence (including an Austrian photograph and a German video), highlights European and international BL case statistics, and outlines obstacles and chances for a potential scientific solution to this long-time controversy.

Keywords Ball lightning • Theories • Psychology • Ball lightning reports • Austria • Germany

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K. Pfeifer and N. Pfeifer (eds.), *Forces of Nature and Cultural Responses*,
DOI 10.1007/978-94-007-5000-5_3,

3.1 Name, Definition, Theory, Simulation, Epistemology

Name: Ball lightning (BL) as a phenomenon has a special name in many languages: In Italian *fulmine globulari*, in French *foudre en boule* or *éclair en boule*, in Spanish *rayo de bola*, in Danish *kuglelyn*, in Dutch *ball bliksem*, in Swedish *klotblixt*, in Finnish *pallosalama*, in Iceland *urdarmáni*, in English *ball lightning*, in German *Kugelblitz*, in Estonian *keravälk*, in Czech *kulový blesk*, in Hungarian *gömbvillám*, in Russian *sharovaya molniya*, in Malaysian *bola petir*, and in Japanese *hinotama*.

Definition. Historical BL records date back as far as 1557 and 1638 (i.e., about 400 years; see the chapter by Doe (2013) in this volume). Scientific BL investigations on an unexplained class of metastable luminous phenomena in atmospheric electricity start with "Sur le tonnerre" of F. Arago (1837). Astrophysicist (and BL observer) A. Wittmann, Goettingen University, reviewed BL phenomenology in 1976: Appearance in thunderstorms, often near cloud-ground lightning, round form under 1 m, color mostly orange to red, opaque and self-luminous, continuous or irregular motion, sometimes stopping, frequent intrusion into buildings, lifetime rarely over several seconds, sound or soundless, also in terminal phase, mostly without traces, also damage and injuries. Barry (p. 33, 1980) called; it "... an atmospheric electrical phenomenon observed during thunderstorms activity ... reported to be a single, self-contained entity that is highly luminous, mobile, globular in form, and appears to behave independently of any external force." Stenhoff (pp. 1–2, 1999): "... it is associated with thunderstorms. It is luminous and roughly spherical, with a modal diameter of 20-50 cm and a lifetime of several seconds. It moves independently through the air, often in a horizontal direction." Rakov and Uman (p. 656, 2003): "... the most commonly reported observation is of an orange- to grapefruit-size sphere ... which is usually red, orange, or yellow in color and is about as bright as a 60 watt light bulb. Ball lightning most often has a duration of a few seconds, during which time it generally moves more or less horizontally (it does not rise as would hot air) after which it decays either slowly and silently or abruptly and explosively. ... The luminosity of ball lightning is roughly constant until it extinguishes. It is most often seen spatially close to and just after a cloud-to-ground flash. There is a significant number of credible reports of ball lightning occurring within metal (aluminium) aircraft [see Doe and Keul 2009, Doe et al. 2009 – A.G.K.]. Ball lightning is sometimes reported to have an odor and sometimes to leave burn marks. Human beings are seldom, if ever, injured or killed by ball lightning;"

Theory, simulation, epistemology: BL publications – 1,600 in Barry's bibliography (1980), 2,400 in Stenhoff's (1999) – lack a secure base of few theories explaining a large set of empirical case studies and backed up by consistent laboratory simulation in spite of continued attempts by (inter)national groups and networks. Turner (2002) called BL science "fragmented" and suggested balancing theory with multifocus experimentation to reproduce and explain natural BL complexity. However, in all international meetings of the International Committee on BL since 1988, theory and models outnumbered field investigations and case research.

Table 3.1 BL models

Internal energy source models
1. Hot air, mixed trace material
2. Dust, droplets, aerosols
3. Chemical reactions, combustion
4. High-density plasma
5. Closed-loop current
6. Air vortex as gas containment
7. EM fields within plasma shell
8. Nuclear reactions, antimatter
9. Miniature black holes
10. Charge separation
11. Maser theory, water vapor
External energy source models
1. Focused atmospheric HF fields
2. Steady, focused current flow
3. Focused cosmic rays
4. Antimatter meteors
5. Electric fields by lightning charge deposit

Summed up by Rakov and Uman 2003

Singer (p. 6, 2002), author of a 1971 BL monograph: "Only a small number of the observations has been investigated to determine the reliability of the eyewitness and to evaluate the report." A comprehensive review of BL investigations is given by Bychkov et al. (2010).

Rakov and Uman (p. 664, 2003) sum up BL *theories* in their lightning encyclopedia (short version in Table 3.1).

With the 16 models shown in Table 3.1 plus two "sensory deception" models trying to explain BL as afterimage or neurological lightning artifact (compare the negative assessment by Keul et al. 2008), 18 parallel explanatory "BL worlds" coexist. The history of BL *laboratory simulation* efforts developed mostly independent of empirical field research. Recently, models and experiments of BL as a combustible object associated with plasma (Emelin et al. 1997; Abrahamson and Dinniss 2000; Dikhtyar and Jerby 2006; Lazorouk et al. 2006; Piva et al. 2007; Bychkov 2010) show a better link between theory, case studies, and laboratory simulation.

No laboratory simulation but an innovative *field experiment* was published by the Uman research group (Hill et al. 2010): At a rocket launching facility at Camp Blanding, FL, used to trigger artificial lightning flashes by the rocket-and-wire technique, eight triggered cloud-ground lightning flashes in 2008 were grounded via an experimental array of about 100 substances and the effects recorded. Ionization or combustion produced flame-like luminosity for up to 0.5 s above saltwater, constant-luminosity silicon fragments falling down for about 1 s, a 0.7 m region of stationary luminosity after arcing above a stainless steel surface, and a glow for about 0.5 s above pine tree sections. The Uman group does not call it BL, but describes optical effects up to 1 s with different causalities – arcs on steel, silicon wafers, saltwater, and timber. A light ball over a steel surface reached 33 cm diameter. Stephan and

Massey (2008) pointed out that a subset of BL events may consist of macroscale molten spheres of burning metallic materials likely to be ejected from a conventional lightning flash to earth.

The *epistemology* of BL encounters several severe problems. Numerous witness reports exist, but "little, if any, scientific documentation such as photographs, videotapes, or other scientific recordings" (p. 656, Rakov and Uman 2003). The blurred definition of BL (seconds – or longer, silent – or explosion, following lightning – or not, etc.) indicates that "there may be more than one type of ball lightning and more than one mechanism by which ball lightning is generated" (p. 656, Rakov and Uman 2003).

3.2 The Psychology of BL: Mental Models, Lay Theories, Paradigms

As the vast majority of BL reports are verbal, social sciences techniques are needed to interpret and evaluate the testimony (Keul 1993b). *Forensic psychologists* have done numerous experimental studies about eyewitness testimony, but not in the BL context, situations, and latency periods (time lag between observation and memory situation). There are interesting findings of this research field: Outstanding details of an action sequence are remembered excellently (98%; Marshall et al. 1971). Central details of an action scene are reported clearly even when they caused fear (Kebeck and Lohaus 1986). Persons tend to overestimate the duration of fear- and stress-loaded events (Sarason and Stoops 1978). Observed details can be distorted by suggestive questioning upon retrieval (Carmichael et al. 1932) as well as by personal and cultural stereotypes. Emotionally upsetting, consequential events are often memorized together with irrelevant details of the event situation ("flashbulb memory"; Brown and Kulik 1977). Falsely remembered details are consistently memorized in this wrong way ("freezing effect"; Kay 1955).

In cognitive psychology, a *mental model* is an internal symbol or representation of external reality, playing a major role in perception, reasoning and decision-making (Craik 1943). Mostly used for human–computer interaction, mental models also explain human interaction with the natural world and concepts of its phenomena (Gentner and Stevens 1983). A mental model is based on hardly qualifiable, obscure, or incomplete facts, is considerably variable, and works as an information filter, causing selective perception.

In social and clinical research, a similar term is used: *Lay theories* are the informal, common-sense explanations people give for particular phenomena, often very different from formal, scientific explanations of what happens (Furnham 1988). Studies on lay theories focused on social and medical phenomena. So far, there is no lay theory on meteorology, with the exception of "ethnometeorology" – native interpretations of phenomena, recorded by ethnology field researchers for the Human Relation Area Files (HRAF). A study on lightning knowledge and folk beliefs was done in Austria and Bavaria (Keul et al. 2009).

European BL investigators are well-aware of the phenomenon of *non-BL-reports*. The mental model or lay theory behind them can be summed up as: "Unusual things happening in a thunderstorm – a peculiar damage, a unexpectedly large damage, or other unexplained things – are caused by ball lightning, a very dangerous phenomenon." When conventional cloud-ground lightning e.g., hits a church, destroys a whole warehouse, or leaves a circular (!) hole in the wall of an apartment, the damage is interpreted as BL-caused. This interpretation is also generated and disseminated by authorities – policemen, fire brigade, insurance people – and the media with a high practical credibility to observers and/or damage victims. The attribution process and resulting BL rumors produce a considerable number of false alarms every year, additional work for BL researchers, and a reason for skeptical scientists to reject all BL reports.

But the psychology of BL reports is more than a simple signal-to-noise ratio with misinterpretations of the uneducated. As a number of theories and concepts still compete for a scientific solution of the BL problem, BL investigations are not a theoryless, inductive game, but follow – implicitly or explicitly – a *research paradigm* (see Kuhn 1962): It, for a time, provides model problems and solutions for a scientific community, i.e., what is to be observed, what questions are to be asked, how they are structured, how results should be interpreted, how experiments are to be conducted, etc. With a plurality of possible theories, competing research paradigms coexist and lead to different labels put on possible BL raw material. Nuclear physicist V.L. Bychkov (2012) describes a shift of BL models "from neutral to charged," from "light and cold" to "heavy and hot" over 20 years. P.v. Doorn (2012) subscribes to a different paradigm, when he denies a connection of BL with lightning, i.e., of BL as a natural phenomenon.

Effects of the psychology of BL interpretation make international scientific discourse necessary. Critical discussions on BL case material and investigations, models, and simulations prevent a split-up of the research scene into a number of rival paradigms with different case selection, investigation and interpretation. The foundation of the International Committee on Ball Lightning in 1988 by Japanese, American, and Russian scientists was the right step (Ohtsuki and Ofuruton 1989). In order not to follow lay theories of the public, a BL investigation has to test first whether something unusual was only *labeled* "BL" or whether an object that meets the scientific BL definition was *actually observed or even recorded.*

Two 2011 case examples will demonstrate what is meant by this initial test:

3.2.1 A German Non-BL-Event Example

On June 6, 2011, according to a local newspaper, shortly after 20:00 CEST, a thunderstorm at Strasburg, Uecker-Randow, Mecklenburg-Vorpommern, Germany (GPS about 53.52 13.74) caused a severe fire at the roof of a prefab apartment block. R. Martens, journalist of NordKurier (2011), wrote: "... during the thunderstorm, a soccerball-sized fireball touched down on block 34-37 of Strassburg Siedlungsweg

1, over the entrance of block 35. The fireball sped southwards over the rooftop and imploded [? – A.G.K.]. . . . Heat set combustible matter on fire under the roof." The fire spread over the whole roof area. Despite an alarm of all local fire brigades, the roof area burned down completely. A solar photovoltaic power generating system installed half a year ago over the full length of the rooftop was destroyed. The UKMO weather map of 00:00 GMT July 7 showed a low over the British Isles with two cold fronts over Germany. There were widespread thunderstorms after 16:00 GMT. G. Diendorfer, head of ALDIS (Austrian Lightning Detection & Information System), did a local lightning scan and found a series of four negative cloud-ground lightning flashes at 18:03:38–39 GMT, ranging between 4,000 and 21,000 A, scattered over about 1 km in the fire area. It seemed likely that a negative CG flash caused a short-circuit in the photovoltaic system which set the whole roof area on fire in a short time. Electric arcs of the system were seen as a moving fireball.

3.2.2 An Austrian BL-Event Example

On August 9, 2011, M. Staudinger, director of the ZAMG Central Institute of Meteorology and Geodynamics, Vienna, informed the author about the phone call of a possible BL witness from Lower Austria. The author contacted her the next day and heard the following: In mid-July 2011, she was outside her Alland home (GIS position 48.057, 16.086) about 20 km SE of Vienna near her car when she heard a loud bang and saw a full moon sized, round, yellowish object fly over her in a westerly direction. It was out of sight after about 2 s. The object had a frayed outline; luminosity was not blinding, and flew in a curve with a hissing sound. Her daughter also saw it from a window of the house. The reporting witness works in radiology and has a professional training in photography. A neighbor later found a scorched spot in his garden where lightning seemed to have struck. As the case was 3 weeks old and confined to verbal data, no field investigation was performed. G. Diendorfer, head of ALDIS (Austrian Lightning Detection & Information System), did a local lightning scan and found a negative cloud-ground lightning flash at July 14, 2011, 9:06:47 P.M. GMT, 9,000 A, right in the observation area. As a lightning footpoint computed from ALDIS lightning detection data may deviate up to 300 m from its true position, it could be deemed a good fit. The Vienna airport Schwechat LOWW reported rain and thunderstorms after 18:20 GMT. The UKMO weather map of 00:00 GMT July 15 showed lows over northern Germany, the northern Adriatic Sea, and the Balkans with a cold front/occlusion over the Alps. It seemed plausible that a local thunderstorm cell at 21:00 GMT resulted in a cloud-ground flash near Alland, Lower Austria, and produced BL as a secondary effect which traveled for some distance and disappeared (Keul 2011).

3.3 BL Report Identification and Investigation

The technical memorandum of COST P18, signed by 30 leading European lightning experts, also lists BL as a research topic (Thottappillil 2005). BL is a natural phenomenon. It provokes cognitive and emotional reactions, but this did not lead to a recorded history of changing phenomenology. Reported objects and their behavior (except aircraft contacts) have been monotonously similar at least since 1900. Their sporadic occurrence seems to rule out systematic instrumental measurements. Typical observations come from lay witnesses with a high variance of trainings/skills. A number of unreported events due to social ridicule and uncertainty about whom to address will exist, but this has not been empirically tested. In many cases, the time lag between observation and reporting is high – usually, media articles or TV on a recent report also lead to several old reports. After 2000, internet use reached such an extent that a well-positioned information homepage (like the author's www.inatura.at/Kugelblitz-Ball-Lightning.7670.0.html) can lead to fast reports. Report sources may be (1) direct contact (mostly via internet), (2) indirect contact (someone else reports case), or (3) media (mostly press reports).

At the start of a BL investigation, the first report material has to be examined and categorized into (a) non-events (misidentifications, hoaxes, other phenomena), (b) missing data/secondhand reports (insufficient details, secondary reports), and (c) sufficiently detailed reports for a personal investigation. Direct contact with the main witness is mandatory, by phone, internet, or mail. In cases of high interest, a field investigation should be done. The decision to handle cases at a distance or via field investigation has to observe financial possibilities – field investigation is cost-intensive, phone/internet/mail contact is not. Without financial support available for BL research (which is the usual condition), expenses should cover outstanding cases, e.g., photographs, videos, traces/injuries. The latter require a fast reaction.

The author uses two schemes: A BL questionnaire for telephone interviews as well as for internet contacts, and a field investigation checklist. Two things are different for BL research compared to other natural sciences fieldwork: There is not only a geographical location, but the initial report comes from a witness who has to be closely looked at, especially when no corroborative physical evidence/traces exist as back-up. Age, education, social situation, profession, health, and eyesight should be considered. If medical symptoms due to BL are reported, a medical check should be advised. If several witnesses were present, separate interviews are necessary to record individual perspectives. Interviews are given voluntarily, so witnesses should be treated in a friendly way, not interrogated. Nevertheless, eyewitnesses may be subjects to illusions, false memory, false interpretations, and ideology, so a critical attitude should be kept and inconsistencies of the observation reports noted.

The best situation for an eyewitness to remember what he/she saw is re-telling it at the observation spot as the environmental cues are present and can be used for understanding. For example, the frame of observation can be clarified – did

the object appear against a wide field of observation or within a limited field of view, so in the second case its trajectory was the visible part of a greater length? To reconstruct the observation duration, rather short in most cases, a simulation experiment ("Now imagine the observation happens again and tell me 'start' when it starts and 'stop' when it ends") at the observation location allows to time the duration with a stop-watch and usually it is found that it was shorter than first estimated by the witness. Also, object size estimates can be done better at the location with other environmental cues present. A field sketch of BL and observer locations, photographs, and measurements, if appropriate, will be taken. In case of physical evidence/traces, photographs/videos should be copied for a closer inspection securing the copyright of the witness. For competent trace examination, special experts have to be asked for an inspection. In the author's fieldwork, traces were rare exceptions (Keul et al. 1993). As BL reports are considered controversial and neither enhance personal careers nor social status, anonymity of the witness(es) should be granted – if desired. Contact with witnesses and with local or even national press/radio/television should follow ethical standards and retain copyrights, not pass on preliminary and/or pejorative conclusions, and not seek financial profit.

3.4 The Montafon Photograph

Photography has the potential to record transient phenomena and allow *post hoc* physical examinations of the record. Valid photographic material on BL is sparse because a time frame of about 5 s and random appearance does not make chance recording likely. There are automatic camera records and cases where an eyewitness saw what the camera recorded. Examples are published and discussed by Barry (1980) and Stenhoff (1999), also by Nikitin et al. (2006) and Bychkov et al. (2010). In the following, the most prominent Austrian BL case and its investigation process is summed up (Keul 1992a, b, 1993a, 1996):

Werner Burger, eyewitness and photographer of the color slide, contacted the author after a press call-for-reports in 1990. Having been sent glossy copies, Keul went to Vorarlberg for a field investigation. Copies of the photo plus reports were distributed to experts asking for their opinions on astronomical, meteorological, and technical aspects. The photo was submitted to several computer-based enhancements for image analysis.

During a spring/summer night in 1978 (exact date not known), Burger watched an approaching front at Sankt Gallenkirch, Vorarlberg Federal Province (western Austria) (GPS 47.018, 9.987, 900 msl). Sankt Gallenkirch has 1,400 inhabitants and lies in the Montafon Valley of southern Vorarlberg, surrounded by mountain ridges over 2,000 m. The observation point was Burger's parents' house at Aussergant near the Silvretta through-road. Burger fixed his reflex camera with wire-release to a tripod and went out on the balcony to take time exposures of lightning flashes. The camera faced Mt. Grappeskogel (2,206 m), a mountain in the east. It was dark and before midnight.

The witness had started just another time exposure, so the camera shutter stood open with the wire-release pressed down, when he heard a peculiar sound, suddenly, "like an Xmas sparkler or the sound of a wire-brush on an edge [intermittently]." Then, just ahead, "a fireball fell down" and Burger -somewhat shocked- let go the wire release before the object actually disappeared. When asked to re-imagine the course of events, the witness gave a time estimate of 3 s total duration with 2 s visual observation time. The fiery object seemed to drop in free fall. The 1978 photographs were taken with a 1 year old Fujica AZ 1 reflex camera, with a Fujinon lens 1:1,8; $f = 55, 30$ mm front lens opening. The camera focus was set to infinity, the exposure handle to "B" (time exposure). The f stop is unknown (range 1.8–16), use of a skylight filter possible. The camera was mounted on a simple movie camera tripod. The photographic material was an AGFA (Western Germany) CT-18 50 ASA color slide film no longer manufactured now. The slides were developed soon after the exposures.

The Mt. Grappeskogel summit has 25° elevation and 100° azimuth (nearly east) from the observation spot. As the summit forms the center of three more linear lightning photos and the witness said he did not move the tripod, it can be assumed that the camera axis also pointed that way when BL fell. The fall area – open farmland and meadows – lies behind a neighbor's house, trees and a pole of the local power line. The 1978 photos had been taken between April and September. It was dark, around midnight, the sky overcast. When the squall line passed over the location, some rain fell. O. Svabik, Climatology Department of the ZAMG Central Institute of Meteorology and Geodynamics, Vienna, found that August 3/4, 1978, probably was the case date.

The witness and photographer, born in 1957, was working for the Silvretta cablecar company in 1978, also running a tourist boarding house together with his wife. His eyesight was normal. He knew of BL from tales of his grandfather. The original diaslide frame measures 23×35 mm (see Fig. 3.1). It is different from the remaining three bluish-violet, overexposed linear lightning slides (still available for inspection) by having no clear background. Above a dark and blurred bottom line and a central, diffuse "cloud," a curved light trail runs from the left upper corner down to the middle of the frame, starting faintly, then shooting out "sparks" to the left, flaring up and terminating suddenly (possibly when the shocked witness released the shutter).

The photo-analysis by interdisciplinary experts had the following results: *Meteor astronomer* Z. Ceplecha, Czechia, noticed the parabolic shape of the trajectory, ruled out a bright meteor (in front of the clouds), and estimated the "faint trail" cross-section to be 1 m for a distance of 400 m. For him, the shape of the sparks was not caused by camera motion as even the two longest and brightest sparks have different trajectories. *Pyrotechnist* C. Feuerstein, Austria, said it was no standard fireworks rocket. The photographed 'sparks' were not present in pyrotechnics, "rather military-like drops with an afterburn, like burning gas or liquid, ignited, thrown out, flaming up." For J. Scheutz, a second Austrian *pyrotechnist*, it could have been a "scorpio bomb," but photographs of the author during one of his fireworks display did not resemble the BL details. Also, firework bombs do

Fig. 3.1 The Montafon, Austria, 1978 photograph (© Werner Burger)

not leave a luminous trail before exploding. Colonel Marterbauer, 81st Austrian *artillery regiment*, said it is only allowed to fire shells in Austria within military training areas – the Montafon valley has no such area. Also, "a shell breaks apart when exploding, and debris fly around. I rule out a shell or grenade definitely." *A field photographic experiment* with W. Burger firing several mountain rescue signal flares neither resembled the luminous track, nor did it produce irregular "drops." *Computer image analyst* P. Marx, UCLA, USA, contacted by BL scientist S. Singer, after digital enhancement of the photo, described a multiple halo effect and turbulence signs of the object's surrounding area. Parts of the "flaming/spark" details may be striation due to lens flare. He noticed that the small, bright processes leading away from the inner area are diffuse and ill defined, perhaps due to their high speed relative to the shutter speed. *Lightning protection specialist* A. Gugenbauer, Austria, assumed an upward lightning flash as an explanation. His hypothesis neither fits the observational data nor photographic details. An observer would not describe a nearby stroke as a ball falling down for seconds. An upward discharge would start at the local power line pole. Why was it not illuminated and captured on the ball lightning slide? A flash also would have resulted in blackout/damage and traces at the pole which were not observed. *Lightning research engineer* and ALDIS head G. Diendorfer found the upward lightning hypothesis implausible. A lightning flash, when photographed, would not form a short segment but a continuous channel from footpoint to slide frame or clouds. A time exposure will not capture streamers or stepped leaders of a lightning flash. *Lightning researcher* D.G. Jordan, a US colleague of Uman, Florida, examined the photograph on a visit to Austria. He said

it was "no standard lightning," wondered why the "sparks" had almost the same shape, and thought the object was "something burning, falling down," generated by a lightning flash. H. Winter, professor of *plasma physics* at the Vienna University of Technology, said: "Something fell from the sky and burned out. ... It was definitely no highly-ionized plasma. ... If the film ... shows a correct color temperature, this is a rather cold phenomenon, a conventional combustion process of 1,500 to 2,000 degrees centigrade at maximum. A plasma, like lightning, would be in the blue color region." *Fire and lightning protection engineer* W. Hattinger, Salzburg, did not see conventional lightning or burning magnesium. But maybe it was a combustible liquid? *Fire brigade training officer* M. Greisberger, Salzburg, denied that: "A burning liquid would not be compact, but dissolve quickly. .. Burning gas does not burn so bright. The outer edge looks reddish, but the core is white, which means a rather high temperature. It is a solid body which burns in its core with a relatively high temperature, and somehow the whole thing is dissolving."

Although the absence of observation frame and landscape details constitutes a weakness of the Montafon photograph, its rich information content and details made the case a controversial issue on BL conferences (such as Los Angeles 1992 and Salzburg 1993) and should encourage further steps of analysis of the photograph by interested experts.

3.5 The Zwoenitz Video

Video or film documents of BL are highly valuable, but almost nonexistent. The few documents were discussed by Barry (1980) and Stenhoff (1999). A 1976 Transvaal, South Africa, video showed a detached round shape near a cloud-ground lightning channel (Eriksson 1977). The alleged 1989 Ashford, UK, BL video was an internal reflection image of the camcorder (Meaden 1990; Bergstrom and Campbell 1991). Today, several internet BL films with questionable origins are available. Anyhow, the widespread use of digital photography/camcorders and webcams made the accidental documentation of BL statistically more probable after 2000.

The following case was field investigated and the material checked by several experts (Keul 2004a, b; Schrattenecker and Baumegger 2004): On April 22, 2003, the author received an e-mail message from teenage brother and sister Sabine and Thomas Fuchs from Zwoenitz, Saxony, Germany: "...we have filmed a phenomenon during a thunderstorm which we assume could be ball lightning." A 332 KB avi-file with a color video sequence of 8 s was attached. A telephone interview revealed the following details: The family lives in an apartment block west of the town centre (GPS 50.634, 12.801). In the evening of April 19, 2003, Thomas fixed his webcam to a chair pointing eastwards through the room window to record possible lightning. The sky was overcast, but no rain fell, and thunder was heard. The webcam recording started at 18:44 CEST computer time. Thomas left the room to eat something and then stopped the record after 4 min. Later, his sister Sabine found a moving light source on the webcam video.

Fig. 3.2 Composite photo of 2003 Zwoenitz video frames (© Thomas Fuchs)

In the video sequence, the flat roofs of prefab apartment blocks were visible under a dark, overcast sky. After about 4 s, half of the avi-file, a yellow-orange, bright light source came out behind the rooftop, rapidly moved upward in the sky following an undulatory, unsteady track with jerks and two brightness maxima before it dimmed or disappeared into clouds after 2 s. The jerky, wavy, blurred appearance looked like a train window reflection at first sight (composite as Fig. 3.2).

The webcam used was a 3-year old Mustek WCam300 with a 1/3 in. color CMOS sensor of RGB24 and 640 × 480 pixel maximum resolution. The camera had manual focus, a fixed f-stop of 2.0, auto exposure, auto white balance, a built-in microphone (set to zero for the BL record), and a 54° view angle. For recording and processing, VirtualDub 1.51 with DivX compression was used. The frame rate used was 15 fps. The webcam was connected to a Toshiba 200 MHz 64 MB RAM notebook. The Mustek 15 fps frame rate at 640 × 480 maximum resolution meant that ten possible frames per second were lost due to system capacity. This caused the image jerks like in silent movies. Four minutes and 3 s were video-recorded at 6:44–6:48 P.M. CEST. The webcam was about 1 m distant from the closed, clean, and dry window, the webcam axis slightly tilted to the left. The family lives in five-storey prefab blocks. In between the blocks captured on film is a meadow with small trees and a playing ground, but no road with traffic. The blocks stand in open, hilly country 500–700 m above sea level. A minor railroad line and a high-tension power line run south–north west of the location. The camera looked into the east. No airfield or military installation is near. No fireworks or festival took place in the community. One of the

teenagers, together with the manager, went onto the flat roof of the opposite prefab block. The rooftop protrusions are exhaust air chimneys. No damage was found there. A second visual report was forthcoming after three local press calls, but dealt with an object touching the ground near a block to the east and time-coincidence is questionable.

The two teenagers were not interested in money and/or publicity – motifs for a hoax –, but wanted to keep the video and their names out of the media until it was properly analyzed. Their parents were also interested in the event.

The 332 KB avi-file was examined by the first author with the Magix video software program Video 2.0 deluxe. Avi-file information said it was recorded with 640×480 resolution, a 10 kBit/s data rate, 24 Bit video file, and MS-MPEG4 V2 compression. Video 2.0 shows second and frame number (25/s). The gray, overcast sky remains empty until frame 04–10. 04–11 shows a blurred light source rapidly rising over or behind the right rooftop. It increases in brightness, seems to leap upward, decreases in brightness, and shows another jerk of motion and a moderate rise in brightness. A third brightness maximum is reached, the light source seems quasistationary, moves on slower, gets very dim, and becomes invisible on frame 06–17. Total visibility lasts from 04 to 11 until 06–16, i.e., 56 frames covering 2 s and 240 ms. Thomas Fuchs managed to get superpositions of his frames onto one image (Fig. 3.2). The undulatory trajectory deviates from a parabola. Visible are two flare phases and three jerks where the light source seemed to jump.

The German weather service (DWD) recorded a flat high over Scandinavia with Germany on its south border on the 06:00 GMT ground map of April 19. At 18:00 GMT, the warm front of a low over France had reached southern Germany with showers and thunderstorms. This warm front was almost stationary by 00:00 GMT. According to local meteorological and radiosonde data, it was bad weather, overcast, with embedded rain showers and scattered lightning discharges, but not very active thunderstorm conditions.

What are the possible interpretations of the Zwoenitz film? A *meteor* does not appear below clouds in an overcast sky. Was it *ordinary lightning*? Diendorfer, electrical engineer and ALDIS director, said the film had nothing to do with cloud-ground lightning. *Reflection?* A simulation video with the Zwoenitz webcam checked the effect of room illumination (which was off on April 19). It appeared as a line of four stationary white blobs of light that go on and off. *Fireworks* are not very likely on a rainy evening with lightning. There was no festival. The filmed light source neither resembles a *fireworks* rocket nor a *signal flare* – explanations also discussed for the St. Gallenkirch BL photograph (see last case history). Flares show parabolic, ballistic trajectories, not waves. The Zwoenitz object moves upward following an undulatory, almost irregular track. Two marked light bursts are visible on the superposition picture. The color temperature is in the yellowish area, getting whiter when flaring up. Like the Montafon BL photograph, this again looks like relatively low temperatures.

On September 16, 2003, a field investigation at Zwoenitz with interviews of the teenagers and their parents, inspection of the webcam site and its vicinity was performed. The room window had standard double glazing and did not blur the view

through binoculars, so did not cause the semi-erratic path of the object on video. The object trajectory started at 85° azimuth NESW (almost east) and 7° elevation. The end of the visible trajectory was at about 70° azimuth and 20° elevation. The trajectory had an angular length of 20–25°. Thus, the angular speed of the object in the sky had been at least 10° per second. For an assumed object distance of 100 m, this would give 65 km/h.

A local journalist found out that on the video record day at 18:45 CEST, the Chemnitz rescue center received a *false fire alarm* from an alarm box at a garden center 1.7 km from the camera position. 18:45 CEST is 1 min after the object recording time on the video. The teenagers said that the PC time could have been 2 or 3 min wrong as it was not calibrated before the April 19 video. Asked about the frequency of false fire alarms during thunderstorms, a fire brigade official said that technical problems like local grid overvoltage were quite common.

G. Diendorfer, ALDIS lightning detection network, Vienna, checked *lightning data* around Zwoenitz on April 19 between 18:40 and 18:50 CEST. In the time interval, 13 lightning flashes occurred in a 20 km radius – seven cloud-to-ground flashes and six cloud-to-cloud. Nine were negative, four were positive discharges. There was no recorded flash between 18:43:31 and 18:46:14 CEST. Then, two negative flashes at 18:46:14 and 18:46:15 with −11.8 and −14.7 kA, about 14 km WSW of Zwoenitz, were possible candidates for grid overvoltage. As the ALDIS network uses GPS time correct within a 3 ms interval, whereas the Chemnitz rescue center has computer time, a difference of 1 min looks not unusual.

A. Geiswinkler, Burgenland power company (BEWAG), Austria, checked possible *high-tension power lineovervoltage*. The 110 and 220 kV power lines around Zwoenitz are operated by Vattenfall Europe Transmissions. According to the company, no internally or externally caused overvoltage was present in the Saxony grid on April 19, 2003, between 18:30 and 19:00 CEST. The Vattenfall data do not support a high-tension power line overvoltage effect. As a local fire alarm started and cloud-to-ground flashes were present, local grid overvoltage may have been present.

To test the Zwoenitz material for possible *fabrication and fraud*, R. Schrattenecker and S. Baumegger (2004), an Austrian camera team for video, film, and postproduction, inspected the original .avi-file with mp42 compression on CD-ROM. Various compression algorithms are used for the digital recording of pictures and sound. These *codecs* (code-decode) help to reduce the data volume when recording or transmitting the digital document. For the Zwoenitz video, the free Microsoft MPEG4 V2 Codec (short name: mp42) was used. Every record produced with a webcam is compressed video material. A frame rate lower than 25 fps (at Zwoenitz : 15 fps) means that the codec will automatically duplicate frames which gives movements on the resulting 25 fps video a jerky quality. Applications that run on the PC simultaneously with the webcam will cause overload and disturb the stable video flow via the bus system of an average home PC. Frames will be left out – “dropped” – during the recording. This produces gaps in the video recording of motion.

The analysis of the Zwoenitz video file used standard Premiere Pro and Photoshop 7.0 tools. For a succession analysis (=matching) to reveal possible compression artifacts and errors, the mp42 video stream was converted into 58 single frames. Thirty-one frames were recorded, three frames dropped – the dark gaps in the trajectory. Of the 31 frames, 17 were recorded as single frames. Other five frames were recorded twice, five frames were recorded three times, four frames were recorded four times. This gives the total of 58 frames. Only 12–14 frames per second were originally recorded and automatically duplicated by the mp42 codec to fill the 25 fps timebase with video information. The jerks and gaps visible in the captured avi-file are not due to irregularities of the moving luminous object but are caused by the mp42 compression as well as by an overload of the PC bus system resulting in dropped frames.

To detect possible cues for compositing (assembling objects or animations into a video record via postproduction) in the videostream, a frame contrast analysis was performed. Eight frames of the record were picked out in Photoshop 7.0, enlarged and examined via color picker and pixel marker. The RGB color value differences of edge pixels selected were moderate, i.e., the luminous object does not show a high contrast to the environment (sky) typical for postproduction implementation. Attempts to "iron out" RGB differences by several MPEG encodings after a possible compositing were not detectable in the pixel matrix of the Zwoenitz material. The analysis was done with seven single frames of the Zwoenitz webcam video with identical results. Therefore, it was concluded that the luminous object was not artificially implemented and was filmed directly (Schrattenecker and Baumegger 2004).

The strength of the Zwoenitz case is that the technical recording conditions of the avi-film are well-known. Further convincing interpretations will not come from the theorist's armchair, but from empiricists willing to test explanatory hypotheses with identical computer equipment. Further international analysis of the material is encouraged. If the Zwoenitz object is BL, it presents a fine grain data set of a 2 s upward trajectory.

3.6 European and International BL Statistics

Brand (1923, 2010) published the first European BL monograph and collected and evaluated 215 reports from scientific journals, cases from 19 European countries and a few overseas. What can be said about published European BL data 90 years later? Results are discussed by Keul (2005, 2006, 2008a), Keul and Schwarzenbacher (1989), and Keul and Stummer (2002).

A BL survey in 21 European countries (Keul 2005) found: BL is acknowledged as a phenomenon by the weather services of 17 European countries (81.0%). Some online staff reports are known from the Austrian Climatological Service. Offline, nonofficial staff reports are known from three countries – Austria, Finland, and Sweden. Authority (e.g., police) and media BL reports are mentioned in 15 (71.4%) of the 21 countries. Lay reports from the public are known from 15 countries (71.4%).

Brand (1923, 2010) had listed case reports from 19 European countries and seven non-European areas. With reports from France, Turkey, Poland, Spain, Belgium, Greece, Croatia, Bulgaria, and Norway, the Brand collection had material from nine European territories not producing any reports or even reply in the European BL Survey (Keul 2005). In the 2005 survey, 11 estimates were given about the phenomenon's frequency. The ranking: ~20/year the Netherlands, 10/year Hungary (except last years, 0–1), 1–5/year Austria (except last years, 0–1), 1–2/year Finland, 1/year Denmark and Czechia, rare in Estonia, UK, Ireland, Belgium, and France (Keul 2005).

BL case documentations exist in 14 (66.7%) of the 21 countries covered: Austria, Denmark, Czechia, Estonia, Finland, Germany, Hungary, Ireland, Italy, the Netherlands, Norway, Romania, Sweden, and the UK. BL case publications exist in 10 (47.6%) of the 21 countries covered: Austria, Estonia, Finland, Germany, Hungary, Italy, the Netherlands, Romania, Sweden, and the UK (Keul 2005).

Published European BL data sets with over 200 reports each exist for Germany, Austria, France, Italy, Hungary, and Russia (Keul 2005). Hentschel compiled 200 German cases; over 150 were added by the author. Other German cases were collected by Wittmann, Schlegel, and Naether (unpublished data sets). Processed Austrian data reach a similar size (Keul and Stummer 2002); more cases await statistical analysis. Hubert (1996) evaluated a collection of 249 reports from France; a new data bank lists 282 observations (Piccoli 2011). Two Italian BL data banks by Toselli (1999) and Carbognani (2006) show a total of 201 reports. Egely lists 281 Hungarian BL cases (1987). Former-USSR data banks contain over 3,000 documented reports (Stakhanov 1979; Grigor'ev et al. 1993; Smirnov 1993). As European and Asian cases are not separated, the whole dataset is used for comparison. British cases still have to be analyzed. Smaller report files exist for other European countries (e.g., Sweden, Denmark, the Netherlands, or Switzerland).

What about the phenomenological and quantitative comparison of the data bank contents? With a total of over 4,400 cases evaluated and published, the joint Eurasian dataset is the largest existing body of BL data. Keul (2008a) gave a first detailed comparison of six national datasets for 22 important case items. Some of them (year, thunderstorm, duration, form, distance, size, color, details) were obtained for all data bank evaluations, some of them (especially witness-related items like gender, age, profession, reaction, number of persons) are only available for the German-speaking and French region of Europe.

- The *gender* structure differs for data acquisition by call-for-reports (Hentschel, Keul) against more academic polls (Hubert).
- *Observation age*: In German-language databanks, 30–70% of the reporters saw BL in their childhood or school years.
- The emotional *reaction* to BL in Germany and Austria was similar – half interested, half frightened.
- *Number of persons*: There were 40–50% single observers in the German-speaking area, but 60% two or more observers in France.

- *Year*: Most BL data banks start around 1900 and end before 2000. Maximum periods were in the 50s and 60s of the twentieth century for four data banks.
- *Month*: All datasets except Italy show a clear summer maximum with 60–80% of cases. The summer peak is steep for Germany, Austria, and the former USSR, and more flat for Italy and Hungary.
- *Daytime*: In four data banks, BL follows the afternoon thunderstorm maximum (between 12 and 18 h). In Italy, 30% later events (18–21 h) were recorded.
- *Thunderstorm* association is a common pattern for 50–80% of BL cases. However, 6–20% are outside thunderstorms, in Italy nearly 40%.
- In German-language countries, about 60% of BL cases report simultaneous *precipitation* and 20–40% a simultaneous *lightning flash*. But a higher proportion (25–60%) shows no lightning flash connection.
- *Object number*: In Germany and Austria, BL is a single object in over 90% of the cases.
- The *duration* data are quite similar: 40–80% lie within the 1–5 s interval; most cases do not last longer than 20 s.
- Over 80 to over 90% report circular, round BL *form*.
- The *distance* object observer is <5 m, i.e., very close range, for 50–70% of the data bank cases. 70–80% fall within a 20 m range.
- The *size* category has its mean, median, or maximum in the 10–50 cm range. 60–80% of the objects are <30 cm, below football size.
- German-language countries report about 75% of sharply defined BL *surface*.
- *Color* data from all six data banks have their peak in the red region of the visible spectrum (50–75%). Typical reported colors are yellow, red, and white.
- *Brightness* is said to be not blinding, non-dazzling, in 55–90% of cases. About 10–25% (in Hentschel's German collection even 44%) are reported as blinding, which puts them near arc and short circuit phenomena, especially with a white-blue color.
- Typical primary *motion* in German-language and former USSR data banks is horizontal with 50–75% of the cases. Other movements are downward, complex, stationary, or rarely upward. Secondary motion like hopping is reported.
- All six datasets distinguish *indoor* from *outdoor* observations – the typical indoor proportion is around 35%, less in Hungary, up to 50% in the former USSR.
- *Residue* is mentioned in 20–30% of the cases, in France even 43%.
- *Sound* is less frequent with 15–20%, *smell* even less with 7–15%.
- *Final explosion* of BL is reported by 30–50% of the cases; in France only by 13%.

The main observational and object parameters of six national BL datasets show more similarities than differences. Although their BL data come from places 3,000 km distant with different climatic conditions, basic features like thunderstorm association, duration, distance from observer, size, color, and brightness form a cluster with defined range. One out of three BL events happen indoors with a wide spectrum of possible object relations. Thirty to fifty percent of the objects terminate with an audible explosion. Residue is a common feature.

To compare the six European/Eurasian datasets with other international data banks, the USA and Japan offer the largest analyzed case material of $n = 513$ (McNally 1966) and $n = 2{,}060$ (Ohtsuki and Ofuruton 1989). The Oak Ridge data bank evaluated by McNally allows to match five patterns with European BL: 85% of the US cases were lightning-related, which is higher for German-language or former USSR data. The US duration maximum of 1–4 s and the size maximum of 13–40 cm fit in with European statistics. The US color rank list red 12%, orange 10.5 %, blue-white 9 %, blue 8.5 %, yellow 7.5 %, red-orange 7.5 %, white 7 %, etc. and the red region with 47% is quite similar. US "sudden decay" (73.5%) is not identical with European "final explosion" (13–58%) but will contain the explosive decay cases. The comparison with the large Japanese data bank is short as only few parameters were published: with 2.6%, thunderstorm association is low for Japanese "hinotama" (which means "fireball" and includes bright meteor observations); however, the monthly BL frequency closely follows thunderstorms with a maximum in August (26%) and July (16%). July and August are also BL peak months throughout Europe. When comparing data internationally, differences in national thunderstorm and BL databanks increase the statistical variance.

So 89 years after Brand (1923, 2010), we have 4,420 cases instead of 215, but without a careful check of data quality. Brand started with 600 and excluded insufficient data sets. As next analytical steps, cases should be georeferenced and phenomenal clusters extracted (such as "blinding," "metal contact," and "white-blue" for possible short-circuit arcs). BL case borderline conditions provide essential information (Keul 2008b; Bychkov, 2012). Former-USSR data banks should be divided into European and non-European case material.

3.7 Obstacles and Chances for a Potential Scientific Solution

After four centuries of BL reports, the ongoing public controversy about the mere existence of BL sounds medieval, like the rest of pre-enlightenment tales and rumors that have survived as scientific fossils. Nevertheless, BL case data are comprehensible to the natural and social sciences and a number of well-documented international cases are on record. What causes epistemological troubles is (a) the short event duration, (b) its random appearance, (c) possible non-observation/non-reporting, (d) interpretations due to emotions and subjective framing of the observers, and (e) a wide range of physical sources and effects interacting under nonlaboratory conditions. What is needed is not new speculative theories but more field research, particularly on residue and photo/video cases, with the aim to identify locations and conditions ("hot spots") where the BL phenomenon appears more frequently and may be subject to records with pre-planned field instrumentation. Stephan et al. (2011) showed this to be a successful strategy with a Texas video record. Only after a reproducible series of high-quality records, laboratory projects will fit in to simulate the natural effects.

Contrary to lay theory fears, BL is not necessarily lethal, but in most cases ends without material effects. Consequently, there was no pressure on the safety and insurance industry to invest money in a scientific investigation. As a result, most BL-interested scientists are part-time and low- or nonfunded. Investing funds in BL research is basic research, but might lead to interesting spin-offs and applications.

In a personal communication on the BL state of the art, V.L. Bychkov, vice-president of the International Committee on Ball Lightning (2012) sees "slow progress, as collection of reliable data is difficult". In the last 20 years, he observed a change of BL theories and models. He argues that progress will come through a closer look on BL interaction with natural material (metals, sands, glass), shifting the BL model "from pure plasma to combustion of solid powders in plasma."

To gather more reliable data, steps to internationalize field research, to refine BL field investigations and to critically assess all field data, would make sense. More intense scientific collaboration was also suggested by the referees of this chapter – with historical and cultural geographers, forensic meteorologists, etc. An innovation for reporting and documentation was the implementation of BL cases as a new event type in the European Severe Weather Database 2012 (ESWD; Holzer et al. 2011).

Acknowledgments The author wishes to thank numerous observers and researchers for providing data on this spurious phenomenon. Anton Puehringer, Axel Wittmann and Karl-Heinz Hentschel did pioneer work in Austria and Germany. Austrian cases were investigated with the help of Michael Karrer and Oliver Stummer. The friendly cooperation of Gerhard Diendorfer, ALDIS/EUCLID, Michael Staudinger and Otto Svabik, ZAMG Central Institute of Meteorology and Geodynamics, Vienna, and Alois M. Holzer of ESSL is appreciated. International contacts with Boris M. Smirnov and Vladimir Bychkov, Russia, Yoshi-Hiko Ohtsuki, Japan, the late Stanley Singer and Karl D. Stephan, USA, Gerard Berger, France, and Robert K. Doe, Great Britain, helped to set our European data into the right perspective. The book project of Katrin and Niki Pfeifer stimulated further reflections on the state of the art. Valuable reviews came from Mark Stenhoff, Jonathan Webb, Vladimir Bychkov, Robert Doe and Peter van Doorn.

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Section 2
Earthquakes and Tsunamis

Chapter 4
How Does a Series of Earthquakes Affect Academic Performance?

Simon Kemp, William S. Helton, Jessica J. Richardson, Neville M. Blampied, and Michael Grimshaw

Abstract Semester 1, 2011, at the University of Canterbury was seriously disrupted by earthquakes. Two studies, one looking at all undergraduate students in the university and the second focussing on introductory psychology students, examined the effects of the earthquakes on academic performance. Over the entire university, grade performance was better than in the comparable period in 2010. Introductory psychology students in 2011 ($n = 585$) showed elevated scores on measures of depression, anxiety, and stress relative to earthquake-unaffected controls and often reported sleep and cognitive disruption, and those with higher scores on such measures tended to have poorer academic performance. The overall finding is one of resilience, as performance on objectively assessed measures was comparable to that of the previous year.

Keywords Earthquake • Academic performance • Cognitive disruption

A number of earthquakes struck in or near Christchurch in the first half of 2011. We looked at how these affected the academic performance of students enrolled in the University of Canterbury during that period.

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K. Pfeifer and N. Pfeifer (eds.), *Forces of Nature and Cultural Responses*,
DOI 10.1007/978-94-007-5000-5_4,

4.1 Earthquakes and the University of Canterbury in Semester 1, 2011

Like other universities in the southern hemisphere, the University of Canterbury's academic year normally begins in February or March. In 2011, Semester 1 lectures started on 21 February, were scheduled to finish on 3 June, and were to be succeeded by a week-long study break and a 2-week test and examination period. The earthquake on 22 February was smaller in magnitude (6.3) than the September one, but its shallow epicentre was within the Christchurch city limits. One hundred and eighty-four people died in consequence of injuries suffered in this earthquake or the many large aftershocks which occurred over the next few hours, and around 7,000 were injured. The inner city was devastated and a year afterwards much remained closed. Perhaps 10,000 houses in the suburbs were subsequently deemed uninhabitable, and very many were damaged. Water, electricity, and sewage connections were cut in much of the city. For most areas, electricity supply was restored within days, and water and sewage within weeks, but a year later, the city's water supply was still restricted (mainly because of leaks in water mains that had not yet been repaired), and some houses still had no functional sewage connection. Total property damage has been estimated in excess of NZ $20 billion (about US$16 billion).

The university, which is located in the north-west of Christchurch and on the other side of the city from the February earthquake epicentre, was immediately evacuated, and remained closed to both staff and students until 21 March. Some (but not all) lectures resumed during the week beginning 21 March, and the missing three and a half weeks of lectures were partly reinstated by severely pruning a planned 3-week break in April and extending the lecture times until 10 June. Very few university buildings were open on 21 March, and most lectures were held in tents or off campus. As the semester progressed, more buildings became available. For example, the psychology building was reoccupied in May, and the library at the very end of the semester (although the electronic library was open before 21 March). However, other buildings, for example, the student association building, the registry, and the commerce building, were found to be seriously damaged and remained closed throughout. (Indeed, these buildings were still closed a year later.) The timetable was revised weekly throughout Semester 1 as more buildings became available and the tents were phased out. In short, the earthquake produced considerable disruption for staff and students.

There were a number of large shocks on 13 June. The largest was of magnitude 6.3, with an epicentre 10 km south-east of the city centre. No one was killed, but the reopened parts of the university were again closed for varying periods. Hence, it was necessary to compress the previously scheduled 2-week examination period. In normal times, New Zealand universities allow for aegrotat grading (from the Latin "(s)he is sick") when students can prove – usually by means of medical certificates – that they were adversely affected by medical and psychological conditions at the time of assessment. Such aegrotat grades can be for either impaired

performance on work or inability to complete it. In recognition of the fact that almost all the students would have experienced the June earthquake (and subsequent swarm of aftershocks), the conditions for obtaining aegrotat consideration for the examinations were relaxed. No medical certificate was necessary, and, in effect, aegrotat grading was available on demand.

4.2 Psychological Effects of Earthquakes

There is a good deal of prior research into the effects of disasters in general, as well as earthquakes in particular, on psychological functioning. (For reviews, see, e.g. Bell et al. 2001, Ch. 7; Peek and Mileti 2002.) Understandably, the main focus of this research has been on debilitating and long-lasting psychological effects, and in particular on the development of post-traumatic stress disorder (e.g. Bergiannaki et al. 2003; Bonanno et al. 2010; Cardena and Spiegel 1993; Neria et al. 2008; Rubonis and Bickman 1991; Sahin et al. 2007). Acute stress disorder may emerge rapidly after a disaster, while post-traumatic stress disorder is normally considered to be a chronic condition that is diagnosable 6 months after the event. Although the symptoms of both are serious, they are relatively uncommon after natural disasters (e.g. Bonanno et al. 2010). On the other hand, less severe and long-lasting complaints are encountered in many people following disasters. For example, earthquakes often produce elevated levels of depression, anxiety, and stress, particularly in women (Chou et al. 2003; Kemp et al. 2011; Potangaroa et al. 2010; Sahin et al. 2007). Overall, there appear to be considerable individual differences in these effects, but most people do not experience long-term severe problems (Bonanno et al. 2010).

It is also possible that the continuous stress produced by a sequence of disasters might affect cognitive performance. Su et al. (2009) reported that the 11 September 2001 terrorist attacks in New York and Washington, DC, led to poorer driving in some areas of the USA, and they suggested these effects were mediated by people's higher stress levels. We were also motivated to consider cognitive effects by the self-reports of Christchurch people following the 4 September 2010 earthquake: Many people claimed to have difficulty in thinking clearly, and the expression "earthquake brain" was often heard as a description of this condition.

The media tend to report earthquakes as single, isolated events, but typically a large earthquake is followed by a series of aftershocks of greater and lesser magnitude. The sequence of Christchurch earthquakes was initiated on 4 September 2010 by a magnitude 7.1 event. A year later over 8,000 shocks had been recorded. The most destructive of these to date – more detail is given below – took place on 22 February and 13 June 2011, but even the lesser events often startled people or woke them from sleep. Thus, sleep disruption was commonly reported (Kemp et al. 2011). It is possible that this affects people's ability to think and decide, either directly as an effect of insomnia or indirectly (e.g. Bernert et al. 2007; Fulda and Schultz 2001).

Kemp et al. (2011) found that people who had experienced the 4 September 2010 earthquake subsequently reported higher levels of cognitive and sleep disruption than those who had not. Helton et al. (2011) found that performance on sustained attention to response tasks was impaired following this earthquake and that those who reported more cognitive disruption (using the same measure as Kemp et al. 2011) showed more impairment on the task. (See also Helton and Head 2012.) On the other hand, it is unclear whether such self-reports and laboratory findings extend to real-world situations requiring cognitive abilities, such as the academic performance of university students on assignments and tests. Students displaced following Hurricane Katrina often performed worse academically at least in the year following the hurricane (e.g. Pane et al. 2008), but the poorer performance may well be a consequence of forced displacement rather than the disaster itself. By contrast, the present studies focus on the performance of those who stayed in the earthquake-affected region. Kemp et al. (2011, Study 2) found that University of Canterbury academic grades in the second semester of 2010 indicated normal performance levels. However, the result is not conclusive. Most assessment was carried out months after the September earthquake. Perhaps final grading was a little more sympathetic than it might have been in more normal times. Nor did this study measure students' levels of depression, anxiety, stress, sleep disruption, or cognitive disruption, and it is important to know if those students who report elevated levels of these states also had poorer academic performance as previous research would suggest (e.g. Surtees et al. 2002; Yasin and Dzulkifli 2009).

4.3 How Did the Christchurch Earthquakes Affect Academic Performance?

We present the results of two studies. The first briefly looks at overall academic performance of undergraduates of the university. The second considers the academic performance of a sample of students who also completed self-report questionnaires in the latter half of May 2011. We compared the performance of this sample with that of a similar group assessed in the previous year. In this second study, we looked at performance both on the overall grade obtained for a course and on specific assessable components of it.

4.3.1 Study 1

Study 1 examined the academic performance of undergraduates enrolled at the University of Canterbury in Semester 1, 2011, and compared this performance to previous years.

Table 4.1 Average and standard deviation of GPAs and percentage of students with an overall failing grade for semester-length courses from Semester 1, 2007, to Semester 1, 2011

Year	Semester	Average GPA	SD GPA	% failing	Number of students
2007	1	4.40	2.65	9.3	9,772
	2	4.32	2.77	11.8	10,111
2008	1	4.30	2.68	10.0	10,123
	2	4.28	2.77	11.8	9,528
2009	1	4.31	2.68	10.6	11,078
	2	4.31	2.73	11.1	10,375
2010	1	4.43	2.60	8.2	11,754
	2	4.52	2.60	8.6	10,545
2011	1	4.84	2.54	7.5	9,692

1. Because some grades are unavailable, the final column is not comparable from Semester 1, 2011, to previous semesters
2. Semester courses only. All full-year courses excluded

4.3.1.1 Method

Ethical and administrative consent was obtained to access grade-point averages of all undergraduate students enrolled between 2007 and 2011. We also obtained information about individual students' gender, faculty of enrolment, and level of study.

Grade points for all courses ranged from 9 (A+) through to 0 (D) and −1 (E). Both D and E are fail grades. Grade-point averages for each student in each semester were obtained by averaging these numbers taking into account the course weighting (some courses carry greater course weights).

A total of 29,360 students (15,567 or 53% of them male) completed at least one semester-length undergraduate course between Semester 1, 2007, and Semester 1, 2011. On 15 August 2011, records were available for 9,692 students (4,749 or 48.9% of them male) who had completed at least one semester-length course in Semester 1 of 2011.

4.3.1.2 Results

Table 4.1 shows the grade-point averages and failure rates for semester-length courses in each semester from 2007 to Semester 1, 2011. The obvious result is that grades were higher in Semester 1, 2011.[1]

[1]It is not easy to find a suitable statistical test of this statement with these data. One rather conservative test asks via a one-sample *t*-test whether the mean grade-point average or Semester 1, 2011, is significantly higher than the next highest mean (Semester 2, 2010). It is ($t(9{,}691) = 12.25$, $p < .0001$).

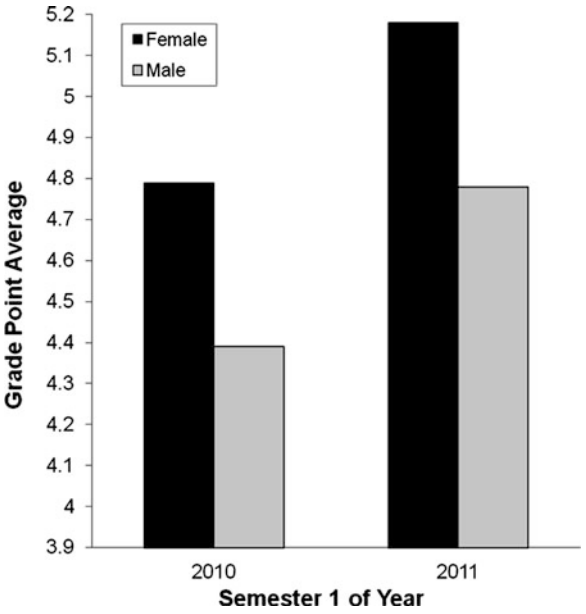

Fig. 4.1 Average GPAs on semester-length courses for male and female students who were present in both 2010 and 2011

Fewer students completed a semester-length course in Semester 1, 2011 than in previous semesters. This was mainly the consequence of students withdrawing from the university following the February earthquake. One possible explanation for why grades increased unusually in this semester was that the quality of the students who stayed was unusually high.

One way to investigate this question is to trace how individual students fared between Semester 1, 2010, and Semester 1, 2011, and Fig. 4.1 shows average results obtained from following the 6,041 individual students for whom these two sets of results were available. On average individual, students improved their grades from 2010 to 2011 ($F(1, 6{,}030) = 193.6, p < .001$); female students did better than male ($F(1, 6{,}030) = 54.5, p < .001$), but there was no interactive effect ($F < 1$).

The preceding result is contaminated to some extent by an overall tendency – discernible, for example, in comparing semester grades from 2009 to 2010, for student grades to improve with progression through an undergraduate degree. Overall, between Semester 1, 2010 and 2011, individuals improved their grades by 0.39 of a grade point, while individual grades between the same semesters of 2009 and 2010 improved by .16 of a grade point. One can "correct" the 2010 improvement by subtracting .16, leaving an "abnormal" improvement of .23 of a grade point. A single sample *t*-test showed this "abnormal" improvement to be statistically significant ($t(6{,}039) = 8.23, p < .001$). Thus, even taking into account a

tendency for poorer students to drop out,[2] the average grades in Semester 1, 2011, were higher than expected.

Of course, there are many reasons for the grade-point averages to have increased. One possibility is that grades were higher because higher grades were easier to obtain in Semester 1, 2011, perhaps because of the more generous aegrotat provisions, perhaps partly because university faculty adjusted their grading to take account of the difficult circumstances of the semester. In Study 2, we examined a smaller group of students for whom it was possible to compare academic performance in 2010 and 2011 in an objective way.

4.3.2 Study 2

Study 2 examined the academic performance of students taking an introductory course in psychology during Semester 1 of 2011. Their performance was compared to that of a similar class in the previous year. The majority of the class also completed a questionnaire that included a variety of self-report measures, including stress, anxiety, depression, cognitive disruption, and sleep disruption, and the relationship between these and academic performance measures was examined. The key questions examined in this study were:

1. Was academic performance different on average between Semester 1, 2010, and Semester 1, 2011?
2. Were there any psychological effects of the earthquake on the Semester 1, 2011, students?
3. Do the students who report the more severe psychological effects have poorer academic performance?
4. Does personality or gender affect academic performance or psychological effects?

4.3.2.1 Method

Academic Performance Measures: Academic performance records were available for students taking PSYC105 (Introductory Psychology – Brain, Behaviour and Cognition) in 2010 and 2011. In both years, the course ran in Semester 1, the academic staff teaching the course were the same, and the basic curriculum was unchanged across the 2 years. The 2010 records listed 835 students, those for 2011, 674 students, the lower number in 2011 reflecting a large number of withdrawals. The formal structure of the course was identical in the 2 years, with the main

[2]One would expect many students who leave the university after one semester or 1 year to do so because their academic performance is poor, and examination of the data showed this expectation was indeed the case.

assessment components being laboratory marks, a research report, and two multiple choice tests. The multiple choice assessments were marked objectively; the research report and laboratories had some subjective component in the marking. In both years, some individual students did not complete all the components. However, in 2011, the second multiple choice test, scheduled for a formal examination period in 20–24 June, came shortly after earthquakes on 13 June. Following aegrotat announcements, an unusually large number of PSYC105 students (121 or 18% compared to 88 or 11% in the previous year) did not complete the second test.

In all years, aegrotat and other adjustments imply that final grades for the course cannot always be obtained by simply adding up an individual's performance on the components, and in 2011, the adjustment and totalling process was unusually complex. Overall, the recorded scores on the individual components are comparable between the 2 years as measures of actual academic performance, but the final grades are not.

Participants and Questionnaire: In 2011, 585 students (165 male) completed the questionnaire as part of a standard research participation requirement. (Because of research disruptions, little else was available to meet a research participation requirement.) They also provided information that enabled matching their questionnaire responses to their overall academic performance in the course. The questionnaires were completed online (via Qualtrics) between 15 May and 1 June 2011. Five hundred and thirty-five respondents were aged between 15 and 24, 31 between 25 and 34. The University of Canterbury Human Ethics Committee approved the research.

The questionnaire was very similar to one used by Kemp et al. (2011) to measure general public responses to the 4 September 2010 Christchurch earthquake. In brief, the bulk of the questionnaire asked respondents how much each of a series of 33 statements "applied to you over the whole period since February 22". Twenty-one statements were taken from the DASS-21 scale (Lovibond and Lovibond 1995a, b), with seven each measuring depression (e.g. "I couldn't seem to experience any positive feelings at all"), anxiety (e.g. "I was aware of dryness of my mouth"), and stress (e.g. "I tended to overreact to situations"). In addition, three statements measured sleep disruption, five measured cognitive disruption, and four were mostly positive statements about social interactions following the earthquake (e.g. "I found my local community and neighbours helpful"). A single random order of the 33 statements was used in all questionnaires. All statements were responded to on the four-point scale normally used with the DASS-21. The scale points are as follows: (0) did not apply to me at all, (1) applied to me to some degree or some of the time, (2) applied to me to a considerable degree or a good part of the time, and (3) applied to me very much or most of the time.

These statements were followed by brief measures of the big five personality traits (taken from Gosling et al. 2003). There were two word or phrase pairs for each of the five traits: extraversion, agreeableness, conscientiousness, neuroticism, and openness. Each pair was followed by a seven-point scale from 1 (disagree

Table 4.2 Average percentage marks on four components and final grade points achieved in PSYC105 in 2010 and 2011

	2010			2011			
Component	*M*	SD	*N*	*M*	SD	*N*	*t*
Laboratories (%)	73.3	24.2	816	73.5	25.2	656	$t\,(1{,}470) = -.19$, *ns*
Research report (%)	63.7	16.2	725	63.2	14.7	590	$t\,(1{,}313) = .55$, *ns*
Test 1 (%)	62.2	13.8	736	63.3	12.1	547	$t\,(1{,}281) = -1.50$, *ns*
Test 2 (%)	64.9	16.4	747	63.9	14.7	553	$t\,(1{,}298) = 1.20$, *ns*
Final GP	3.47	3.00	835	4.28	2.76	670	$t\,(1{,}503) = -5.38$, $p < .001$

In 2011 (but not 2010), 23 students were credited with aegrotat passes. Such passes have been equated to a C− (GP = 1)

strongly that these words or phrases apply to you) to 7 (agree strongly that these words or phrases apply to you). Respondents were asked to consider each pair as "a description of what you are *normally* like". The final scores were averaged over the two pairs (after reverse scoring where appropriate).

The questionnaire also contained requests for mostly factual information. Not all of these results are presented below, and we omit description of them here. We did ask for ratings of how damaged their accommodation was, with options of no apparent damage of any kind (1), some but no really major damage (2), it is badly damaged but I can live in it (3), and uninhabitable (4), and how many hours sleep they had had per night on average since the earthquake.

4.3.2.2 Results

We present firstly comparisons of the 2010 and 2011 students on the different measures of academic performance, secondly the questionnaire results, and finally the relationship between the questionnaire measures and later academic performance. Note that the 2011 sample for the 2010–2011 comparison was larger than that available for the following analyses because not all students completed the questionnaire.

Comparison of 2010 and 2011 Results: Table 4.2 compares the 2010 and 2011 results on the different components of assessment and the overall final grade. The individual components are presented as percentage marks; the final grade as a grade point. For all four components, those who failed to complete the work (or, in the case of the laboratories mark, at least some of it) are regarded as missing. Neither the more subjectively assessed pieces of work (laboratory mark and research report) nor the objectively assessed work (the two tests) showed any significant differences between the years. On the other hand, the final grade point was clearly higher in 2011, with the average grade B− rather than C+. In total, 226 of the 674 students were granted higher grades than they would have otherwise obtained in response to aegrotat applications.

Table 4.3 Average cognitive disruption, sleep disruption, positive experiences, hours slept and DASS-21 stress, anxiety, and depression scores. Male and female means and the Cronbach α for the scale are also shown

	M	SD	α	Male *M*	Female *M*	*d*
Cognitive disruption	1.24	.74	.82	1.01	1.33***	.43
Sleep disruption	1.16	.80	.81	0.77	1.32***	.69
Positive experiences	1.45	.61	.60	1.32	1.50**	.30
Hours slept	7.12	1.43	–	7.41	7.00**	.29
Stress	15.1	9.8	.88	11.1	16.6***	.56
Anxiety	10.3	8.5	.82	7.2	11.5***	.53
Depression	11.0	9.1	.88	9.1	11.7**	.28

The results of a two-tailed *t*-test between male and female means are shown: *$p < .05$; **$p < .01$; ***$p < .001$. *d* is a standardised measure of difference between men and women (equal to the difference in means divided by the overall standard deviation)

Questionnaire Results: Scores on the three DASS-21 scales were calculated by simple addition and then multiplication by 2. This procedure is commonly used because it enables comparison with norms obtained on DASS-42 scales. The scores thus range between 0 and 42 on each scale. A number of studies provide general public norms for the DASS scales (e.g. Crawford et al. 2011; Crawford and Henry 2003; Henry and Crawford 2005), but the most comparable norms seem to be from a sample of 717 first-year psychology students at the University of New South Wales (Lovibond and Lovibond 1995b). This sample was 68% female (as against 72% in ours) and obtained mean values of 10.5 (SD = 6.9) on the stress scale, 5.2 (SD = 4.8) on the anxiety scale, and 7.2 (SD = 6.5) on the depression scale. Our sample shows significantly (*t*-test, $p < .001$) elevated values on all three measures. Comparison with verbal norms for the three scales indicates that our average respondent suffered from mild stress and depression and moderate anxiety (Lovibond and Lovibond 1995a). The cognitive disruption, sleep disruption, and positive effects scales were obtained by averaging over the items (and can thus range from 0 to 3). Table 4.3 shows the average scores obtained as well as the average number of hours the respondents claim to have slept per night.

The table also shows separate means for male and female students: As found previously (Kemp et al. 2011), women reported more anxiety, stress, depression, and disruption following the Christchurch earthquakes than men. Indeed, average male scores are in the normal range for all three DASS-21 scores, while average female scores are in the mild range for stress and depression and moderate range for anxiety.[3]

[3]Lovibond and Lovibond (1995b) do not give separate male and female means for their student sample. Crawford and Henry's (2003) UK general public sample show slightly but significantly higher full DASS scores on anxiety (4.0 versus 3.0) and depression (6.1 versus 4.9) for females. However, these differences are based on a different population as well as being somewhat smaller than those shown here.

Correlations between the different measures shown in Table 4.3 were calculated. Positive experiences correlated weakly but positively with the other variables, and hours slept moderately and negatively with the other variables. However, the other measures were all quite strongly positively correlated with specific correlations (r) ranging from .60 (depression and sleep disruption) to .83 (stress and anxiety). The pattern of intercorrelation is similar to those previously reported, especially for the components of the DASS (e.g. Crawford and Henry 2003; Kemp et al. 2011; Lovibond and Lovibond 1995a, b).

Correlations between these seven measures and the five personality scales were also examined. Trait neuroticism was significantly associated with sleeping fewer hours ($r = -.14$), reporting more cognitive ($r = .32$) and sleep ($r = .32$) disruption and higher stress ($r = .41$), and anxiety ($r = .38$) and depression ($r = .37$) scores. Anxious people were slightly less conscientious ($r = -.08$) and depressed people slightly less extravert ($r = -.09$). Extraverted ($r = .14$), agreeable ($r = .18$), and conscientious ($r = .09$) respondents reported more positive experiences. (All correlations mentioned were significant at $p < .05$, two-tailed.) Thus, only trait neuroticism produced reasonably substantial correlation with any measure.

Finally, 231 respondents reported no damage to their homes, 295 some damage, 46 bad damage, and 12 that their homes were uninhabitable.

Questionnaire Measures and Academic Performance in 2011: The average final grade point of those who completed the questionnaire and the course was 4.83 (SD = 2.40). Comparison of this figure to that for the whole class (see Table 4.2) indicates that those who completed the questionnaire were more successful students than those who did not.

As dependent variables for the remaining analyses, we used four components of PSYC105 assessment, the final grade obtained (expressed as a grade point), and the grade-point average that each student obtained on *all* papers completed in Semester 1 at the University of Canterbury (UCGPA). Table 4.4 shows the (pairwise) correlations obtained between each of these measures and the different predictor variables. In general, greater sleep disruption and anxiety are significantly associated with lower performance on all the measures except the research report; greater cognitive disruption and stress predict lower performance on the second test, the final grade for the course, and the GPA for all courses taken in the semester, and greater depression is associated with a lower laboratory mark and lower final grades for both this and other courses. Generally, these effects are not large, either in terms of the sizes of the correlations or by comparison with trait conscientiousness.

Table 4.5 shows the results of regressing the different dependent variables on all the predictor variables simultaneously (using the simple least-squares method). All six regressions obtained high levels ($p < .001$) of overall statistical significance, but for no regression is the proportion of variance accounted for by the predictor variables very high. We also conducted parallel regressions for male and female students separately, but these showed similar patterns and are hence not reported.

Some features of Table 4.5 are worth comment. Reporting sleep disruption or sleeping fewer hours has a consistent effect on performance and appears more

Table 4.4 Pearson correlation coefficients between measures of academic performance and predictor variables obtained from the questionnaire

	Labs	Res Rept	Test1	Test2	Grade	UCGPA
Female	.09*	.18*	−.01	−.08	.06	.08*
Age group	−.04	−.08	.03	.07	−.02	.03
Damage?	−.04	−.01	.05	−.01	.02	.0
Hours slept	.11*	.12*	.13*	.16*	.16*	.20*
Cognitive disrupt	−.07	−.05	−.07	−.13*	−.08*	−.15*
Sleep disrupt	−.12*	−.05	−.12*	−.16*	−.13*	−.18*
Stress	−.05	−.01	−.03	−.11*	−.05	−.12*
Anxiety	−.14*	−.08	−.11*	−.19*	−.16*	−.20*
Depression	−.14*	−.08	−.04	−.10	−.10*	−.18*
Positive experiences	.06	.10*	.03	−.01	.07	.05
Extraversion	−.02	.02	−.17*	−.17*	−.12*	−.06
Agreeable	.09*	.18*	.08	.09*	.10*	.12*
Conscientiousness	.22*	.22*	.13*	.08*	.21*	.21*
Neuroticism	.02	−.03	−.02	−.02	−.01	−.02
Openness	−.06	.05	.05	.01	.0	.01

Two-tailed test of significance * $p < .05$

Table 4.5 Effects of regressing four performance variables from Study 2 on predictor variables derived from the questionnaire

	Labs	Res Rept	Test1	Test2	Grade	UCGPA
Female	−.08	−.16∗	−.02	−.07	−.07	−.10∗
Age group	−.03	−.10∗	−.03	−.09∗	−.02	−.05
Damage?	−.04	−.04	−.05	−.02	−.01	−.01
Hours slept	−.05	−.10∗	−.11∗	−.12∗	−.12∗	−.14∗
Cognitive disrupt	−.11	−.01	−.07	−.05	−.03	−.00
Sleep disrupt	−.16∗	−.10	−.16∗	−.07	−.13∗	−.17∗
Stress	−.24∗	−.21∗	−.30∗	−.23∗	−.33∗	−.22∗
Anxiety	−.21∗	−.14	−.16∗	−.23∗	−.29∗	−.15
Depression	−.16∗	−.06	−.01	−.03	−.07	−.14∗
Positive experiences	−.02	−.04	−.03	−.02	−.05	−.02
Extraversion	−.03	−.04	−.23∗	−.20∗	−.17∗	−.11
Agreeable	−.08	−.12∗	−.04	−.09∗	−.06	−.08
Conscientiousness	−.20∗	−.18∗	−.13∗	−.07	−.19∗	−.18∗
Neuroticism	−.09	−.02	−.01	−.07	−.05	−.09
Openness	−.07	−.03	−.11∗	−.08	−.03	−.03
R^2 (as % of variance)	12.5	13.1	11.5	11.8	14.9	15.2

Except for the final row, all values are beta-weights derived from ordinary least-squares regression

Two-tailed test of significance * $p < .05$

important than reported cognitive disruption. The effect of stress is apparently anomalous in that heightened stress improves performance on all measures, while heightened anxiety and depression detract from it. As remarked earlier, stress correlates highly with anxiety and depression, and those who were more affected by the earthquakes were likely to have heightened stress, anxiety, and depression.

Table 4.6 Values of three academic performance variables predicted by multiple regression if levels of earthquake-related predictor variables are increased by one or two standard deviations (SDs) from the sample average or lowered by one standard deviation

Predicted scores	Test 2 (%)	Psyc105GPA	UCGPA
Lower EQ predictors −1 SD	67.9	5.30	5.41
EQ predictors at sample mean	64.4	4.83	4.69
Increase EQ predictors +1 SD	61.0	4.38	3.98
Increase EQ predictors +2 SDs	57.4	3.89	3.23
EQ-related predictors in regression equation	Hours slept	Hours slept	Hours slept
	Stress	Sleep disrupt	Sleep disrupt
	Anxiety	Stress	Stress
		Anxiety	Depression

Actual variables used in the equations are shown above. Moving an EQ-related predictor variable −1 SD lowers its value for sleep disruption, stress, anxiety, or depression but increases the hours slept. Moving an EQ-related predictor variable +1 SD correspondingly raises its value for sleep disruption, stress, anxiety, or depression but lowers the hours slept

Nevertheless, individuals who suffered elevated stress but not elevated anxiety or depression levels may actually have improved their performance in consequence of the earthquakes.[4] Recall here that moderate levels of arousal often do have a beneficial effect on performance generally (cf. Bell et al. 2001, ch. 4; Yerkes and Dodson 1908).

The preceding reasoning suggested that stress, and perhaps anxiety and depression, might have curvilinear effects on performance, with moderate levels benefiting performance, while higher levels detracted from it. Accordingly, we investigated this possibility for all three of these variables on the six dependent measures, but no significant quadratic effects were found.

Table 4.6 depicts implications of the regression results. For three of the performance measures, the significant predictors shown in Table 4.5 were selected. (e.g. female, hours slept, sleep disruption, stress, depression, and conscientiousness for UCGPA.) The average row of the table shows the predicted score of the dependent variables obtained when the average value of each predictor variable is entered. (Apart from minor variations arising from missing values, this simply equals the sample mean.) The other rows show the effects of varying the predictor variables (e.g. hours slept or stress, but not gender or any personality trait) which were likely to have been affected by the earthquake. Such predictor variables are shown in the table. The predicted performance levels from varying the predictors by 1 or 2 standard deviations from the sample averages were calculated and are presented. (Note that for this analysis, increased stress as a result of the earthquakes actually has a beneficial effect on performance, as it does in Table 4.5). Much issue could be

[4]The high correlations between stress and anxiety and stress and depression raise the question of whether the relatively high positive beta-weights for stress in the regressions are artefacts of multicollinearity. But multicollinearity is really a problem when it leads to unstable regression results, and similar positive beta-weights for stress were obtained for all six dependent variables.

taken with these results as a predictor of real-world performance. However, they do serve as a very rough indicator of the size of effects that might be obtained. Note that a grade point of 5 is a B, 4 is a B−, and 3 a C+.

4.3.3 Discussion

Overall, the results presented in these studies are consistent with the existence of three rather different effects of the earthquakes on academic performance.

Firstly, as measured by the objective indicators of Study 2, average academic performance was unaffected by the February earthquake, the subsequent aftershocks, and accompanying disruption to home and study life. Various administrative measures taken mainly to ameliorate the suspected effects of the 13 June earthquakes increased grades somewhat relative to previous years. This finding emerges most conclusively from the fact that PSYC105 ended up with a higher overall grade-point average in 2011 than 2010 even though average performance on the components was unchanged.

Secondly, the earthquakes appear to have raised stress depression and anxiety levels and increased sleep and cognitive disruption. Yet the PSYC105 survey was actually conducted when one might reasonably expect these variables to be closer to normal levels than at any other time in the semester. Recall that the surveys were completed in the second part of May when one would expect recovery from the February earthquakes, as measured both by seismic activity and reoccupation of normal university premises, but before the 13 June quakes. Study 2 shows that, overall, the combination of increased stress, anxiety, depression, sleep, and cognitive disruption is associated with deteriorated academic performance. Although the results shown in Table 4.5 indicate that the predictors in combination do not account for very large percentages of variance in any of the dependent variables, nonetheless, as Table 4.6 shows, the expected deterioration in performance is large enough to be noticeable.

Thirdly, more subtly and debatably, students who, for whatever reason, did not suffer adverse psychological effects may have actually performed at a slightly higher level than normally expected. Study 2 shows that overall real (i.e. unadjusted) student performance was about the same in 2011 as in 2010. Yet it appears that many of them had their (real) performance lowered by the psychological effects of the earthquake. This suggests that in order to maintain the roughly similar average performance between the 2 years, the performance of those in 2011 who had relatively low levels of earthquake-related anxiety or sleep disruption may have been better. There are a number of reasons for such an effect. Perhaps the psychology students were on average academically abler or better motivated in 2011 than those in the previous year because the less able or less motivated ones withdrew. The closure of many bars, night clubs, and opportunities for casual employment in Christchurch, especially in the closed central city, may have made for fewer distractions. It is possible that many students threw themselves into their work as

a way of coping with the earthquakes or living in a damaged environment (e.g. Bell et al. 2001, ch. 7). In this context, it is worth remarking that many faculty were surprised and impressed by the strong motivation of their students when the university reopened in March.

Although overall academic performance was not affected, there is good evidence that the students were psychologically affected by the earthquakes. Study 2 showed clearly elevated values on the three DASS scales compared to the Australian student results of Lovibond and Lovibond (1995b). They are also elevated above the norms for the Australian general public (Crawford et al. 2011), Australian adolescents (Szabó 2010), the UK general public (Crawford and Henry 2003), and above the average values found for a small previous New Zealand general public sample (Kemp et al. 2011). However, it is possible that the effects arose at least in part by the respondents knowing that they would shortly have to sit tests or produce final assignments after spending the semester in a suboptimal learning environment, rather than by the earthquakes themselves.

While norms for a comparable population were available for the DASS scales, this was not true for the cognitive disruption, sleep disruption, or positive experiences measures. Comparison with the earthquake-affected general public sample of Kemp et al. (2011) indicates that our respondents reported more cognitive disruption, approximately the same level of positive experiences, and less sleep disruption. Whether these differences arise from differences between the samples or different timing of questionnaire delivery (Kemp et al.'s questionnaires were mostly completed within a month of the 4 September earthquake) is unknown.

In general, women reported being more anxious, stressed, and depressed, as well as experiencing more sleep and cognitive disruption. Similar results have been noted previously both following disasters in other countries (e.g. Potangaroa 2006) and in a general public sample following the 4 September 2010 Christchurch earthquake (Kemp et al. 2011). However, the gender effects here (as indicated by d) were smaller than those found with the earlier Christchurch general public sample. Again, there are a number of possible reasons for the smaller effect size. Interestingly, there was little evidence that these self-reported gender effects were reflected in differences in gender effects in academic performance.

Overall, Study 2 indicates that the students, particularly if female, were more anxious, stressed, and depressed than a normal sample and probably experienced abnormal sleep and cognitive disruption, but the study tells us little about the mechanism for such effects, and a number of possibilities remain open. For example, were people more stressed because they had relatively little sleep, because they lived in daily fear that the next aftershock might be massive, or because everyday life was simply more difficult? Did the reported sleep disruption come about because people were more stressed, or because they were actually woken by aftershocks?

The anomalous behaviour of stress as a predictor of academic performance has already been remarked. Perhaps our results in some way reflect a distinction between performance-enhancing and performance-detracting arousal (Bell et al. 2001, ch. 7). It is possible that the most severely stressed students may have withdrawn earlier and thus we see only part of the expected inverted-U function relating performance

to stress. It is also worth noting that Yasin and Dzulkifli (2009) found that lower achieving students in normal circumstances had higher levels of depression, anxiety, and stress as measured by the DASS. Thus, readers may feel – as we do – that they would like to see the anomalous stress result replicated before too much theorising is done with it.

Some other features of the results are also puzzling. For example, there has been enormous attention paid by the New Zealand media to the problems of people living in badly damaged homes. However, having a damaged home had little effect on academic performance in Study 2 and, by extension, may not have affected work performance in the wider community much either. Similarly, the kind of social support suggested by our positive experiences measure does not seem to have helped students perform well academically, although presumably it was pleasant to receive.

4.4 Conclusion

The earthquake appears to have elevated depression, stress, and anxiety levels in students, and they also reported both sleep and cognitive disruption. Individuals reporting more of such problems generally also had poorer academic performance. Yet, the average student's academic performance seems to have been little affected, even when objective performance measures were investigated.

The wider implication of the results is that disasters like earthquakes may not always produce the deficits in performance on tasks that involve thinking and deciding that one might anticipate. Our findings are consistent with those of Bonanno et al. (2010) that a majority of those exposed to a natural disaster are resilient and typically maintain, or rapidly regain, a trajectory of healthy functioning.

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Chapter 5
Vulnerability and Disaster in Thailand: Scale, Power, and Collaboration in Post-tsunami Recovery

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Abstract This chapter examines the 2004 Indian Ocean tsunami's impacts on coastal regions of Thailand with a focus recovery dynamics and the role of community-based organizations. With more than 8,000 killed and thousands homeless in Thailand, coupled with heavy impacts to fishing villages and large-scale loss of livelihoods, recovery challenges have been extensive. Patterns of uneven geographic development among a culturally and socially diverse population produced different recovery dynamics by location across the impact zone. Based on extensive fieldwork in the region by the lead author, we examine recovery dynamics in a representative coastal village. We begin by reviewing the historical geography of the area and how development patterns shaped local vulnerabilities prior to the tsunami. This provides context for analyzing impacts and response and recovery dynamics at the research site, with a focus on the diverse ways local leaders, displaced residents, government agencies, and NGOs promoted a variety of recovery strategies. We consider how relief organizations dealt with a culturally diverse population with substantial pre-disaster vulnerabilities, including the limitations of state-centered "top-down" approaches to recovery. Alternative approaches based on local leadership and collaborative networks across geographic scales proved more successful at coupling vulnerability reduction with local programs of recovery.

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K. Pfeifer and N. Pfeifer (eds.), *Forces of Nature and Cultural Responses*,
DOI 10.1007/978-94-007-5000-5_5,

We conclude with a discussion of the role of participatory approaches and local institution building in vulnerability reduction and capacity building in the region.

Keywords Tsunami • Collaborative approach • Thailand • Disaster recovery • Coastal Community Center • Vulnerability

5.1 Introduction

On 26 December 2004, a magnitude 9.2 earthquake occurred in a subduction zone off the west coast of Northern Sumatra. The Sumatra-Andaman earthquake was the third largest magnitude event ever recorded and triggered a series of destructive tsunamis that affected 14 countries bordering the Indian Ocean (Tibballs 2005; UNDAC 2005). These waves reached far as Africa, with the worst damage and highest casualties in Indonesia, Thailand, Myanmar, Sri Lanka, India, and the Maldives. The result was the most devastating tsunami disaster in recorded history, overwhelming communities along thousands of kilometers of coastline (The World Bank 2006; UNDAC 2005). The event caused an estimated 230,000 deaths and left millions of people homeless, many of whom were among the poorest in the region (Telford et al. 2006). It also produced massive damage to infrastructure and buildings as well to coastal marine ecosystems and the livelihoods dependent on them (UNEP 2005). Total losses were estimated at US$9.9 billion (Telford et al. 2006), although given the lack of accurate economic and demographic indicators for many areas, this must be considered an approximation.

In Thailand, the tsunamis struck the west coast of the southern region, impacting six coastal provinces (Fig. 5.1). Overall, 100,000–120,000 people were estimated to have been affected by the events in Thailand (UNDAC 2005). The official number of fatalities and missing persons was more than 8,200, 2,463 of whom were foreigners, mostly tourists (Telford et al. 2006; The World Bank 2006). Over 1,400 children were orphaned, and about 60% of the indigenous populations in the region were affected. The tsunami inundated at least 400 fishing communities damaging or destroying more than 4,200 small fishing boats and 1,100 larger fishing trawlers (UNDAC 2005). As a result, more than 30,000 people lost their primary livelihoods in fisheries, creating substantial impediments to recovery in these communities (UN Thailand 2008). The tsunami also destroyed some 6,800 houses in Thailand, displacing thousands and creating substantial sheltering issues in the wave's aftermath. There was significant damage to harbor facilities and highways in the region, creating further economic losses and impairing transportation and business activity necessary for recovery (UNDAC 2005). Thailand experienced the second largest economic loss of all affected nations, estimated at US$2.09 billion, with $16 million alone in the fishing industry (The World Bank 2006; UNDAC 2005). These disruptions posed significant challenges to long-term livelihood recovery among affected persons and industries in the region (UN Thailand 2008). Coastal environmental damage was also significant and included damage to coral reefs,

Fig. 5.1 Areas affected by the tsunami in Thailand (Source: Authors)

coastal vegetation, mangrove forests, and wetlands, as well as salt contamination of agricultural fields, land subsidence, and loss of endangered species (UNEP 2005). Reports by local fishers also indicate that impacts on local marine ecosystems caused significant drops in fish catches in the first year after the tsunami affecting livelihood recovery in the sector.

5.2 Challenge and Opportunity in Thailand's Recovery

Although support from international aid agencies was substantial, with more than US$13.5 billion flowing into the 14 country impact zone (Flint and Goyder 2006), given the chronic poverty and underdevelopment of many stricken areas, the recovery of human-environment systems has been variably difficult and protracted. The Thai government spent US$1 billion on tsunami aid, and while not requesting international assistance, it did receive an additional US$69 million provided by international agencies (The World Bank 2006). However, the prevalence of an inflexible state-led top-down management approach in Thailand resulted in relief and recovery programs often incapable of adapting to local conditions and cultural differences, thus missing opportunities to enhance local livelihood security. Further,

the prioritizing of tourism and tourist infrastructure by the Thai government, in a push to encourage international investment, meant that non-tourist zones were often neglected (Rice 2005).

Given a large-scale disaster affecting culturally and economically diverse people and communities in terms of ethnicities, religions, and livelihoods, the challenges of developing appropriate recovery programs that rehoused people and reestablished livelihoods in Thailand were formidable. In a coastal disaster of this sort, there is also a need to seek reductions in physical and social vulnerability to mitigate against possible recurrence. To better understand recovery processes, in this chapter, we examine the case of one heavily impacted village, Bann Hadd Diaw.[1] The village is typical of many coastal communities in Thailand with mixed economies based primarily around fishing and related commercial activities. Bann Hadd Diaw comprised people from various ethnic backgrounds, including indigenous groups, Southern Thais, Chinese-Thais, Thai migrants from other regions in Thailand, and immigrants from Myanmar (Burma). These people hold different beliefs and religions such as indigenous spiritual religions, Buddhism, Islam, and Christianity. Their livelihoods ranged widely from garbage scavengers and day laborers to employed staff and managers in local firms and to business entrepreneurs. As the case reflected this diversity of ethnic groups, religions, and livelihoods in the southern region of Thailand, we use this case to illustrate how locally based, collaborative recovery programs can work both to promote recovery and to reduce vulnerability to hazards while they also increase local capacities to manage environmental change and build resiliency (e.g., Plummer and Armitage 2007; Marshall 2010; Gallopín 2006).

We describe how a grassroots collective approach to response and recovery shaped local efforts to reestablish homes and livelihoods after the tsunami (see, e.g., Boano and Garcia 2011; Schilderman and Lyons 2011). The case study concerns a community-based organizing program that developed into durable civil society organizations and multiscale social networks to support social change. The particular dynamics of this recovery process also worked to reduce existing vulnerabilities, as will be illustrated by applying Wisner et al.'s (2004) "Pressure and Release" (PAR) model of vulnerability dynamics. Discussed below, this framework argues that historical sources of vulnerability (root causes) intersect with various contemporary processes (dynamic pressures) to differentially produce hazard vulnerabilities that can turn hazard events into disasters. Lastly, we employ recent "politics of scale" literature from political ecology to analyze the effectiveness of scalar strategies and cross-scale dynamics as used strategically by civil society groups in the impact zone.

[1]These names are pseudonyms. The use of pseudonyms is to protect confidentiality of people involved in data collection activities. Names of individuals, organizations, and case studies can be considered direct and indirect identifiers and have been changed in the research in order to protect privacy of informants. Moreover, maps of the case study site are omitted because their unique geographical forms can be indirect identifiers of people and places, thus violating confidentiality agreements.

We do note that, unlike First World disasters (see the accompanying chapter by Lynham and Noy (2013) on the historic Hilo (Hawaii) tsunami for an example) where accurate censuses and economic indicators are available to chart recovery as a temporal process, in many parts of Thailand, including our study site, quantifying most aspects of recovery is virtually impossible. This derives from a lack of accurate census figures due to the presence of substantial numbers of undocumented and unregistered residents and from lack of economic indicators due to the informal nature of substantial elements of local economies that produce no accurate quantifiable measures.

5.3 Research Approach

To examine complex post-disaster social processes, the study relied on a suite of research methods appropriate to qualitative research using a naturalistic paradigm (Shkedi 2005; Lincoln and Guba 2000; Merriam 2002; O'Leary 2004). Our approach embraces the idea of interwoven, complex relationships rather than linear causality, with attention paid to local geographic and cultural contexts (Shkedi 2005). The lead author conducted more than 100 in-depth interviews with a range of key informants including area residents both inside and outside the impact zone, marginalized indigenous groups, political leaders at various levels, NGO and government personnel, and other key players involved in relief and recovery programs (see Hutanuwatr 2009). Interviewing relied on semi-structured protocols, adapted to different populations as respondents, was selected. The general approach was based on an iterative process using selective sampling: that is, based on preliminary field work, initial respondents were identified from key players of potential interest (NGO personnel, displaced persons, local leaders), and then, as information was developed through initial interviews, a new round of respondents could be identified (see Hutanuwatr 2009, for a complete discussion.) In addition, ten focus groups were conducted to better assess, in a group context, views on recovery programs and needs at the site. The lead author also engaged in extensive participant observation activities during the data-gathering phase. The types of social situations observed included a variety of public meetings, political activities related to community recovery, public panel discussions of tsunami recovery, and participation observation in the newly constructed neighborhoods.

Most of the interview and focus group data were gathered over a 1 year period in 2007–2008 (the funding period), with initial site visits in 2005 and 2006 to refine the research protocol as well as a concluding 2009 visit during the 5 year post-tsunami memorial activities. Lastly, a variety of agency and NGO reports on the humanitarian response as well as academic research on the tsunami's aftermath are also employed here. Combining data from stakeholder interviews, focus groups, other key informants, and a large number of agency reports provides important triangulation of our findings and provides good evidence of the validity and reliability of our findings. However, because this study is based on a naturalistic

paradigm, the primary concern is not statistical generalization but rather generating an in-depth understanding of local conditions and dynamics (Shkedi 2005) in order to understand a complex and changing post-tsunami environment.

A major focus in the hazards literature, and one we use here, is on people's vulnerability, that is, people's abilities to avoid, cope with, and respond to loss from environmental disturbances (e.g., Hewitt 1983, 1997; Watts and Peet 2004; Hill and Cutter 2001). More specifically, vulnerability comprises differences in exposure to a biophysical hazard event and people's abilities to manage the effects of that exposure (Turner et al. 2003). Vulnerability is always connected to particular resource use strategies since these directly connect to livelihoods and land uses to local environmental conditions (Adger 2006). Recovering from disaster involves mobilizing resources to restore livelihoods in a geographic context of socioenvironmental change while also addressing future hazard exposure (Collins and Bolin 2007; Pelling 2003). To understand vulnerability in a disaster context, it is first necessary to examine the historical geographical conditions which have shaped social, cultural, and political-economic characteristics of an area as these can directly influence the distribution of environmental risks people face (Davis 2002; Turner et al. 2003).

5.4 A Case Study of the Bann Hadd Diaw

Bann Hadd Diaw,[1] located on the west coast of Thailand (see Fig. 5.1), was selected as a study site because of its potential to enhance understandings of hazard vulnerability and recovery dynamics. Its history helps reveal embedded cultural and social conditions which later shaped tsunami recovery. The first inhabitants of the village site were indigenous ethnic groups who sustained themselves through fishing and related subsistence activities. These groups, known locally as "sea gypsies" or "sea people," came from one of three different ethnic groups, Moken, Moklen, and Urak Lawoi (Arunothai et al. 2006). In Bann Hadd Diaw, Moken appears to be the primary ethnicity of its early inhabitants. The Moken generally followed a nomadic way of life, involving seasonal migrations for subsistence purposes, traveling on boats during the summer, and settling during the monsoon season (although some groups remained largely on land) (Arunothai et al. 2006; APP 2008, 2009). Although later adopting Buddhism or Christianity, rituals related to animism and ancestor worship remain in practice today (APP 2008, 2009). Their local knowledge and careful observation of sea level change prior to the tsunamis helped many of them survive the 2004 disaster by prompt evacuation from beach areas (Arunothai 2011).

In the 1970s, the Bann Hadd Diaw area became a center of tin mining, attracting migrants from various parts of Thailand, creating a local mixed economy of traditional subsistence fisheries with nonrenewable extractive industry. In contrast to older Thai communities where whole villages are often strongly tied to kinship networks, our study site was a relatively new community comprised mostly of recent

migrants from elsewhere in Thailand. It was segmented into place of origin groups rather than kinship groups which, according to informants, resulted in weak social cohesion at community level. Despite economic prosperity in later 1970s, the village suffered high crime rates and general social disorganization. Much of the elevated crime rate has been attributed to numerous conflicts over cash profits gained from once prevalent mining (The Network of Tsunami-Impacted People 2005).

A drop in global tin prices in the 1980s spelled the end of the mining industry in the area and its income-earning opportunities. Many mining families shifted into an expanding fishing industry working on boats, in seafood factories, as marine engine mechanics, and in local aquaculture operations. In the 1990s, new tourist facility construction in an adjacent village attracted yet more migrants; as laborers moved into Bann Hadd Diaw, the village serving to house workers engaged in nearby construction. This influx of construction workers put additional pressures on local housing, driving of costs and reducing availability for locals. Among these newcomers were low-wage Myanmar laborers, serving both construction and fishing industries. The influx of these migrants, many undocumented, produced substantial change to labor force composition and to cultural diversity (and divisions) within the village in the pre-tsunami era.

The growing economy and the migrants attracted to it diversified and expanded the area population in the last 20 years, marginalizing local indigenous people in the process. By the time of this research, Moken occupied only small housing clusters in the larger village. A Moken elder reported that as population densities increased with new migrants, indigenous people were increasingly displaced from their preferred beach areas (where they lacked land tenure) to the inner district of the village, as wealthy landowners gained control over beaches. Other Moken reported that many of their traditions had to be adapted to the changing environment as they were displaced inland. Rituals that were originally conducted in the once prevalent coastal forests were later done under a single tree due to widespread deforestation in the area. Many of the indigenous people interviewed for this project reported feeling marginalized in the growth process and the resultant cultural discrimination that came with the migration of ethnically dominant Thais to the village.

Such divisions among social groups were not limited to ethnic Thais and the indigenous populations. Tensions between Myanmar laborers and Thais in the village persisted even after the tsunami, as reported in interviews and community meetings during the recovery. Accumulated group divisions and distrust between social groups, some dating back to the1970s, have been a persistent cultural feature of the site, producing challenges to collective action both before and after the tsunami.

In 2004, the population of Bann Hadd Diaw was estimated at 6,000 people; this included 4,000 registered residents and an estimated 2,000 unregistered residents and undocumented immigrants (The Network of Tsunami-Impacted People 2005; CU-SRI 2005). By this time, the village was a center for fishing ranging from large-scale industrial operations to smaller-scale low-technology traditional fishing typical of the Moken. Although more than 70% of the population's income was

above the national minimum standard, wealth tended to be concentrated in small groups of elites long associated with the commercial fishing economy.

As a relatively dense community located on a flat area near the ocean, lacking any disaster mitigation or preparedness plans, the village suffered badly from the 2004 tsunami. Waves surged inland 500–1,500 m, taking many lives and destroying most physical structures. Including the unregistered population, approximately 1,500 people were estimated to have died and 500 were injured (CU-SRI 2005). Based on official impact maps and aerial photos, more than 80% of the built area of masonry homes and businesses was destroyed by wave action. A villager recalled:

> Before the tsunami, along the beach it was like a slum . . . very dense [informal housing]. [Materials] were wood and metal sheets. When the tsunami hit, [waves] easily passed through. Metal sheets . . . nails [were carried by the waves] . . . so that people were killed . . . each household had 9 to more than 10 members. They died very quickly. (interview 11/9/07)

Another woman described the emotional trauma during the first few days after the impact as search and rescue was under way:

> [after the tsunami I] stayed at the [regional government center] for 3-4 days. I could not find my husband . . . [I] searched for my children, crying for them at the hospital. [I] was afraid that they could not survive. We were scattered all over. (interview 11/27/07)

Disruption to lives and livelihoods was substantial and the reconstruction needs extensive. The large-scale damage to buildings and infrastructure, including the loss of virtually all housing stock, made sheltering and housing people a critical first need.

5.5 A Collaborative Approach to Recovery

After the tsunami, at least 15 government and NGO relief organizations were established in the study area. However, most organizations had rigid and specified recovery missions that did not address more fundamental political-economic issues necessary for vulnerability reduction. One exception was what came to be known as the Coastal Community Center (CCC)[1] which was organized in one of the housing camps for the displaced through the efforts of community organizers. The CCC embraced a collaborative approach, working with stakeholders to find solutions to local needs and to develop programs responsive to local conditions and cultural differences among residents.

The seeds of the CCC began shortly after the tsunami when a Thai advocacy group experienced in slum and community organizing arrived in the disaster zone to help establish and manage a relief camp near Bann Hadd Diaw (see Fig. 5.2 for overall timeline) (The Network of Tsunami-Impacted People 2005). The key advocate in the organization described the situation at that time:

> We arrived on the third day after the tsunami. It was chaos. Chaos like a war . . . People comprised many types. There were governmental officers who busily yelled at tsunami

General Timeline

2004	
December 26	: tsunami
December 29	: community advocates arrive in Bann Hadd Diaw
2005	
early January	: establishment of relief camp and core of CCC organized
mid January	: start of some occupational working groups
late January	: organization of transitional shelter
	: gathering of tsunami-impacted communities and early network formation development
April	: establishment of community bank
May	: organization of supplemental permanent shelter
December	: closure of the relief camp
	: relocation of the community bank to village site
	: establishment of CCC in the village area
	: construction of new housing underway at multiple sites
2006	
August	: establishment of national scale network and related political activities
2007	
July	: establishment of community cultural center
April-December	: development of community preparedness plans and a community disaster preparedness center
	: Network political events to influence national policy
2008	: Continued network cross scale political activity
January	: CCC conducts evacuation drill to test preparedness plans

Fig. 5.2 General timeline of Coastal Community Center (CCC) activities

> victims 'don't take things like this' or Sub-District Organization staff who tried to organize piles of donated items as if they did not know what to do... and there were people who attempted to get maximum amounts of relief and donation items... and there was another group who just sat there. [We] didn't know why... [We] gave them moral support. [some of them mumbled] '[I] can't find our child's body.' At that moment, most people were completely dazed. Their children were dead. They could not find the bodies. [They] saw no future. (interview 7/31/08)

Advocates met with those victims best able communicate after the shocks of the impact. They discussed what steps were needed to rapidly improve conditions for affected persons, organizing a housing camp for the displaced as a first step. This took the form of a tent city which was quickly established in early January 2005. A community leader recalled:

> People [tsunami victims] started moving in [the camp] because the district government center [where some tsunami victims were sheltered] at that time was full of noise pollution. Helicopters took off and landed frequently. People were annoyed and wanted to move out [of the district center]. (interview 10/16/07)

The relief camp ultimately housed 3,500 displaced persons, more than half the estimated population of Bann Hadd Diaw, mandating extensive management and organizational efforts to maintain housing and sanitary conditions. A center for

camp management was established, and it was this community-based organization that later evolved into the CCC, a durable grassroots community institution. A key-organizing advocate described:

> The establishment of the center is akin to setting up a base of operations. It is a center for establishing a system that helps to create an organization . . . [treating the relief camp] as a real community. There were [organizational] structures, governance, community committees, participation, and societal problem-solving. (interview 7/31/08)

Planning for a community institution like this in the housing camp was not typical of the relief culture found in the area where too often displaced persons were treated as helpless victims who were not consulted by program managers.

It is in the management of this temporary housing site that the application of a collaborative approach started. The center gradually recruited camp residents to be active participants in disaster-relief management, empowering residents to select their representatives for the camp's managing committee and including displaced residents in the problem-solving process. In addition, camp residents voluntarily worked on committees which were established to address issues in the camp such as security, donations, and transitional shelter. Several meetings were held per day, ranging from small group meetings between organizers, committees, and resident representatives to large meetings attended by all camp residents. The two-way communication in these meetings allowed tsunami victims to engage the camp managers, especially in the decision-making process. An active citizen recalled one of the key decisions that all camp residents made in a group meeting:

> Regarding transitional shelters, they [meeting moderators] asked us who should be the first priority to move in? We decided those who are in difficulties should be the first. So who are those in difficulties? The injured, the pregnant, elderly, [and] children should get the shelters first . . . so we moved our tents row by row to build transitional shelters and then let the injured, elderly, and pregnant women stay there first. (interview 10/31/07)

As the participatory process developed, camp residents gradually took responsibility for managing specific tasks in the camp in order to learn how to organize the workforce and make autonomous decisions. Residents' responsibilities started with small tasks, such as communal cooking, and later dealt with more complicated missions including organizing disaster aid, managing temporary shelter, and developing a local savings bank. As camp residents' participatory roles were gradually increased, the camp took one of the most complicated missions—organizing a community bank. The community bank was established about 3 months after the tsunami in order to make use of donations over the long term. This community bank became a deposit center used by savings groups as well as a source of micro-credit loans for occupational working groups. Profits from the community bank were used, in part, for community welfare programs such as health care, scholarships, and senior welfare.

As those affected by the tsunami increased their organizational responsibilities in later 2005, the organizers slowly withdrew their involvement, continuing to provide access to intellectual, material, and financial resources when needed. A local CCC leader affirmed: "the advocates are very strong in their principle that

community members must run operations by themselves . . . [and they must] think for themselves. Outsiders can't do it for them" (interview 10/16/07). These efforts helped community members to adjust to the uncertainties and hardships of the relief phase but they also worked to develop new institutional capacities. Not only were resources provided for short-term survival, but a suite of practical skills were developed by training community members in problem-solving, decision-making, community organizing, and recognizing their legal rights.

At the end of 2005, the center for camp management and the community bank were relocated to the original village site, and the CCC was formally established in Bann Hadd Diaw, where it continued its organizational activities. The key advocate said in an interview:

> We thought that this format [of camp organization] is the format that would be able to move with the people when they moved and it did. All activities and [organizational] structures can be implemented in the actual community. (interview 7/31/08)

A group of active community members from the camp (some 20–30 people) became instrumental in the long-term operation of the CCC, and by 2008, around 2,000 members (40% of the village population) had invested in the community bank. The increase in access to political influence, training in civic skills, and grassroots democratic organizing are developments that are consistent with vulnerability reduction as will be discussed below. As local recovery gained traction through 2005 and housing stock was slowly replaced, the CCC shifted their organizational mission from short-term relief issues to longer-term recovery and development activities.

Housing reconstruction was a complicated patchwork of projects by various relief organizations and government agencies. The bulk of housing units provided for free to displaced persons (1,368 houses in seven housing projects) were funded either by private donations through NGOs or by the government. The designs and locations of six of these projects were set by the donor organizations, and there was no local consultation about size, location, or features of the homes. A seventh project allowed residents to rebuild on their property (in the inundation zone) using one of two fixed designs. Alternatively, they were provided with building materials and could provide their own labor to rebuild. These top-down approaches to housing had the advantage of more rapid rebuilding using fixed design structures and preselected locations, but many of the new homes lacked traditional design features or were too small for typical Thai households with extended kin. A number of these homes either remained unoccupied, were rented out, or sold, with the owners rebuilding culturally appropriate homes at other sites (Hutanuwatr 2009).

Two other smaller housing projects funded by NGOs in the area used a participatory housing approach originally developed for slum dwellers and other low-income households. These projects, totaling 100 homes, targeted lower income persons in the village, particularly those who were renters prior to the tsunami. In these participatory projects, the location, design, and construction of homes were all collectively managed, including the use of "sweat equity" in building (see Fig. 5.3). These projects were designed to address discriminatory eligibility requirements in

Fig. 5.3 Post-tsunami housing for disadvantage residents in Bann Hadd Diaw (Source: Authors)

the larger housing projects that provided housing only to former homeowners. As one resident who rented prior to the disaster reported:

> People who can receive government-built houses must have owned a house before the tsunami . . . must own their own land and their houses that were damaged. However, there was another group of people who were tenants [before the tsunami]. The new [government] construction was for the owners. These tenants have been here for a long time. Some of them have been here 10 years. They could not rent [houses] from others anymore.[2] (interview 1/28/08)

One problem facing all housing projects was physical safety of the locations where housing was to be built or rebuilt. Complicated land tenure issues created substantial difficulties in terms of optimizing housing location for projects. Major issues were physical hazard exposure and the need to live reasonably close to the coast for employment access in fishing industry. Safety issues were an important factor in the two participatory housing projects examined here. As one community leader described:

[2]Designs of government-built houses were targeted to single-family households. Space for rent for informal economic activity typical of homes in the area was not incorporated in these designs, underscoring the culturally inappropriate nature of these top-down projects.

> There were not many choices left [for a new housing project location]. The villagers required that it must not be [in an area] reached by the tsunami. Second it must be located in Bann Hadd Diaw. Third, it must not be a land locked plot . . . [it] must be close to higher ground. That is [in this project location] a hill is close to the entrance of the project . . . If a tsunami comes, we can run to the hill. (interview 11/28/07)

These alternative housing projects contributed to vulnerability reduction by addressing social inequities in housing safety and ensuring disadvantaged persons had access to safe living circumstances outside the inundation zone (Fig. 5.2). Although the participatory projects provided culturally appropriate housing in relatively safe locations, they had the disadvantage of taking for more time to construct than the standardized design projects (Hutanuwatr 2009).

To enhance future community safety, in 2007, the CCC took the lead in developing community disaster preparedness and evacuation plans. As a prelude to holding community response drills in January 2008, hazard maps and evacuation route diagrams were produced and distributed, and a community center for disaster preparedness was established. In an evacuation drill to test the plan, the CCC coordinated various stakeholders including governmental agencies, health-care providers, village leaders, and diverse social groups in the village. Minorities, including undocumented immigrants, were included in the event to ensure that all in the community could be evacuated (see Fig. 5.2).

By mid-2008, with the support from the government, the private sector, and NGOs, at least 95% of the displaced population from Bann Hadd Diaw had been able to move into new permanent housing. Approximately half of this new housing had various reinforcement measures incorporated or was located outside the known inundation zone. It is worth noting that almost 40% of the new housing supplied to residents in Bann Hadd Diaw was constructed in areas some distance from the historic village site. Some of these sites were purely residential with no employment opportunities, thus creating livelihood difficulties for residents at the relocation sites. Because of the geographic dispersal of a portion of new housing, the village experienced a population decline. In interviews with villagers, “quiet” was a term used to describe the level of economic activity in Bann Hadd Diaw. However, the fishing sector had resumed previous levels of activity by 2008, while those trained in CCC occupational groups were launching new businesses in the village.

5.6 The Politics of Scale in Disaster Recovery

A central element of the CCC’s evolving organizing strategy was identifying specific connections between local problems, national policies, and global factors. This was pursued by working in a network of community-based organizations in the affected region. Scaling up its efforts to address policy issues at national and international scales became a critical part of its changing mission. Emergent concerns for many community-based organizations were the potential effects that new neoliberal trade and tourism policies being pursued by the Thai government would

have on local communities. Various national and regional trade initiatives, including the Free Trade Agreement, Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSEC), and Indonesia-Malaysia-Thailand Growth Triangle (IMT-GT), were all seen by civil society groups as posing significant threats to local economies. Neoliberal trade and development agreements such as these open local markets to foreign competition, drive wages down, and put pressure on public spending on the behalf of foreign capital (Harvey 2005), something that civil society groups were well aware of. In addition, the Thai government's neoliberal tourism policy, with its strong emphasis on foreign investment in tourist infrastructure and prioritizing restoration of the tourist industry over other sectors, was increasingly criticized by the CCC and other organizations in the tsunami-affected zone. Local opposition to tourism policy in particular was grounded in concerns over the ways that foreign investment in tourism infrastructure was known to displace local residents through land dispossession and deny them traditional livelihood opportunities (e.g., Rice 2005).

Making visible local cultural practices and values was one strategy the CCC and other community-based organizations employed to counteract pressure for tourist-oriented development. Building cultural centers and community museums that displayed local cultural materials and practices was used to highlight a community's history and articulate a sense of place ownership. These cultural projects represented an effort to resist the homogenizing influence of large-scale, Western tourist developments prevalent in coastal Thailand. Cultural displays and performances also worked to highlight the importance of minority cultures (Fig. 5.4) in the region. For example, in community-led public events for an annual tsunami memorial, traditional Moken dances and other musical performances were major elements, giving public voice to the traditions of minorities in Bann Hadd Diaw.

Beyond these efforts, the CCC pursued a variety of legal strategies in an effort to change the Thai Nationality Act to provide more rights to minorities, including their right to receive government disaster aid. Although efforts at changing the Act were not successful during the course of our research, in early 2012, the Act was passed by the Senate and is in an implementation phase. The Thailand Interior Ministry remains opposed to the Act as it could grant citizenship to up to one million sea gypsies, highland groups, and long-time undocumented residents, the Ministry fearing that it will attract more "illegal immigrants" (Ekachai 2012). The pressure of civil society groups did result in concessions granted by the government prior to the passage of the full Act. In 2008, the government initiated a program to provide citizenship to more minorities, an important first step in political recognition and participation by marginalized groups. Various tactics, including demonstrations, public panel discussions, and formal complaints, filed by minority groups influenced the provincial administration to acknowledge difficulties that minorities faced in recovery. Gains in political influence by these efforts appear to be a direct result of shifting political activities from local scale politics into new political domains at the provincial and national levels.

While the CCC strategically changed the scope and scale of its mission during our study period, it was also engaged in building regional civil society networks,

Fig. 5.4 Traditional performance in a community-led public event (Source: Authors)

working in collaboration with groups from 18 other tsunami-affected communities in the area. The lead advocate described the background:

> We didn't plan to work at only one community, but also intended to expand . . . 'horizontally.' After our relief camp was getting in shape [in 2005], we sent advocates to survey other tsunami-impacted provinces. . . . both advocates and volunteers from villagers went out to survey . . . Our camp then provided support. (interview 7/31/08)

As early as 1 month after the tsunami, civil society groups from affected communities in the region met at the Bann Hadd Diaw housing camp to establish a network of tsunami-impacted communities. These provincial and trans-provincial networks enhanced the local efficacy of individual groups through the exchange of material and information resources. As with engaging national policy, the CCC's regional networking influenced provincial level social policy, particularly in the case of marginalized and vulnerable ethnic minorities excluded from disaster aid programs. Network participants were allowed to redistribute and reallocate tsunami aid among themselves, creating a more equitable system for the distribution of resources across the region. In this case, since the Bann Hadd Diaw relief camp received overwhelming amounts of material donations, the CCC distributed excess aid to other communities in need of resources. Communities in the network exchanged information regarding their recovery experiences, including management of housing programs, savings groups, and community banking. More importantly,

network members provided mutual support at numerous public events including tsunami memorial events held in affected communities. These events were important in drawing attention to key issues in post-disaster recovery and preparedness, including health issues, gender discrimination, and the marginalization of migrants and minorities by assistance programs.

By August 2006, these regional networks began to fully engage in a national political agenda, collaborating with political reform movements that preexisted the tsunami. Among key activities of this new national network were proposals for new parliamentary legislation — the Council of Community Organizations Act and the Council of Political Reformation Act — which were approved by the national parliament in 2008. While legislative acts are usually proposed by members of parliament, the fact that these grassroots community network members were able to be part of drafting legislation reflects a significant scalar shift of their political efficacy from local to national. In addition, both legislative acts also enhanced local democratic procedures by including community organizations as decision-makers in development projects at the provincial and national levels. In this case, the disaster opened up a political space for local organizations to militate for democratic processes and greater national participation for small communities.

To situate this in the geography's politics of scale literature, building networks can be understood as a scalar tactic, one in which locally based organizations change the geographical scale they operate in to take advantage of political openings and points of leverage (e.g., Bolin et al. 2008). In this case, one motivation to construct networks at the national scale was to create a framework for people with common challenges to address national policies. The key advocate for the CCC explained how the idea of slum network development was transferred to tsunami recovery advocacy:

> [We] expanded [the Slum network] to four regions [of Thailand] and then proposed the [national] Slum Act. It is not reasonable if slum-dwellers in Bangkok propose the new act for just themselves [because] the issue will then be at the local level, but what we did is to elevate the issue to [the] four regions [of Thailand]. (interview, 7/31/08)

Working at a national scale via a network of stakeholders was a technique to increase collective access to political influence and to initiate new legislation supporting the national political role of civil society groups.

Geographers have documented that civil society and marginalized groups can employ changes in scales of operation (e.g., from local to regional) as a political strategy to gain negotiating power (e.g., Kelly 1997; Brown and Purcell 2005; Bolin et al. 2008). That is, if an organization is unable to achieve change at one scale, it can shift political scales and move into new arenas where it may gain political advantage. Of course, establishing national networks may lead to a *scalar trap*, which in this case implies getting locked in at one scale (i.e., national) while ignoring other scales when seeking political solutions (e.g., p. 608, Brown and Purcell 2005). However, in the case reviewed here, support among network members showed that operating at provincial and national scales in this context increased the political efficacy of the network, as well as its ability to obtain recovery resources for local communities.

5.7 Collective Action, Vulnerability Reduction, and Resilience Building

According to Wisner et al. (2004), such scalar changes in political system dynamics leading to increased access to power are critical in efforts to address the root causes of hazard vulnerability. As civil society groups in this study demonstrate, disaster recovery can provide an opportunity to reduce vulnerability by establishing safer housing, developing more secure livelihoods and promoting more equitable and environmentally appropriate community development (Ozcevik et al. 2009; Berke and Campanella 2006). There is also evidence from the recent literature that the use of networks in disaster management is an area of growing importance (Berke et al. 2011; Wood et al. 2008; Takako and Shaw 2011; Wisner 2011; Hay et al. 2011).

CCC's activities can be characterized as consistent with a Wisner et al.'s framework for reducing social vulnerability. This framework, called the reverse Pressure and Release (PAR) model, contends that vulnerability reduction requires (a) achieving *safe conditions* by (b) reducing *dynamic pressures* and by (c) addressing *root causes* of vulnerability. That is, by reversing the historic geographic processes whereby vulnerability is produced to begin with, safer and more equitable communities can be developed. Reduced hazard exposure, structural mitigation, disaster preparedness, and improvements in the local economy are examples of strategies to achieve safer conditions. Dynamic pressures (e.g., lack of local institutions, the absence of appropriate skills, and rapid unplanned urbanization) can be addressed through local institutional capacity building and expanding social capital through education, training, and management skills. Political economies that produce uneven geographical development, with pronounced inequities in hazard exposure, which constrain livelihood opportunities, and generate large power and wealth asymmetries are among the root causes of vulnerability (Wisner et al. 2004; see also Crawford 2011).

While not explicitly identifying its mission as vulnerability reduction, the CCC's relief and recovery efforts as well as its multiscale networking strategies appear compatible with the aims of reducing vulnerability. Figure 5.5 provides an overview of what we identify as key points in vulnerability reduction that CCC programs and political activities targeted, based on a PAR schematic. The bullet points in the diagram reflect specific elements identified in the case study. The central point is that to achieve durable reductions in hazard vulnerability, it is necessary to ultimately address foundational causes of socioeconomic inequality, poverty, unsafe housing, and livelihood insecurity. Failure to do so will likely result in previous patterns of vulnerability, reasserting themselves over time and setting the stage for the next disaster (Wisner et al. 2004; Wisner 2011).

When vulnerability is reduced, community resilience can be increased (Turner 2010). While the concept of resilience can be considered from diverse perspectives, one of the key aspects in this concept is the capacity to adapt to shocks and stresses

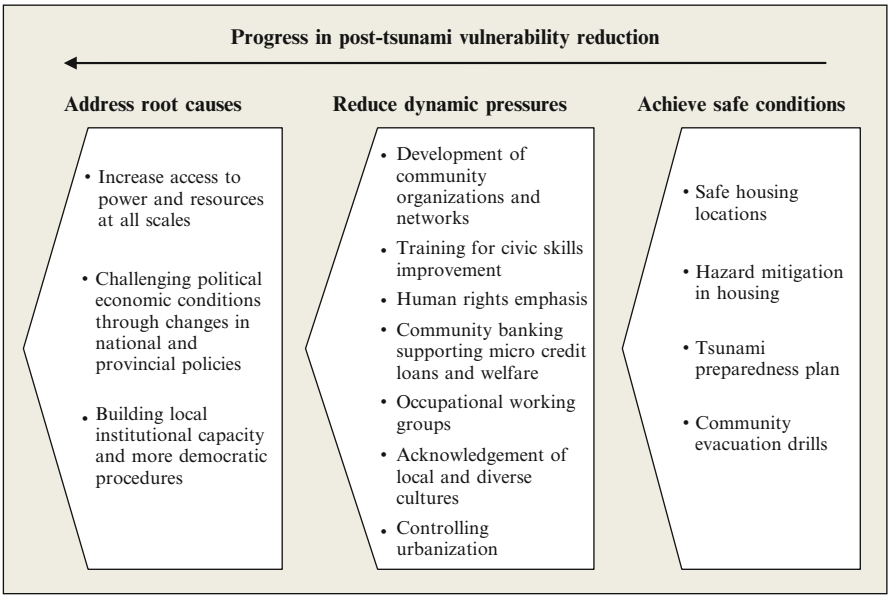

Fig. 5.5 Schematic of the CCC's vulnerability reduction actions (Adapted from Wisner et al. 2004) (Source: Authors)

(e.g., natural hazards) (Walker et al. 2004; Turner et al. 2003; Holling 1973). In the Urban Climate Resilience Framework, community's adaptive capacity largely depends on *institution*, which is defined in the framework as rules, regulations, or mechanisms that shape interaction among different actors, and actors and system services (Moench et al. 2011).

Institution can be explicitly established such as building codes, access acts, and decision rules or implicitly embedded in the societies such as culture, norm, and participatory behaviors (Moench et al. 2011; Miller and Rivera 2011; Nakagawa and Shaw 2004). These institutions may hinder or facilitate the development of adaptive capacities (Moench et al. 2011). While literature indicates significant institutional roles of collaborative culture in building resilience (e.g., Miller and Rivera 2011; Adger et al 2005; Nakagawa and Shaw 2004), the relationships between institutional characteristics and adaptive capacities are not fully understood (Moench et al. 2011).

This case study, in turn, helps adding to this discussion by demonstrating the institutional strategies that facilitated communities to adapt to emergent challenges (e.g., short-term survivals, aid management, and permanent shelters) and to address the underlying socioeconomic issues (e.g., human rights, inequity, and poverty). Findings from this case reemphasize the ideas that institution supporting adaptive capacities can be the one that (a) increases rights to disadvantaged groups, (b) promotes engagements of multi-stakeholders especially marginal people in decision-making process and shared problem-solving, and (c) facilitates exchanges and learning among stakeholders (Moench et al. 2011; Miller and Rivera 2011; Maly

2011; Prasad et al. 2011; Asia Pacific Adaptation Network 2011). While Nakagawa and Shaw (2004) showed the significant role of preexisting institution in recovery capacity, this case study demonstrated the importance of institutional development in the aftermath of the tsunami. It showed that even though pre-disaster institution did not fully support community resilience, it was possible for communities and disaster aid agencies to initiate new institution critical to adaptive capacity through the application of the collaborative approach in post-disaster phases.

5.8 Challenges to Collaborative Action in Disasters

In a culturally diverse (and divided) population in a landscape of uneven geographic development, organizational and network participation will not be universal. In our study, there were tsunami-affected villagers who were not involved in the CCC or the institutions it established. One of the primary reasons appears to be that cultural differences are not easily resolved in a collaborative context, especially with the time pressures of a post-disaster environment. While the CCC stressed collective communicative processes, some villagers preferred individual approaches. For example, ethnic minority Moken indicated that they felt uncomfortable in large meeting characteristic of the CCC approach. They explained that in their culture, they do not argue or discuss issues in large public fora but instead resolve conflicts in small groups. They also felt that if they were involved in a community organization, the numerically dominant Thais might exploit and "look down on them."

Local political issues also led some villagers to not join the CCC. As the Center gained more power and changed the texture of governance in Bann Hadd Diaw, some villagers viewed the CCC's actions as self-serving political strategies to gain popularity in local elections. Others were distrustful because of a perceived lack of transparency in CCC operations. These concerns also applied to other community organizations working in the area. In numerous interviews, there were complaints voiced about conflicts of interest in an organization's activities. This suggests the importance of internal and external transparency in each organization's approach to recovery and vulnerability reduction. Nevertheless, this case demonstrates that even though persistent social divisions and an absence of pre-disaster organization were prevalent in the village, it is possible to mobilize collective action and establish effective post-disaster community organizations through collaborative mechanisms that ultimately can work to reduce people's vulnerability.

5.9 Implications for Vulnerability Reduction

We have documented how CCC's multiscale approach to policy and programs did make meaningful advances in overcoming pre-disaster community divisions and developing new grassroots institutions. As described here, new institutional

arrangements have contributed to vulnerability reduction in this coastal region. Using a grassroots collaborative approach was instrumental in the development of a suite of post-disaster recovery strategies attuned to the needs of a culturally diverse population with a significant presence of marginalized, socially vulnerable groups. It appears likely that this approach can help reduce their vulnerability over the long term as evidenced by its general consistency with the vulnerability reduction model highlighted in this chapter (Wisner et al. 2004). The programs described here offered a flexible and evolving strategy for achieving recovery outcomes, consulting closely with those who most directly needed assistance while at the same time creating new institutional arrangements that enhance local capacities to manage future stressors. Of course, whether the specific strategies employed in this low-density setting in a developing country can be applied in complex high-density urban settings is unknown (see Crawford 2011). Nevertheless, a collaborative approach, out of necessity, is responsive to cultural and class diversity and can be an important tool in both promoting disaster recovery while also addressing longer term development needs of local populations.

Top-down, state-controlled programs such as seen in Thailand can come into conflict with local movements and organizations, delaying effective recovery. If the demonstrated effectiveness of civil society organizations using a grassroots approach to develop appropriate recovery programs is acknowledged by national governments, unnecessary conflicts and domain disputes can be avoided. This in turn could accelerate the instantiation of locally responsive recovery programs that address longer term vulnerability and livelihood security issues, particularly for those marginalized and disadvantaged by race, class, gender, or ethnicity (Bolin 2006). In this instance, the imposition of a state-driven neoliberal agenda to promote free trade and tourism, often the expense of sustainable local economic practices, can exacerbate local vulnerabilities in the interest of foreign capital flows (Harvey 2005; Rice 2005). In the case study presented here, through the use of multiple networks working a variety of geographic and political scales, civil society organizations were able to promote local development and vulnerability reduction strategies as a counter to large-scale tourist development promoted by the national government.

The various pathways taken by the CCC as it developed programs, organized local residents, and developed provincial and national networks necessarily required considerable time. It is worth noting that during post-disaster recovery, time pressures can be severe and pose challenges for meaningful community involvement. This is further complicated by forced relocations after large-scale events, disrupting local networks through geographic dispersal. In this case, the temporary housing camp for the displaced became the target of initial organizing efforts, later transferred to the reconstructed village. The process of rebuilding a village and developing new institutions to increase equity and reduce vulnerability was several years in the making. A “command and control” approach takes far less time than democratic involvement and institution building, however much it may lack in community empowerment and flexibility. It has been suggested that pre-disaster collaborative activities in planning for future hazard events are promising strategies

to reduce the pressure of time constraints in a disaster (Berke and Campanella 2006). That is, if collaborative relationships are established prior to hazard events, they can more easily be activated in the event of a calamity than if they have to be established post-event.

Collaborative approaches tap local knowledge and can promote a deeper understanding of the geographic specificities of vulnerability in a place in ways that state-directed and managed programs often cannot. While governments can typically offer resources that NGOs and civil society groups are not able to, programs can too often reinforce preexisting vulnerabilities by disallowing assistance to marginalized groups such as undocumented immigrants and those who lack legal claims to assistance (see Bolin and Stanford 1998 for a US case). In such instances, state-centered programs that are not responsive to local conditions and preexisting inequalities will too often reproduce or exacerbate those inequalities and corresponding hazard vulnerabilities. The case study presented here offers one example of a multi-scalar approach to recovery, vulnerability reduction, and political reform in a specific cultural, geographic, and political-economic context. Although Bann Hadd Diaw comprised diverse cultural and economic groups and was typical of coastal communities in Southern Thailand characterized by fishing-based economies and recent tourism influence, the specific problems and recovery needs that emerged in Bann Hadd Diaw after the tsunami and the particular ways the CCC and other organizations dealt with those problems cannot necessarily be generalized to other places and hazards. As this study adopted a qualitative research approach using a "naturalistic paradigm," the "transferability" of findings from this study can be facilitated through descriptions and contextual information, which was incorporated into the limited space available in this chapter (Merriam 2002; Lincoln and Guba 1985). Additional research using cross-case comparison would be beneficial and necessary to better understand collaborative processes across a suite of sites. In a more general sense, however, addressing preexisting vulnerabilities during the recovery process, working to enhance livelihood security, and advocating for political reform all can work to promote greater equity and risk reduction at a local scale and these efforts can be compared.

Acknowledgements This material is based upon work supported by the National Science Foundation under Grant No. 0623644, a National PERISHIP Awards, the SCION Natural Science Association, the Helios Education Foundation Scholarship, and the Herberger Institute for Design and the Arts at Arizona State University.

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Chapter 6
Disaster in Paradise: A Preliminary Investigation of the Socioeconomic Aftermaths of Two Coastal Disasters in Hawaii

John Lynham and Ilan Noy

Abstract In spite of a long history of coastal disasters worldwide and detailed studies of their short-term impacts, there is still little information about the longer-term economic and socioeconomic consequences of these events. The long-term impacts of natural disasters are "hidden" since distinguishing them from other post-disaster developments is difficult. A decade after an event, how many of the observed changes in an economy can confidently be attributed to the event itself? Because the long-term effects of coastal disasters have rarely been studied, they remain unaccounted for in any pre- and post-disaster planning and policy decisions. We focus on the 1960 tsunami and the 1992 Hurricane Iniki on Hawaii and Kauai islands, respectively. The other Hawaiian Islands, which were not hit by the tsunami or hurricane, provide an ideal control group that potentially enables us to distinguish between long-term impacts and other post-disaster developments. We describe the regional macroeconomy for the Hilo region in Hawaii and the immediate aftermath of the tsunami. We use Hurricane Iniki to demonstrate how to disentangle long-term consequences on Kauai and speculate what were the long-term impacts of 1960 Hilo tsunami.

JEL: Q54, R11

Keywords Coastal disasters • Disaster impact • Hilo • Tsunami • Hurricane • Hawaii

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K. Pfeifer and N. Pfeifer (eds.), *Forces of Nature and Cultural Responses*,
DOI 10.1007/978-94-007-5000-5_6,

6.1 Introduction

A large number of papers examine the short-term economic impact of specific disasters, and there is some comparative research on the short-term impact of disasters more generally (e.g., Belasen and Polachek 2008; Noy 2009; Strobl 2012). But research on the long-term (10 years or more) socioeconomic impact of disasters is sparse; we know very little about long-term post-disaster trajectories or other economic and socioeconomic dynamics following disaster events (Cavallo and Noy 2011). Despite its importance, the reason why this issue has not been examined carefully is the difficulty involved in separating actual long-term effects caused by the disaster from those that would have still occurred even if the disaster had not.

In attempts to identify the economic impact of disasters on national economies, Skidmore and Toya (2002), in a widely mentioned paper, find a positive association between disaster frequency and long-run gross domestic product (GDP growth). They interpret this positive correlation as caused by a Schumpeterian creative destruction mechanism whereby the destruction of public and private infrastructure leads to a speeding-up of adoption of new technologies. In similar work, Ewing et al. (2005, 2009) find labor market improvements following a hurricane and a tornado, respectively. On the other hand, Noy and Nualsri (2007) and McDermott et al. (2011) use different empirical techniques and similar data sources and find, on average for developing countries, an adverse long-run effect on GDP (and little impact at the national level for developed/wealthy countries).

Another project, Cavallo et al. (2010a), examines the impact on the national economy of specific catastrophic natural disasters and concludes that the evidence on a long-term adverse effect is driven by a few cases in which disasters were temporally associated with, and possibly caused, a dramatic political regime change. The prototype they identify is the large earthquake in Iran of 1978, which was then quickly followed by the Islamic Revolution of 1979 and the Iran-Iraq war that started in 1980. While the earthquake probably did not directly cause the collapse of the Iranian economy (a decrease of almost 50% in per capita incomes in the decade that started in 1979), it most likely contributed to it. Most accounts describe the earthquake as a trigger for the Islamic revolution, both because of dissatisfaction with the existing regime's handling of the disaster and as it enabled Islamic organizations to get valuable experience and "feet on the ground" in much of the country when assisting in disaster recovery (e.g., Keddie 2006).

The failure to establish robust patterns regarding post-disaster economic developments has led to some investigation of local impacts. In a related series of influential papers, several authors investigated the long-term impact of large-scale war-related destruction using geographically detailed bombing data from World War II Japan (Davis and Weinstein 2002, 2008), the American-Vietnam War (Miguel and Roland 2011), and Germany during World War II (Bosker et al. 2007). The first two papers failed to find any long-term impact of the bombing campaigns on the distribution of economic activity, while the latter identifies evidence of long-term adverse impact of city destruction in Germany on city-size distribution. However, this "impact-of-war"

literature answers a different set of questions, since it is less clear that wars (and their associated destruction) are exogenous events. In fact, there is a large literature that argues otherwise, especially for civil wars. As endogenous events, attempts to disentangle the causes of war from its consequences are challenging.

To summarize, the literature on the long-term impact of economic shocks is inconclusive, but the weight of the evidence suggests no long-term impact of even catastrophic shocks at the national level. Several papers, however, do point to some potentially long-term impacts at the local/regional level, and this observation is our motivation to examine much more carefully the cases of two disasters in Hawaii: the 1960 tsunami in Hilo (generated by a catastrophic earthquake in Chile) and an unusually strong hurricane that destroyed much of the large infrastructure on the island of Kauai in 1992.

It is important to note at the outset that Hawaii's experience with disasters is not unique, as the economy of both of the affected islands is similar in important respects to other islands and coastal regions. Understanding what happened there may inform us on what to expect when destructive natural events hit vulnerable coastal areas elsewhere. This chapter is organized as follows. Section 6.2 provides some background information on the State of Hawaii. Section 6.3 describes the tsunami that struck Hilo, its short-term economic impacts, and discusses what the long-term effects may have been. Section 6.4 builds on Section 6.3 by separating out the long-term economic impacts of Hurricane Iniki on the island on Kauai. Section 6.5 concludes with a general discussion and lessons for the future.

6.2 The State of Hawaii

Today, the State of Hawaii is home to nearly 1.3 million people. In 1960, the population of the Hawaiian Islands which comprise the State of Hawaii was about 632,000 while in 1992 it was around 1.1 million.[1] The state includes four counties: the City and County of Honolulu and Hawaii, Maui, and Kauai Counties.[2] Honolulu and Hawaii counties are composed of the islands of Oahu and Hawaii, respectively, while Kauai County includes the island of Kauai and the tiny island of Niihau and Maui County includes the islands of Maui and the much more sparsely populated Lanai and Molokai. About 80% of the population lives on the island of Oahu (City and County of Honolulu), while the rest is divided about 8% each in Maui and Hawaii counties and 4% on Kauai.[3]

[1] Source: State of Hawaii, Department of Business, Economic Development & Tourism, http://hawaii.gov/dbedt (accessed 31/05/2012).

[2] "Hawaii" is used both as the name for the whole Hawaiian archipelago and US state and for one of its constituent islands/counties.

[3] Data are obtained from the University of Hawaii Economic Research dataset, www.uhero.hawaii.edu (accessed 31/05/2012).

Similar to many other islands in the Pacific, tourism is the largest private sector industry today, but in 1960, agriculture and US federal government spending (much of it military related) still dominated the economy, while by 1992, tourism was already the dominant sector that generated most income from outside the state. Although the counties differ in terms of population, they are nonetheless quite similar in terms of their economic activity. In 1960, the year of the Hilo tsunami, the population of each county was 500,409 for the City and County of Honolulu, 61,332 on Hawaii, 42,576 on Maui, and 28,176 on Kauai.

In 1991, the year before Iniki hit Kauai, the resident population of Oahu was 850,500, Hawaii's population was 127,300, Maui's was 105,600, and Kauai County's was 53,400. In the same year, real per capita income (measured in 2012 dollar units) was $39,600 for the City and County of Honolulu, $27,600 for Hawaii County, $32,160 for Maui County, and $31,440 for Kauai County.[4] As for visitor arrivals, there were 4.8 million visitors to the City and County of Honolulu, 1.1 million to Hawaii County, 2.2 million to Maui County, and 1.2 million to Kauai County (UHERO 2010).

Although both Kauai and Hawaii counties have a rich agricultural history, plantations throughout the islands have been in rapid decline since the 1970s. Today, agricultural activities account for only a small share of the state's economy. Currently, most of the federal government's military presence is on the island of Oahu (11% of Oahu's total economic activity), and military spending is no longer a dominant aspect of the economy of either Kauai or Hawaii Island.

As the most populated island and the home of state government, Oahu has served as the "hub" of economic activity in the state. For example, in 2005, of the $406 million in exports from Kauai, 60% were directed to Oahu. Only 8% were directed to Hawaii County and 9% to Maui County with the rest being exported out of the state. This is similar for the other neighbor islands, including the island of Hawaii ("big island")—where Oahu is by far the largest consumer of goods from all the other counties, and it has been this way since the early part of the twentieth century.

There are no other significant export sectors or domestic manufacturing. Since the counties (islands) are largely exporting comparable products (sugar and other agricultural products) and services (mostly tourism), they are subject to similar external political and economic shocks. Not only do the counties share similar economic structures (albeit different in size) but as they belong to the same political entity, they are subject to the same institutional and legal frameworks. Most taxes are handled at the state level, and most expenditures are also decided at the state level; for example, uniquely in the United States, the public education system includes a single statewide school district.

[4]Unless stated otherwise, all dollar amounts are presented in terms of real 2012 dollars, adjusted using consumer inflation data.

6.3 The Hilo Tsunami of 1960

Tsunami is a Japanese term for large, sometimes destructive waves. Most ocean waves are caused by wind, but tsunami are different. Tsunami are caused by sudden changes in the topography of the sea floor such as slippage along underwater faults, underwater avalanches, or underwater volcanic eruptions. The majority of tsunami are caused by fault movement. Underwater fault movement displaces the Earth's crust, generates earthquakes, and, if it ruptures the sea floor, produces a sudden change in water level at the ocean surface. If the sea floor is lifted or dropped vertically, this will generate a tsunami. Tsunami are not very high (typically only about 1.6 ft tall) but they move extremely fast. They typically go undetected in the open ocean until they reach shallow nearshore waters and begin to pile up.

On the 22nd of May 1960, a tsunami was generated off the coast of Chile as a result of a major earthquake there. The tsunami struck the Hawaiian Islands 15 h later, just after midnight on the 23rd of May 1960; the tsunami was moving at a speed of approximately 445 miles/h. In general, the wave action along Hawaiian shores was noticeable but not very significant or destructive (akin to a sped-up tidal change). However, in Hilo Bay on the island of Hawaii, the third wave of the tsunami converted into a bore. For comparison, on the island of Oahu, the average run-up recorded was 7 ft. In Hilo, run-ups as high as 35 ft were recorded near the waterfront area directly south of the breakwater (see Fig. 6.1). This was surprising given that Hilo is sheltered from the direct approach of waves originating in Chile and the harbor is protected by a seawall.

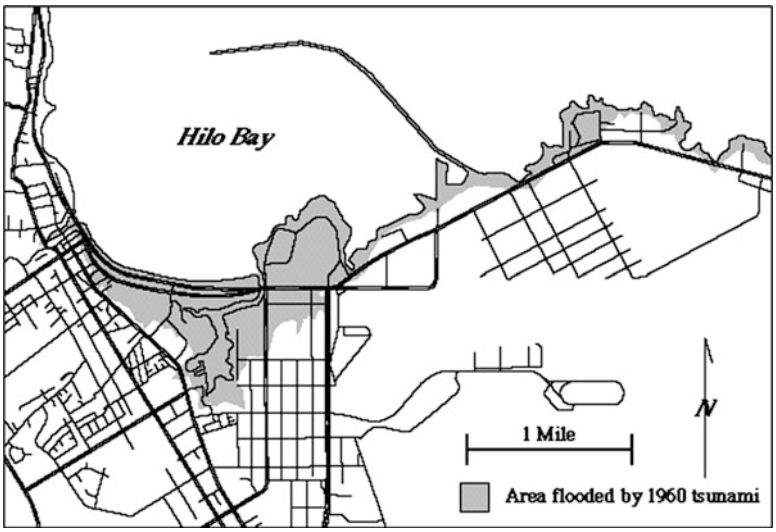

Fig. 6.1 Map showing the area in the town of Hilo that was flooded in the 1960 tsunami (Image courtesy of the US Geological Survey)

The 1960 tsunami killed 61 people and injured 282 (Cox and Mink 1963). All deaths and injuries occurred in the town of Hilo. This is despite warnings issued at 6:47 p.m. on the 22nd of May, at least 5 h before the tsunami's arrival. Warnings were issued by radio, television, public address, and in person. Only a third of the residents in the inundated areas chose to evacuate, as many did not feel there was much of a risk and the warnings were quite ambiguous (Lachman et al. 1960). This reaction is surprising since Hilo experienced an even deadlier tsunami in April, 1946 (159 people died)—this event led to the establishment of the Pacific Tsunami Warning Center that issued the 1960 alert and is still operating today.

In terms of physical damage, the brunt of the tsunami's force was focused on Hilo. Nearly 600 acres were inundated, and in about half of this area, all buildings were destroyed completely (Eaton et al. 1961); the large number of wooden frame buildings meant that few structures remained standing (see Fig. 6.2). In terms of the size of the destroyed area, this would be equivalent to 60 blocks in downtown Manhattan. The destruction was most severe along Kamehameha Avenue, the main thoroughfare of the city. On the rest of the island of Hawaii, only about a dozen other buildings were damaged. A number of automobiles, tractors, and large machines were also destroyed in Hilo. Rocks weighing 22 t were lifted from the harbor seawall and carried as far as 600 ft inland. There was hardly any damage to the other islands in Hawaii. Only a total of eight houses were destroyed on Maui, one on Lanai and none on Oahu, Molokai, or Kauai. There was some flooding and damage caused to buildings' walls and their contents but nothing compared to the destruction in Hilo.

6.3.1 Economy of the Hilo Region in 1960

In 1960, the city of Hilo was the center of economic and governmental activities on the island of Hawaii. At that time, 42% of the island's population lived in Hilo. The city and its vicinity accounted for 70% of gross retail sales and 83% of gross wholesale receipts. Almost all nonagricultural manufacturing activities were located in the city. The major sources of income on the island were agricultural (dominated by sugar but including other crops and animals) and some tourism.

6.3.2 Economic Impact of the Tsunami

The estimated damage to residential, business, and public properties was almost $169 million (see Table 6.1 for a more detailed breakdown).[5] Beyond loss of life and direct physical damage, a number of Hilo-based businesses suffered as a result of the tsunami. The State Department of Labor and Industrial Relations reported that

[5]The majority of the information in this section is sourced from Hung (1961).

Fig. 6.2 Hilo, May 1960; night photo of Mura's repair shop, debris piled as high as the roof (Reproduced by permission of Pacific Tsunami Museum—Hawaii Tribune Herald Collection)

Table 6.1 Estimated damages in 2012 US$ from the 1960 tsunami in Hilo

Type of damage or loss	Amount
Commercial and industrial buildings	55,296,000
Stocks, fixtures, and business losses	49,920,000
Public works and utilities	29,184,000
Residential buildings	17,664,000
Emergency losses	7,833,600
Residential furnishings	6,144,000
Piers, wharves, contents	2,304,000
Miscellaneous personal property	614,400
Total	*$168,960,000*

Source: US Corps of Army Engineers, Hilo Harbor, Hawaii, Report on Survey for Tidal Wave Protection and Navigation, Honolulu, 1960, p. C–32

158 firms were directly affected by the tsunami. According to their records on the 15th of June 1960, of these 158 firms, 29 had resumed business at their prior site, 58 had relocated, and 71 were still not operating. A separate survey[6] conducted on the

[6]The survey was conducted independently by Nobuo Maruyama and reported in Hung (1961).

Table 6.2 Businesses affected by the 1960 tsunami in Hilo

Date	Source	Total businesses	Resumed business	Relocated	Not in operation
15-Jun-60	State Department of Labor and Industrial Relations	158	29	58	71
15-Aug-60	Hawaii Redevelopment Agency (Mr. Nobuo Maruyama)	172	44	63	65
Jul-61	Hawaii Redevelopment Agency (Mr. Nobuo Maruyama)	174	40	90	44

Source: Hung (1961)

15th of August 1960 found that 172 firms had been damaged or destroyed and of these: 44 reopened at their prior site, 63 relocated, and 65 were still not operating. A follow-up survey conducted in July 1961 found that a total of 174 firms had been affected and of these: 40 reopened at the same site, 90 had relocated, and 44 were still not operating. See Table 6.2 for a summary.

Unemployment on the island of Hawaii shot up in the month following the tsunami but appeared to recover quite quickly in the months following (Fig. 6.3). The unemployment rate was 4.4% (980 people unemployed) in May 1960 but jumped to 7.1% (1,639 people) in July. It then declined gradually, probably due to employment created by recovery and relief efforts, with the unemployment rate in November 1960 falling back to similar levels to November/December 1959. However, the unemployment rate began creeping back up in early 1961, and by June 1961, a year after the tsunami, the unemployment rate was 1.6 percentage points higher than what it had been in May 1960, just before the tsunami hit. This pattern of immediate losses in employment, followed by gains as a result of the cleaning and rebuilding effort and an eventual disappearance of these gains, was observed in the aftermath of other cases of natural disasters as well. It also represents a significantly different trend from employment figures for the whole state (of which Hawaii Island is only a small part). Employment in the whole state was growing continuously through this period (the 1960s).[7]

A survey conducted by Hung (1961) directly after the tsunami indicates the types of jobs that were lost as a direct result of the tsunami (see Table 6.3). The majority of job losses were in the retail sector (158 jobs), with the majority of these related to the sale of food and drink. The next two biggest sectors for job losses were services (45) and manufacturing (32). Not too surprising given the agricultural nature of the Hawaii Island economy at the time, the vast majority of the job losses in manufacturing were also food related.

In terms of lost revenue, of the 158 firms that suffered major losses, 138 reported their gross receipts in 1959 and 1960. Gross receipts for all 138 firms in 1959

[7] See State of Hawaii (1978), table #4.

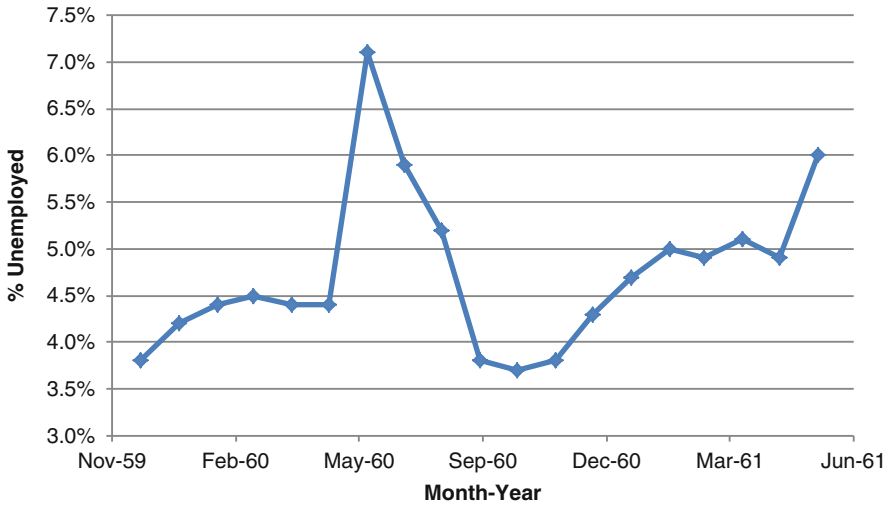

Fig. 6.3 Unemployment rate before and after the May 23, 1960 tsunami (Source: Department of Labor and Industrial Relations, Bureau of Employment Security)

Table 6.3 Unemployed as a result of the tsunami as of June 17, 1960. The numbers refer to the number of people employers reported as unemployed due to the tsunami

Business type		Number unemployed
Manufacturing	Food	27
	Wood, printing, fabricating, apparel	5
Transportation, communication, utilities, warehousing		1
Wholesale		20
Retail	Apparel	15
	Food	36
	Auto, service	23
	Eat, drink	63
	Miscellaneous	21
Services	Personal, business	25
	Hotels	3
	Theaters, recreation	17
Fishery		21
Total		*278*

Source: Hung (1961)

were $169,048,988 and declined to $138,580,562, representing a loss in revenue of over $30 million (18%). Similar to the rapid decline in unemployment following the initial surge, and despite these firms incurring heavy losses, other businesses in the Hilo area actually experienced an increase in sales in the months following the tsunami. For example, in a survey conducted by the Bank of Hawaii, from March

to December of 1960, for those retailers that were still operating in December 1960, apparel sales increased 6% and general merchandise sales increased 7%. Undamaged stores experienced a rise in business because of a lack of competition, and there was a substantial increase in sales as a result of special sales of flood-damaged goods at reduced prices. Overall, the tax base on the island of Hawaii increased from the year 1959–1960.

The tsunami also affected where people chose to reside: a large part of the 1,155 families in the leveled Kaikoo region of Hilo moved to the two new areas allocated for that purpose; Lanakila Housing Project and the Waiakea area. Although the population of the city of Hilo decreased slightly from 25,966 in April 1960 to 25,775 in July 1960, it was back up to 26,871 by January 1st of 1961. Building activity, not too surprisingly, increased greatly on the island of Hawaii in 1960 and the first half of 1961. For example, the total number of building permits issued rose from 1,260 in 1959 to 1,406 in 1960. This was largely driven by the building boom in the city of Hilo to restore damaged and destroyed properties.

As more and more people chose to move inland following the tsunami, the value of land in the south Hilo district rose considerably. This is not reflected in the "assessed" value of the land but is reflected in the sale value of land. All 30 properties actually sold in the area shortly after the tsunami experienced an increase in price, despite no actual physical improvements to 93% of the properties. In fact, 57% of these properties experienced price increases of over 50% with some increasing in value by more than 200%!

Based on these raw numbers, it appears that the economy of the city of Hilo rebounded fairly quickly after the tsunami. However, it is difficult to disentangle genuine economic improvement from (i) broader macroeconomic trends and (ii) the temporary boost in local economic activity generated by repair and rehabilitation projects. In order to distinguish the actual impact of the tsunami from the broader trends and to differentiate between the short-term boost and longer-term impacts, we need to be able to construct a counterfactual that would approximate for us the way Hilo would have developed had the tsunami of 1960 not happened; this procedure will necessitate more data collection from primary sources. As an example of how to construct such a counterfactual, we examine the second big natural disaster to hit Hawaii since statehood, the 1992 hurricane that passed over the island of Kauai.

6.4 Hurricane Iniki of 1992

Hurricane Iniki was the third hurricane to hit Kauai in the second half of the twentieth century, but the direct destruction wrought by Iniki was unprecedented.[8] This category four hurricane landed on the south shore of Kauai in the afternoon hours of September 11, 1992. Four people were killed, 25,000 were affected, and

[8]The other two hurricanes were Dot in 1959 and Iwa in 1982.

there was 7.7 billion (2012 US$) in destruction of infrastructure and property.[9] According to the National Oceanic and Atmospheric Administration (NOAA 1993), 14,350 homes were damaged or destroyed on Kauai; electric power and telephone service were lost throughout the island, and only 20% of power had been restored 4 weeks later. Crop damage was extensive; tropical plants such as banana, sugarcane, and papaya were destroyed, and fruit and nut trees were broken and uprooted.

At the time of the hurricane, Kauai was experiencing the effects of a prolonged and painful recession in Japan and, to a lesser extent, in the continental United States. The other Hawaiian Islands were also experiencing the impacts of these recessions. At that time, Japan was important for Hawaii's economy both because of the dominance of Japanese tourism in international arrivals and the very large inflows of Japanese foreign investment, especially in real estate. To separate the effect of the hurricane from the effect of the Japanese recession and the aftermath of the Gulf War and the US recession, a counterfactual scenario for Kauai without the hurricane needs to be established. The easiest way to do that is through a comparison with other regions that experienced the same external pressures, possessed the same structural vulnerabilities, but were spared any hurricane damage, namely, the other Hawaiian Islands.[10]

The massive destruction of property and infrastructure resulted in a dramatic rise in unemployment. Unemployment was already inching up from a low of around 3% in 1990 to 6.8% just before the hurricane as the Japanese economy was suffering from the aftermath of its real estate and stock market bubbles. However, immediately after the hurricane, unemployment on Kauai shot up to 19.1%. It took Kauai's labor market 7 years (until the second quarter of 1999) to recover to its previous pre-Iniki unemployment rate of 7%, while the number of private jobs available did not return to pre-Iniki levels until 2002, but even then, the recovery never brought Kauai back to its pre-Iniki trend. Evidence presented in Coffman and Noy (2012) suggests that Kauai experienced a permanent loss of about 3,400 private sector jobs (almost 15% of employment on the island)—see Fig. 6.4. This figure, as well as all the results cited here from Coffman and Noy (2012), was constructed using the synthetic control methodology described in Abadie et al. (2010). This same methodology is also used in Cavallo et al. (2010a). In essence, the methodology constructs a synthetic counterfactual data series from a weighted average of observations from other, unaffected, regions (in this case, unaffected Hawaiian counties). The weights are estimated statistically to maximize fit using

[9] All data is from EM-DAT, The International Disaster Database, http://www.emdat.be/ (accessed 22/05/2011). EM-DAT cites 5 billion in 1992 US$. We converted these to 2012 US$ using CPI data.

[10] The counterfactual Kauai without the hurricane in the following figure is constructed as a weighted average of the other Hawaiian Islands. For details see Coffman and Noy (2012).

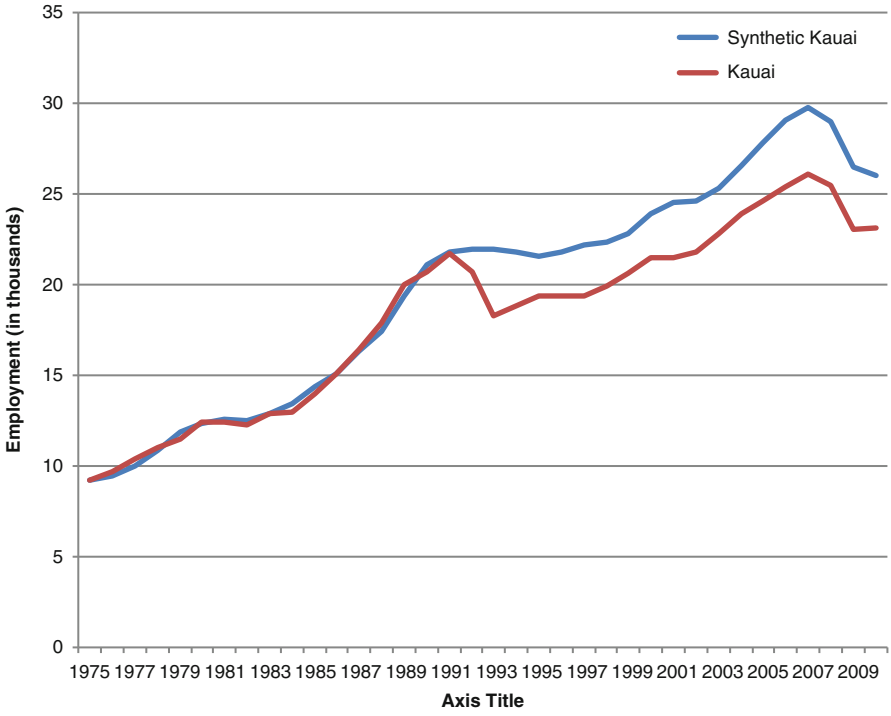

Fig. 6.4 Total private sector employment in Kauai and synthetic comparison (in thousands) (Source: Coffman and Noy 2012)

pre-disaster data from the affected (Kauai) and unaffected regions. A similar picture can be observed when the populations of Kauai and the counterfactual no-Iniki Kauai are compared.

Kauai's population trajectory shifts in 1992. After many years of rapid growth, Kauai's population grew much slower in the decade following the hurricane. It began to grow more rapidly again around 1999. However, Kauai never regained the population that left after the hurricane; Coffman and Noy (2012) estimate that Kauai's population would have been about 12% higher had Iniki never happened. This decrease in population was likely caused by the diminished employment opportunities following the hurricane. Over time, once residents realized that some jobs will not be coming back, some left as well.[11] Eventually, per capita incomes returned to their pre-Iniki (and counterfactual) level, but the island's population has not. Kauai's experience with Iniki could have been much worse as it received substantial reconstruction funds from state and federal sources. This infusion of

[11]For example, the most famous Kauai hotel at the time, the Coco Palms—a popular destination for the Hollywood set, never reopened; at the time of writing, the property is still shuttered and awaiting reconstruction a full 20 years after it was damaged.

funds surely enabled a quicker recovery than it would otherwise have been the case. However, even so, by most measures, the economy of Kauai only recovered after nearly a decade, and at least in the size of its population, it has never fully recovered to this day. Of course, whether the absence of a complete recovery was undesirable for Kauai is not immediately clear; many on the island today praise its relative tranquility and its smaller population.

The case of Kauai demonstrates that the long-term impact of a large natural disaster, while hidden, may be identified given the appropriate comparisons and construction of counterfactuals. The case of the Hilo tsunami is also instructive. *Prima facie* evidence suggests that Hilo recovered very quickly, with employment and population in particular returning to their pre-tsunami trends within a couple of years. However, before 1960, Hilo was the center of economic activity and the center of gravity for the island of Hawaii; while some time later, the main economic center of Hawaii Island shifted to the other (west) side of island—frequently referred to as Kailua-Kona.[12] The reasons and timing of that shift are unclear; but it is plausible that the destruction to the coastal areas of Hilo in the 1960 tsunami contributed to the subsequent tourism boom shifting its center of activities to the Kailua-Kona region; a shift that drove this movement of the economic center of gravity westward.[13]

6.5 Other Comparisons?

Almost all the research on the impact of disasters on the economy of a specific region focuses on the short-term, but even this research makes interesting and suggestive observations that can assist us in identifying any general patterns regarding the long-term impacts of disasters. Vigdor (2008), for example, documents significant population declines in a carefully constructed investigation of Katrina's impact on New Orleans. As Vigdor acknowledges, it is impossible to separate these declines from a general declining trend in the area's population that long predates Katrina (and which Katrina clearly accelerated); at this point, it is difficult to predict whether the population of New Orleans will converge back to its pre-inundation trend, but the evidence seems to suggest that will not be the case, and that, not unlike Kauai's case, the population will never completely recover. Similar predictions have been made regarding the population of the northeast coast of Japan (the Tohoku region) that was most heavily impacted by the 2011 earthquake and tsunami.[14]

[12]Named after the two largest towns in the area.

[13]A similar shift of the economic center of gravity in California, from San Francisco to Los Angles, is sometimes attributed to the 1906 San Francisco earthquake that destroyed much of the city's downtown (e.g., Winchester 2005).

[14]Clearly, the area around the damaged Fukushima-Daiichi nuclear power plant may never recover completely, but in our context, we are interested in the long-term consequences of the tsunami further north in the Tohoku region (see Noy 2011).

Another informative comparison is the earthquake experienced by the Japanese port city of Kobe in 1995. At the time, this was the biggest natural disaster to have hit Japan since the Great Kanto earthquake of 1923, and it was the costliest disaster of its kind in modern global experience. The perception at the time, and to this day, is that the Kobe region recovered quickly and efficiently and was back to "normal" in 3–4 years (Horwich 2000). Evidence presented by Chang (2009) and duPont and Noy (2012) both suggest that the recovery was not complete and that incomes in Kobe are today about 10–15% lower directly because of the earthquake.

All of these cases—Hilo (1960), Iniki (1992), Kobe (1995), and New Orleans (2005)—are, of course, disasters in high-income countries. This may be important since there is much evidence to suggest that, in the short term, if recovery is faster, the more funds for reconstruction are available. A massive post-disaster reconstruction program by the government, which was implemented in all these cases, may not be feasible and affordable for a lower income country to implement. In addition, accurate data to monitor economic recovery in lower income countries is rarely available (see the accompanying chapter by Hutanuwatr et al. (2013) on the 2004 tsunami in Thailand, which uses a qualitative research approach to chart the process of recovery).

Thus, the long-term economic or socioeconomic impacts of catastrophic disasters on the impacted regions in middle or lower income countries are largely unknown. The massive earthquake that hit Port-au-Prince, Haiti, in January 2010 is an exceptional case—the most deadly disaster (relative to the size of the country's population) in modern history—but it still may be instructive. The earthquake killed about 2.5% of the country's population, and estimates suggest that damages were valued at more than a 100% of GDP (see Cavallo et al. 2010b). For comparison, the Kobe earthquake destroyed about 2–3% of GDP. Clearly, the magnitude of this disaster will overwhelm any country, especially one as poor as Haiti.

Even though multilateral international organizations, and many governments, promised financial support for Haiti following the earthquake, previous examinations of similar cases suggest that there will be a significant shortfall and that the amount of funds actually disbursed will not be sufficient to even cover the initial damage, let alone to enable the country any upgrade of its infrastructure (Becerra et al. 2010).

To summarize, we argue that the long-term economic impacts of disaster events are potentially very substantial, even though they are difficult to identify with the passage of time. Many predict that the future costs of natural disasters will increase substantially because of climate change and especially to coastal areas which are vulnerable to tropical storms, flooding, and earthquake-generated tsunami. If this indeed will turn out to be what the future holds, we should be doubly concerned about the future long-term economic consequences of coastal disasters.

Acknowledgements This work was funded by a grant from the National Oceanic and Atmospheric Administration, Project R/IR-22, which is sponsored by the University of Hawaii Sea Grant College Program, SOEST, under Institutional Grant No. NA09OAR4170060 from NOAA Office of Sea Grant, Department of Commerce. The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA or any of its subagencies.

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Section 3
Volcanic Eruptions and Plagues

Chapter 7
Responses to Natural Disasters in the Greek and Roman World

J. Donald Hughes

Abstract Ancient Greek and Roman records contain many references to natural disasters. Analyzing the immediate reactions to the events, as well as the ensuing responses, is only possible where there is dependable evidence. Two case studies offer eyewitness accounts of disaster, as well as archaeological and scientific studies. These are the plague that struck Athens in 430 BCE during the Peloponnesian War, described by Thucydides who witnessed and suffered from it, and the eruption of Vesuvius in 79 CE, recorded in letters by Pliny the Younger, who saw it and fled from it during its height. The victims of these disasters were plunged into confusion and uncertainty about what to do to survive. In many cases, social cohesion dissolved, and individuals broke norms and traditions. Some sought help from the gods, and others felt there were no gods. In the aftermath, leaders responded with measures intended to help people, restore the body politic, and rebuild. Although frustrated by physical and social barriers, they achieved a degree of success.

Keywords Athens • Greece • Naples • Pericles • Plague • Pliny • Rome • Thucydides • Typhoid • Vesuvius • Volcano

7.1 Introduction

References to natural disasters are scattered through the surviving documents of the ancient Greeks and Romans, and abundant geological and archaeological evidence offers confirmation for them. The Mediterranean area is the unstable meeting place of several of the Earths moving tectonic plates, so that earthquakes are common, as are sporadic volcanic eruptions of various kinds and intensities, from the explosion

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K. Pfeifer and N. Pfeifer (eds.), *Forces of Nature and Cultural Responses*,
DOI 10.1007/978-94-007-5000-5_7,

of the island of Thera in the seventeenth century BCE to the relatively constant rumblings, smoking, and lava flows of Mount Etna. Thucydides (3.89) gives an excellent circumstantial account of a tsunami that struck the Aegean seacoasts in 426 BCE and concludes that the cause was an earthquake (Papadopoulos and Chalkis 1984). Pliny the Elder (*Historia Naturalis* 2.82, 83, 86) remarks that earthquakes cause waves at sea and inundations on land. A major earthquake off the west coast of Crete in 365 CE created a tsunami that killed thousands of people in the Nile Delta and elsewhere around the coasts of the eastern Mediterranean (Stiros 2001, 545–562). Other earthquakes caused landslides and avalanches (Guidoboni 1994). The climate, although much admired by northern Europeans, is unstable, with extreme variations in rainfall from year to year producing heat and cold waves, flood, and drought. Floods are natural disasters because they result from excessive precipitation, but they are much more sudden, and carry damaging material such as rocks and silt, when forests have been removed from the watersheds by fire and/or cutting by humans. The latter is certainly true of the floods of the Tiber River in Rome, which increased in frequency over the centuries as the land upstream was deforested (see Aldrete 2007). The predictable annual flood of the Nile in Egypt provided a blessed gift of water and fertile soil, but either low or very high floods could bring lean years and famine (Garnsey 1988). Winds such as the sirocco and mistral cause sand- and dust storms, while thunderstorms are an annual occurrence, and cyclones and tornadoes or waterspouts are not uncommon.

Another class of natural disasters caused by various organisms is reported by the ancient sources, including locust invasions, diseases of crops and domestic animals, and irruptions of commensal rodents and insects. Most noteworthy were the plagues that killed appreciable proportions of human populations during their attacks. *Nosos* and *loimos*, the Greek words for plague, are general terms for disease; in Latin, the equivalents are *pestis* and *pestilentia*. The most-noted instances in ancient Greek and Roman sources are the plague of Pericles in Athens, which began in 430 BCE; the plague of Marcus Aurelius in Rome, 165 CE; and the plague of Justinian in Constantinople, 542 CE. These diseases, which are not easy to identify, occasioned the loss of as much as 20–40 % of the population in the areas they affected. Malaria, which incrementally invaded the Mediterranean basin, became an undulating drain on health and population rather than a sudden disaster, and although the fact that mosquitos are the vector was unknown, people learned to avoid living in wetlands, building villages on hilltops where possible (Sallares 2002).

It is clear that many natural disasters can be identified in the classical Mediterranean world, but it becomes more problematic to recover the responses of people and societies to disasters. There are several important reasons for this. One is the simple lack of evidence for some periods and places, especially from early times and less urbanized areas. Literature survives from the upper, educated class, from those who could write it and whose texts were valued by later generations of literati. Another factor is that many descriptions of disaster were written long afterward, lacking direct sources of information and possibly corrupted by tendentious explanations that had arisen in the interim. It is also all too easy for a writer to imagine how he and his society might have reacted in a similar situation

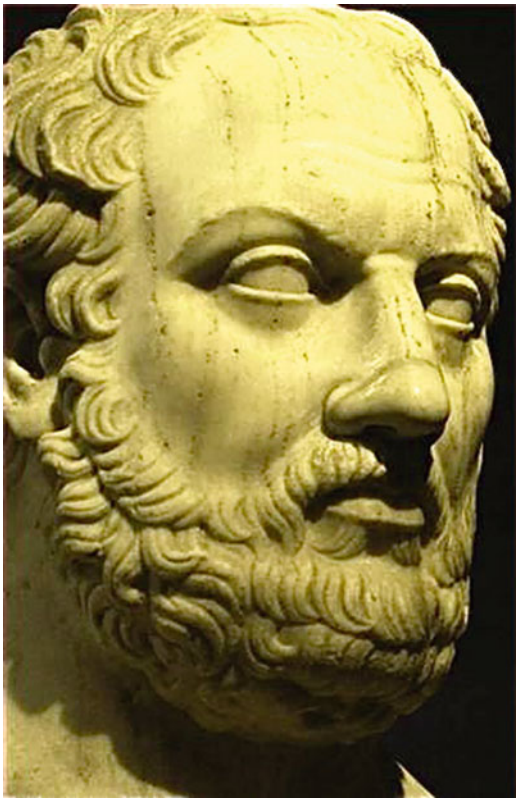

Fig. 7.1 A bust of the historian Thucydides, who described the plague in his history, *The Peloponnesian War* (Source: Downloaded from Wikipedia in public domain)

and to impute that reaction to different people living under other circumstances and with different traditions and beliefs. This occurs with a historian writing in Roman times about classical Athens, Plutarch, for example, or with Christian writers like Eusebius or Sozomen writing about what they considered to be pagan antiquity. It can be a pitfall for historians writing in the present age too, this author included, if we are not careful.

I will therefore select two ancient disasters for consideration where we have a first-hand commentator who was qualified to give an eyewitness account of the disaster and the responses made by his contemporaries. The fortunate survival, both of the writers and of their documents, is quite rare in the ancient period. Modern historians, buried as they may find themselves under avalanches of diaries, correspondence, official government reports, etc., may not appreciate how lucky ancient historians consider themselves when they discover that they have a genuine primary source that has been dependably preserved.

The first case is the plague that struck Athens near the beginning of the Peloponnesian War. The historian who recorded it, Thucydides (see Fig. 7.1), not only witnessed its progress but also actually suffered from it himself and survived. The second case is the eruption of Mount Vesuvius in 79 CE that destroyed several

Italian cities and damaged others and was described by Pliny the Younger in letters to his friend, the historian Tacitus. Pliny had an unobstructed view of the eruption and fled from his house through the ash fall, returning later.

7.2 The Plague of Athens

The onset of the plague of Athens occurred in 430 BCE, in the second year of the Peloponnesian War. Pericles (see Fig. 7.2), a general and the leading statesman in Athens, had led Athens into war against Sparta. Since the Spartans were the most-feared army in Greece, while the Athenian navy ruled the waters of the adjacent seas, the Athenians had built strong walls around the city and parallel walls

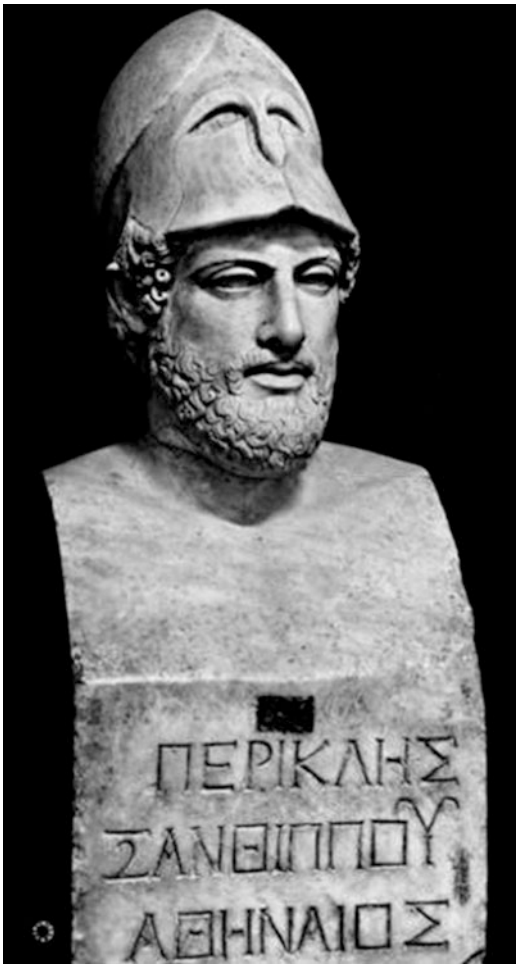

Fig. 7.2 Pericles, the great Athenian general and statesman (Source: Downloaded from Wikipedia in public domain)

Fig. 7.3 Remains of the Wall of Themistocles that surrounded the crowded city during the time of the plague (Source: Photographs were taken by J. Donald Hughes)

connecting it with the port of Piraeus (see Fig. 7.3) so that they could have naval and mercantile access to the sea without exposing themselves to Spartan incursions on land. When the war began, Pericles ordered the Athenians to abandon their farms and other holdings and move inside the walls, abandoning the countryside to the Spartans, who made an annual invasion and ravaged the crops but did not attack the walls. Conditions inside the city were very crowded; in the emergency, citizens occupied every bit of ground even including sacred groves. Estimates of the Athenian population vary, but it is probable that the normal peacetime population in metropolitan Athens and Piraeus was around 100,000, with perhaps 200,000 additional in the rest of Attica. Recognizing that many Athenians were absent from the city with military expeditions on land and sea,[1] it still seems safe to say that the population within the walls at least doubled as a result of the Periclean decree. Ships brought food and other necessities into Piraeus, and it was through the port that the plague also arrived. Thucydides reported that the first cases appeared there.

The author of the eyewitness account of the plague was Thucydides, who says that he started writing his history of the Peloponnesian War the moment the war started, which implies that his record is contemporary with the events he relates (Thucydides, *Peloponnesian War*, 1.1). He could have, and undoubtedly did, revise his text later, but the document is not complete, since it breaks off 6 years before the end of the war, that is, 20 years after the plague arrived in 430 BCE. Most historians believe that he died around 410.

[1]Hanson 2005, p. 80, estimates that the trireme warships in the navy required 40,000–60,000 sailors.

He was an Athenian citizen of an elite family with interests in Thrace (northern Greece) including gold mines at a place called *skapte hyle* ("excavated forest") that ensured his wealth and position. He was an admirer of Pericles, the democratic leader of Athens, in an apparent break from a background that included connections with the most prominent conservative oligarchs. This is exceptional since family and political loyalties went hand in hand in Athens. What Thucydides liked about Pericles was the ability to guide the democracy and keep it from foolhardy actions, at least most of the time. Unfortunately, from Thucydides' point of view, the Athenians did not always heed Pericles' advice, and there were always more radical demagogues ready to urge the people to overreach themselves.

Thucydides places his description of the plague immediately after his recounting of Pericles' funeral oration in honor of the Athenian military men who had died during the first year of the war against Sparta. This speech, one of the greatest in all written history, is a stirring democratic manifesto. The sudden descent into the horrific details of the plague's effects is arguably the starkest transition in ancient historical literature. In his book, Thucydides does not spare his readers' harrowing descriptions of the cost of war in human lives and suffering, but his measured opinion is, "The thing that did the most damage and which destroyed the most human life was the virulent plague" (Thucydides, *Peloponnesian War*, 2.47–48; Luginbill 2011, 198).

Rumors reported by Thucydides (2.47–48) said the disease had originated in Ethiopia, spread down the Nile through Egypt to the dominions of the Persian emperor, and then to the island of Lemnos and other parts of the Athenian alliance before advancing to Athens through Piraeus.

The nature of the illness was unknown to anyone, including physicians who frequently died of it after visiting the homes of the sick. Thucydides does not try to guess the name of the contagion but gives a detailed clinical description of the symptoms, which he knew well because he had experienced them himself and wanted his readers to recognize them if the disorder should recur:

> Many who were in perfect health, all in a moment, and without any apparent reason, were seized with violent heats in the head and with redness and inflammation of the eyes. Internally the throat and the tongue were quickly suffused with blood, and the breath became unnatural and fetid. There followed sneezing and hoarseness; in a short time the disorder, accompanied by a violent cough, reached the chest; then fastening lower down, it would move the stomach and bring on all the vomits of bile to which physicians have ever given names; and they were very distressing. An ineffectual retching producing violent convulsions attacked most of the sufferers, some as soon as the previous symptoms had abated, others not until long afterward. The body externally was not so very hot to the touch, nor yet pale; it was of a livid color inclining to red, and breaking out in pustules and ulcers. But the internal fever was intense; the sufferers could not bear to have on them even the finest linen garment; they insisted on being naked, and there was nothing that they desired more eagerly than to throw themselves into cold water. And many of those who had no one to look after them actually plunged into the rain tanks, for they were tormented by unceasing thirst, which was not in the least assuaged whether they drank little or much. They could not sleep; a restlessness that was intolerable never left them. While the disease was at its height the body, instead of wasting away, held out amid these sufferings in a marvelous manner, and either they died on the seventh or ninth day, not of weakness, for their strength

Fig. 7.4 Remains of plague victims found in a pit in Athens; note the disorderly arrangement of the burials (Source: Downloaded from Wikipedia in public domain)

> was not exhausted, but of internal fever, which was the end of most; or, if they survived, then the disease descended into the bowels and there produced violent ulceration; severe diarrhea at the same time set in, and at a later stage caused exhaustion, which finally with few exceptions was fatal. For the disorder which had originally settled in the head passed gradually through the whole body, and, if a person got over the worst, would often seize the extremities and leave its mark, attacking the privy parts and the fingers and the toes; and some escaped with the loss of these, some with the loss of their eyes. Some again had no sooner recovered than they were seized with a forgetfulness of all things and knew neither themselves nor their friends. (Thucydides, *Peloponnesian War*, 2.49)

Modern medical historians are just as confused about how to diagnose the ancient disease as Thucydides and the Athenian doctors were. No present-day communicable malady matches exactly this list of symptoms, but disease organisms can mutate genetically and phenotypically, and this is certainly possible over a period of 2,500 years. Nevertheless, numerous attempts, some of them very convincing, have been made to identify the outbreak as bubonic plague, typhus, measles, anthrax, smallpox, hemorrhagic fever, or even toxic shock syndrome or Ebola virus. Typhoid fever is possibly the most likely candidate; a study of the dental pulp of the skulls of victims by Dr. Manolis Papagrigorakis (2006) and others at the University of Athens found in a burial pit that can be dated to the first years of the Peloponnesian War (see Fig. 7.4) shows DNA sequences similar to those of the bacterium that causes typhoid. I recited a list of the symptoms reported by Thucydides to Dr. Eric A. Hughes, M.D., Ph.D., a recognized authority in the field of communicable disease and my son-in-law, and he immediately suspected that it was typhoid. Thucydides writes that carrion-eating birds and dogs either died of the plague or escaped it by not touching the bodies of the dead. Typhoid is known to have canine and avian victims.

Typhoid epidemics are common in history and have not disappeared. As I write (2012), they are raging in parts of sub-Saharan Africa, such as Zambia, Zimbabwe, and the Democratic Republic of Congo, with millions of victims. Usually, outbreaks are local and caused by contamination of water and food by fecal material from infected persons or animals. A rumor reported by Thucydides said that the Peloponnesians (the Spartans and their allies) had poisoned the open reservoirs that supplied Piraeus. He did not believe the rumor, and it is unlikely that the Spartans were guilty since they were not suffering from the plague (Thucydides, *Peloponnesian War*, 2.57),[2] but the story does connect its spread with the water supply. It is more likely that the city's water was contaminated after the plague entered, given the overcrowded conditions. There were numerous wells, local springs, and cisterns that might have received sewage, and even the bodies of victims crazed with thirst, whereas the main supply came through an aqueduct that ran 7.5 km (2.3 miles), from nearby Mount Hymettus, built in the sixth century BCE by the tyrant Peisistratus and his sons, with branches added later from other mountains including Parnes and Penteliko (Tassios 2006, 2007). These were tunnels with vertical airshafts usable for maintenance access built at a distance apart of 40–50 m; the diameter of these shafts is about 1.5 m (4–5 ft), and many of them still exist (Crouch 1993). Outside Athens, the conduits met in a large reservoir, from which the water was distributed by a ramification of underground channels throughout the city. The main one under the agora, which supplied the main springhouse called Enneakrounos ("fountain with nine spouts"), is high and broad enough to allow two men to pass in it. Often pipes of baked clay, about 20 cm (8 in.) in diameter, were laid within them (Koutsoyiannis et al. 2008). This system was built to prevent enemies from interfering with it, but the Spartans, in control of everything outside the walls, could have cut the aqueducts at times, inadvertently causing the Athenians to use sources inside the city that, unknown to them, carried the disease organisms. Whether there was interference with the aqueducts or not, the crowding would have caused water shortage and the use of many sources other than the aqueducts (Hanson 2005, 65, 68).

The plague struck perhaps 50 % of the Athenians who were in the city and killed 25–30 %. The army in the field also suffered from it, especially Hagnon's troops who were sent to northern Greece to help in the siege of Potidaea. The conditions of an army camp located in one position for a long time make the spread of disease easy, and Hagnon returned to Athens after the loss of 1,050 out of his 4,000 men, a 26 % death rate (Thucydides, *Peloponnesian War*, 2.58). The outbreak recurred twice, in 429 and in the winter of 428–427, and the depletion of Athens' manpower undoubtedly contributed to the eventual Spartan victory in the war.

The reactions to the plague as reported by Thucydides are not always those that might be expected by those with some knowledge of ancient Greek literature.

[2]Thucydides says that very few of the Peloponnesians caught the plague, although they had invaded Attica and were aware of the many funerals being held for its victims. They did not invade in 429, fearing the plague.

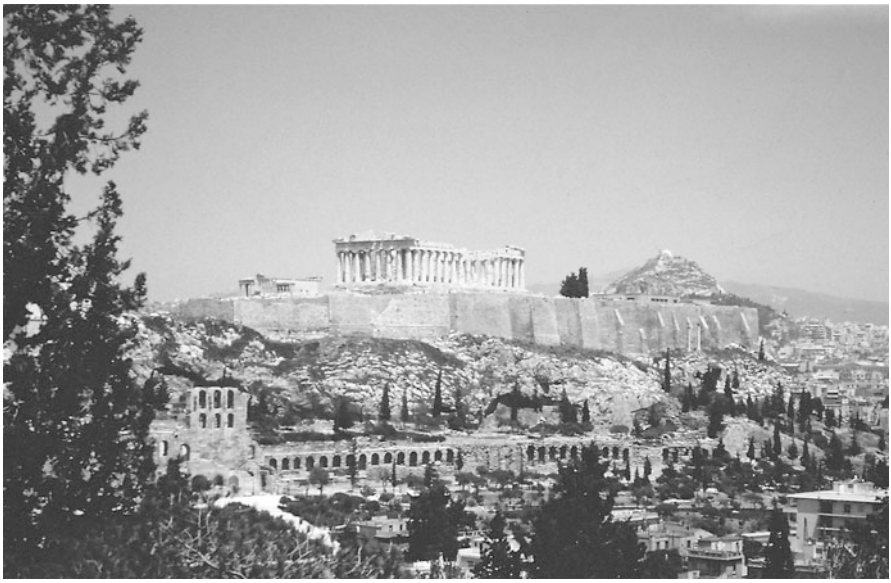

Fig. 7.5 The Acropolis of Athens and the Parthenon seen from the Hill of Philopappos (Source: Photographs were taken by J. Donald Hughes)

The Homeric poems (*Iliad*, 1, 33–67) say that the gods, Apollo in particular, send pestilence when they are angry. They do this not to punish some sin or moral failure but to avenge dishonor against themselves or those they protect. It would be reasonable to expect that the Athenians would ask which of the gods had smitten them with the plague and which offerings to make to mollify the divine anger. Nothing of the sort is mentioned by Thucydides, who says people noticed that those who worshipped the gods died with the same frequency as those who did not. He does say that old men remembered an ancient oracle that said "A Dorian [Spartan] war shall come and with it a pestilence" (2.54.2). Then, further showing his skepticism in matters of religion, he notes that the word *loimos* (pestilence) is pronounced about the same as *limos* (famine) and that the oracle could be taken in more than one way, as often happened. Another oracle, from Apollo at Delphi, promised the Spartans that he would fight on their side, and since Apollo's weapons in the *Iliad* are arrows of plague and that the plague did not affect the Spartans, Thucydides recalls that some Athenians believed that depressing interpretation of the oracle. The Spartans, fearing that they might contract the plague from the Athenians, did not invade Attica in 429, although they returned the next year. But the connection of disease with the gods remained; a temple to Asclepius, the god of healing and son of Apollo, was erected near the Theater of Dionysus below the south side of the Acropolis in 420 BCE (see Fig. 7.5), after the abatement of the plague (Mitchell-Boyask 2008, 1). Sophocles' play *Oedipus Rex*, written soon after or even during the Athenian plague, opens with a disease devastating Thebes, and although in the play the cause of the disaster is refusal to accept an oracle of Apollo, the

chorus specifically blames the plague on Ares, the god of war. Sophocles' Theban plague was undoubtedly a reference to the Athenian plague he had experienced and the character Oedipus a likely metaphor for Pericles.

A skeptic of religion, Thucydides is also a keen observer of the political and moral behavior of humans in times of crisis. He is the most astute social critic among ancient historians, analyzing the underlying reasons why individuals on different sides of a conflict make the decisions they do. He shows that in times of war and other disasters, they abandon more embracing considerations of community life for narrow personal interest, and society degenerates into partisanship and even anarchy. He portrays this clearly in the case of the plague. Since those who helped friends that had the disease usually caught it themselves, others decided to leave them to suffer. The sacrosanct way in which burial rites were held by the ancient Greeks is illustrated by the character Antigone in Sophocles' play of the same name, who was willing to die in order to give her brother burial. But Thucydides says that facing the ongoing destruction of human life by the plague, the Athenians abandoned the most-hallowed rituals for cremating the dead, even throwing corpses on the funeral pyres of strangers. This is confirmed by archaeological evidence showing the neglect of traditional burial customs, in that skeletons among the 150 found in the plague pit mentioned above that were found at the lower levels were better arranged but in a chaotic state near the top as if they were simply thrown in (pp. xii–xii, Mitchell-Boyask 2008; see also Baziotopoulou-Valavani 2002).

Those stricken by the disease crowded into sacred spaces and surrounded the shrines of springs. Those who cared for others in spite of the risk Thucydides honors with the term *aretê*, a virtue comparable with that of heroes (Allison 1983, 14). Those who survived an attack did not catch the disease again, or if they did, it was a mild case, so many of them thought their lives were charmed and did help the sick. But the majority, he further notes, facing the likelihood of infection and death, abandoned any respect for the gods or the laws and decided to spend their money quickly and enjoy themselves in any way they pleased.

There were also political reactions. The Spartans and their Peloponnesian allies laid waste to the countryside of Attica for a second summer, and the plague returned virulently, while the Athenians remained crowded inside the city walls. At such a time, Thucydides understands people look for someone to blame. In this case, the blame fell on Pericles. He had started the war, so it appeared to his opponents that the way to deal with disaster was to compromise with the enemy, and now, the assembly sent ambassadors to Sparta to arrange for peace, but they failed. Thucydides says that Pericles had anticipated this turn of events and gives what he claims is the speech of Pericles intended to rally the citizens and gain support for a new war effort. Since Thucydides probably heard the speech, and almost all his audience had heard it as well, we can accept it as representing the intent of Pericles on that occasion and the response to disaster that he recommended.

In the speech, Pericles marshals his arguments to urge his fellow citizens to value the greatness and safety of the state higher than their individual interests. This means continuing the war effort, for which the majority of citizens had voted little over a year before. "Your country has a right to your services," he insists, asking that they

not fail their fathers who had brought Athens supremacy on the sea. The emergency calls for courage and united action. "Cease then to grieve for your private afflictions, and address yourselves instead to the safety of the commonwealth" (Thucydides, *Peloponnesian War*, 2.61.4).

The catastrophe of the plague, he recognizes, could not have been foreseen. The exigencies of a war with Sparta had been predictable, but not this. "Before what is sudden, unexpected, and least within calculation the spirit quails; and putting all else aside, the plague has certainly been an emergency of this kind" (Thucydides, *Peloponnesian War*, 2.61). From the perspective of the eyewitness, this is correct; nothing was understood about the cause of the disease, the conditions conducive to its spread, or possible means of moderating its severity. The only way to face the unknown malady was acquiescence. Pericles assigns the origin of the pestilence not to Apollo, nor to "the gods" in general, but to an undefined *ouranos* ("heaven"), which might be understood in various ways by his listeners: "The hand of Heaven must be borne with resignation, that of the enemy with fortitude; this was the old way at Athens, so don't be the ones who prevent it from being true today" (Thucydides, *Peloponnesian War* 2.64).

The speech had results; he had persuaded the Athenians to give up attempting negotiations and to put their energy into continuing the war. But they did not feel any better about him for telling them what they needed to hear. Thucydides sees these events through the lens of his personal admiration of Pericles and his political support for the leader's policies:

> As a community he succeeded in convincing them; they not only gave up all idea of sending [negotiators] to Sparta, but applied themselves with increased energy to the war; still as private individuals they could not help smarting under their sufferings, the common people having been deprived of the little that they ever possessed, while the upper classes had lost fine properties with costly estates and buildings in the country, and worst of all, had war instead of peace. In fact, the public feeling against him did not subside until he had been fined. (Thucydides, *Peloponnesian War* 2.65)

But they then felt better and reelected him as general.

Pericles offered no predictions about the future course of the plague. That, too, was unforeseeable. But he could try to deal with the losses it had inflicted. To help restore the number of citizens, he sponsored a law to make it easier to gain citizenship: in the past, one had to prove that both his parents were Athenians, but henceforth, only one Athenian parent would be sufficient.[3] We can only wonder if he felt he was in danger of it. Two of his sons had caught it and died. His speech indicates that he intended to lead Athens through the rest of the war, but that was not to be. Within a few weeks, he contracted the plague and died from it. Thucydides estimates the total number of plague deaths among the Athenian military as 4,400 heavily armed infantry and 300 cavalry (who were from the upper class), along with "a number of the multitude" (3.87). The worst result of the plague

[3]Pericles benefited from this new law, since he had a son also named Pericles, whose mother Aspasia was a non-Athenian. The younger Pericles became a citizen as a result.

according to Thucydides was that it killed Athens's best leader at the time when he was most needed. The plague returned in the 2 years after Pericles' death and then slowly disappeared. Athens fought the war for another quarter century, punctuated by a cold war "peace" involving proxy wars and a hubristic but ultimately tragic campaign in Sicily. The generals that succeeded to power were hawks like Cleon, doves like Nicias, and an infamous traitor named Alcibiades who was rehabilitated by his fellow citizens in time to lead Athens into defeat.

7.3 The Eruption of Vesuvius

An image of Mount Vesuvius painted in the quiescent years of the early first century CE represents a mountain robed in the green of vineyards and presided over by a benevolent Bacchus who is at the same time a bunch of ripe grapes, appropriate for the god of wine (see Fig. 7.6).[4] The artist, and the people who lived in the towns and farms overshadowed by the mountain, had forgotten that it was a volcano. It was not that Romans were ignorant of volcanoes. Mount Etna on Sicily, just across the strait of Scylla and Charybdis, smoked almost all the time and coughed up lava fairly often, and small islands in the Tyrrhenian Sea such as Vulcano and Stromboli put on a good show as well. Silius Italicus writes of a flare-up of Vesuvius in 217 BCE "with flames worthy of Etna" (*Punica* 8.653–655, 12.140–157), which is possibly confirmed by stratigraphy in the local area and ice core evidence from distant Greenland (De Boer and Sanders 2002, 80; Stothers 2002, 182–185). An earlier explosion detected by modern volcanologists is the Avellino eruption of Vesuvius around 1640 BCE, which covered the area that is Naples today (Sulpizio et al. 2010, 559). Diodorus Siculus (*Bibliotheca Historica* 4.21.5), Vitruvius (*De Architectura* 2.6.2), and Strabo (*Geography* 4.5.8), all writing before 79 CE, thought that the rocks and activity on Vesuvius indicated past eruptions (De Carolis and Patricelli 2003, 41). Strabo believed they had ceased, saying, "one might infer that in earlier times this district was on fire and had craters of fire and then because the fuel gave out, was quenched" (Strabo, Geography 4.5.8.). Seneca leaves Vesuvius off his list of well-known volcanoes (Seneca, *Quaestiones Naturales* 6.1, 6.27). Pliny the Elder (*Historia Naturalis* 2.110) lists all the volcanoes he has heard of, and other places where fire comes out of the ground, including some near the Bay of Naples but does not include Vesuvius. He must not have recognized its volcanic character or perhaps thought it was extinct and not worth mentioning. It is therefore not surprising that when Pliny the Younger on one day in 79 CE[5] was called away from his books to

[4]This painting of Vesuvius was discovered in 1879 on a wall in the Casa del Centenario, one of the largest houses in Pompeii. It is now in the National Archaeological Museum, Naples.

[5]The date given in the manuscripts is August 24, but archaeological evidence, including wind direction and the fruits and other vegetable remains found in Pompeii, suggests a date in autumn (Rolandi et al. 2007).

Fig. 7.6 Vesuvius, as it appeared before the eruption, with Bacchus (the god of wine) covered with grapes. The original was found in the House of the Silver Wedding, Pompeii (Source: Downloaded from Wikipedia in public domain)

see what he described as an awesome cloud shaped like a pine tree, with a trunk rising up in the air to a high elevation where it spread out (see Fig. 7.7), what we might call a "mushroom cloud," he had to guess which place it was coming from. Soon afterward, he learned that it was Vesuvius.

Pliny was 17 years old at the time, son of Roman upper-class parents from the lakeside town of Como in the Alps. His mother, Plinia Marcella, was the sister of Pliny the Elder, renowned author of *Natural History*, a comprehensive encyclopedia of the Roman state of knowledge about every aspect of nature, which is extant, as well as several histories that are mostly lost. Uncle Pliny was in residence as prefect (admiral) of the most important naval base in the Roman Empire at Misenum in the Bay of Naples, within sight of Vesuvius (see Fig. 7.8), and his sister and nephew were staying with him at his villa there (see Fig. 7.9). He had no children, so his will (to be read all too soon) adopted the younger Pliny and endowed him with his

Fig. 7.7 Umbrella pines; Pliny the Younger compared the cloud rising above Vesuvius to the shape of this pine tree (Source: Photographs were taken by J. Donald Hughes)

Fig. 7.8 View of Vesuvius from Naples near Misenum. This is the same general view that Pliny and his uncle Pliny the Elder had of the volcano (Source: Photographs were taken by J. Donald Hughes)

Fig. 7.9 The replica of the Villa of the Papyri at the Getty Museum, Malibu, California. The villa occupied by Pliny the Elder in Misenum may have been similar (Source: Photographs were taken by J. Donald Hughes)

very considerable wealth and extensive properties. Pliny the Younger's father had died when he was young, so he lived with his mother, Plinia Marcella; his uncle and his guardian Lucius Verginius Rufus were with the army on the German frontier most of the time while he was growing up. In the years after 79, Pliny rose rapidly in the *cursus honorum*, the ladder of position and political power. He studied law

under Quintilian, entered the Senate, was chosen Consul (the highest Senatorial office), and became a member of the judicial council of the emperor Trajan. This is the trajectory of a man whose life was dedicated to supporting the political structure of the Roman Empire. Finally, he was appointed imperial legate (governor) of the province of Bithynia and Pontus (between the Sea of Marmora and the Black Sea in what is now northwestern Turkey). We are lucky to have a generous sampling of his copious correspondence, including letters to emperors and literary figures such as Tacitus, writer of the *Histories* (Pliny the Younger, *Epistles* 6.16, 6.20), to whom the letters describing the eruption were written about 25 years after the event.[6] While we must allow for distortion of memory over the intervening time, Pliny's vivid account conveys the impression of immediacy.

The disaster had hit without any definite warning; Pliny notes that there had been (see Newbold 1982) tremors for many days before the eruption, but no one had taken them seriously because they occur frequently around the area. Indeed, a strong shock in 62 CE, a few months after his birth, had devastated Pompeii and other places, with damaging aftershocks as much as 2 years later, without an eruption. The local people responded with determination to rebuild houses and public buildings and to restore the aqueduct; the damage was still being repaired at the time of the eruption in 79 CE. In the 62 quake, according to Seneca (*Quaestiones Naturales* 6.1.1–2, 27.1.1–4, 28.1–2), gases had killed 35 flocks of sheep near Vesuvius, an indication that the earthquake was stimulated by volcanic activity. Pliny the Elder (*Historia Naturalis* 2.85) connected earthquakes with some eruptions but did not identify them as warning signs of volcanic activity.

The connection of earthquakes with subsequent eruptions of Vesuvius is still being investigated by seismologists today, and it is now possible to distinguish earthquakes that precede a volcanic eruption from other seismic phenomena (Cioni et al. 2000, 138). Most of the epicenters of earthquakes in the region have been in the Apennines, 50–60 km (30–37 miles) northeast of Vesuvius (Nostro et al. 1998). Today, volcanologists also measure the rise and subsidence of the ground level as a result of the swelling of the magma chamber under the volcano before an eruption and its release afterward. This affects the apparent sea level, with flooding during periods of subsidence, which is notable on the columns of temples built near the sea, due to markings left by sea creatures such as shellfish (see Fig. 7.10).

Volcanological investigations south and east of the mountain have found a series of shallow deposits of ash, lapilli, and fine scoria indicating that relatively small eruptive incidents did occur over the years before 79 CE. The eminent Icelandic volcanologist Haraldur Sigurdsson (1999, 61, 67; Sigurdsson et al. 1985) believes that a small explosion occurred in the night or morning before the awesome event at noontime, which may have alarmed some of those closest to the caldera (Sigurdsson 2002). The family in Misenum seems not to have been aware of it, although noises like distant thunder had been heard for a few days (Jashemski and Meyer 2002).

[6]It is not known whether Tacitus made use of Pliny's information in his Histories, since his narrative breaks off in 70 CE, 9 years before the volcanic disaster.

Fig. 7.10 These columns show the evidence of past sea levels by the marks left by shellfish during times when the water was higher. The land rose and fell as the magma underground swelled or was released by volcanic activity (Source: Photographs were taken by J. Donald Hughes)

Pliny says that his uncle was intensely interested in the phenomenon the moment his sister told him about it and climbed up to where he could get the best view. His lifelong devotion to natural science asserted itself. He decided to take a small ship across the bay to observe at closer hand, and invited his nephew to join him, but the younger man decided that reading about the past was more important to him than observing the present, so he stayed behind. On leaving the house to board the boat, the elder Pliny was given a letter from his friend Rectina, who was in her villa at the foot of Vesuvius, and could get away only by boat. He decided to try to rescue victims of the eruption and ordered the fleet to assist. Finding that shallow water and debris from the volcano prevented him from landing, he used the wind to cross the bay to Stabiae, where he found that another friend, Pomponianus, had loaded his boats to escape but could not due to the contrary wind and rough waves. Demonstrating unwarranted calm in the face of danger, Pliny the Elder bathed, dined, and took a nap. By then, the stones and ash had piled up so deep that they threatened to trap him in his room. He and his friends realized that if they decided to remain there, they would be buried, so they went down to the shore in total darkness with pillows tied on their heads as protection against falling rocks. Then Pliny, an obese man who had trouble breathing, died overcome by ash, gases,

and overexertion, and the others had to abandon his body. It was found 2 days later, his nephew learned, clothed, and looking more asleep than dead. Experience studying modern volcanic disasters indicates that death in circumstances like this most likely results from asphyxiation due to fine ash filling and plugging the lungs and esophagus, but the reason Pliny died while his companions survived is probably his corpulence, overexertion, and weak constitution.

Meanwhile, the volcanic fallout was approaching Misenum, and the younger Pliny was not only observing the reactions of others to the disaster but also demonstrating them himself. First, denial. Like his uncle, he had a bath followed by dinner and then tried to sleep but was roused when his mother, terrified, broke into his room. They sat on the terrace while Pliny resumed his reading of Livy, rejecting the warnings of a friend of his uncle. Then, since the house was shaking violently and threatening to collapse, they decided to flee from the town, along with a crowd of others. Their carts were thrown around by the earthquakes. They paused, only to see the seawater retreating in advance of a tsunami and the ominous pyroclastic cloud approaching across the bay over Capri to the cape of Misenum itself. He and his mother fled a little further then stopped because absolute darkness overtook them. He heard the vocal exclamations of the refugees:

> You could hear women lamenting, children crying, men shouting. Some were calling for parents, others for children or spouses; they could only recognize them by their voices. Some bemoaned their own lot, others that of their near and dear. There were some so afraid of death that they prayed for death. Many raised their hands to the gods, and even more believed that there were no gods any longer and that this was one last unending night for the world. Nor were we without people who magnified real dangers with fictitious horrors. Some announced that one or another part of Misenum had collapsed or burned; lies, but they found believers. It grew lighter, though that seemed not a return of day, but a sign that the fire was approaching. The fire itself actually stopped some distance away, but darkness and ashes came again, a great weight of them. We stood up and shook the ash off again and again; otherwise we would have been covered with it and crushed by the weight. I might boast that no groan escaped me in such perils, no cowardly word, but that I believed that I was perishing with the world, and the world with me, which was a great consolation for death. (Pliny the Younger, *Epistle* 6.20)

Here, as in response to the plague of Athens, people are shown either beseeching the gods for help or denying their existence. Those with a Stoic view might well have thought they had come to the cyclical fiery end and renewal of the universe (Fisher and Hadley 1979, 9–15). Pliny does not report anyone blaming the likeliest gods, Vulcan himself or the malevolent Titans, who were imprisoned under volcanoes according to mythology. And yet the gods were seen as causes of disasters like this. Martial, who was a contemporary of Pliny, lamented the destruction of a rich agrarian landscape (Stefani 2010):

> This is Vesuvius, green yesterday with viney shades; here had the noble grape loaded the dripping vats; these ridges Bacchus loved more than the hills of Nysa [his home]; on this mount of late the Satyrs set afoot their dances; this was the haunt of Venus, more pleasant to her than Lacedaemon; this spot was made glorious by the fame of Hercules [Herculaneum]. All lies drowned in fire and melancholy ash; even the high gods could have wished this had not been permitted them. (Martial, *Epigrams* 4.44)

Fig. 7.11 The shape of a man recovered by inserting plaster into the cavity left by his body, in Pompeii (Source: Downloaded from Wikipedia in public domain)

Beside the eyewitness accounts, we have striking evidence of the last moments of the victims of the disaster in the form of hollow impressions in the compacted ash of Pompeii that, filled with plaster and then freed from these molds, reveal the forms of humans and other animals, including clothing, their physical positions, and even in some cases their expressions (see Fig. 7.11). In Herculaneum, the bones of people who had fled to the docks in hope of escape, but were killed instantaneously by the incredibly rapid arrival of heated mud and gases, have been found (see Fig. 7.12). Many more will undoubtedly be discovered as excavations continue.

The immediate reaction of people was to save their lives by any means possible. Some decided to flee, and these at least had a chance, since it seems the majority of residents did survive. Others sought shelter inside their homes, temples, or other buildings, and these mostly died of suffocation by ash or the hot gases accompanying pyroclastic flows.[7]

[7]Pyroclastic rocks are fragmentary volcanic rocks consisting predominantly of pumice and volcanic ash. Pyroclastic flows are hot, turbulent avalanches of pumice, ash, and gases that pour down the slopes of a volcano at high speed, sometimes faster than 100 kph (62 mph).

Fig. 7.12 A colonnade on the former coastline of Herculaneum, where many people fleeing the eruption were overtaken and killed by the pyroclastic flow (Photographs were taken by J. Donald Hughes)

In a sense, the volcano had created a trap; the very lushness of the vineyards and other vegetation was the result of prior eruptions. Volcanic deposits can become some of the richest agricultural lands on Earth because they contain a wide variety of the elements needed for plant growth. In the Mediterranean region, these rich black soils contrast with the meager red and yellow soils that develop on the prevalent limestone base (Fisher et al 1997). They attract farmers to the very places that may be in danger of further eruptions. In addition, the pozzolano ash deposits that were the main ingredient of Roman concrete attracted miners to the region around Vesuvius (De Boer and Sanders 2002, 74–107; Darley 2011, 18). The only effective plan to avoid damage and loss of life from eruptions is to avoid settlement on volcanic soils near an active volcano. Because the length of time between eruptions can be many years, generations, or even millennia, the short-term economic needs of people lead them to bet against a new eruption in their own lifetimes or those of their children. This virtually assures future disaster.

The response of the Roman government after the eruption was to offer aid. The reigning Emperor Titus (see Fig. 7.13), to whom the elder Pliny had dedicated his *magnum opus*,

> showed not merely the concern of an emperor but even a father's surpassing love, now offering consolation in edicts and now lending aid so far as his means allowed. He chose commissioners by lot from among the ex-consuls for the relief of Campania, and the property of those who lost their lives by Vesuvius and had no heirs left alive he applied to the rebuilding of the buried cities (Suetonius, *Titus* 3–4).

Fig. 7.13 Titus was emperor during and after the 79 CE eruption. He organized relief efforts for the survivors of the disaster (Source: Downloaded from Wikipedia in public domain)

So says Suetonius, who had served on the staff of Pliny the Younger and was often critical of emperors but gave qualified praise to those like Titus whom he considered to be fair and devoted to government (Sebesta 2006). Titus himself went to the stricken area after the eruption; we know this because he was there when a major fire hit Rome the next year (Scarth 2009, 83). It is probable that his reimbursement for lost property actually worked and that well-to-do Romans were able to rebuild their villas on the shores of the bay, although they may not have been in a hurry to reoccupy them. Survivors could be helped to resettle in nearby towns. However, the restoration of the deeply buried cities soon appeared to be impossible. Repair had always taken place after earthquakes, but the sites of Pompeii and Herculaneum were not reoccupied in ancient times. Residents and looters tunneled into Pompeii, breaking through walls as they looked for treasure. In Herculaneum, the solidified pyroclastics defeated any such efforts. “When this wasteland regains its green, will men believe that cities and peoples lie beneath?” asked Statius (*Silvae* 4.4). Evidently not. Farms were opened above the phantom ruins, but the sterile volcanic ashes were transformed into soil of exceptional richness only after decades (Allison 2010). This favored speculators wealthy enough to acquire land and wait until agricultural development was profitable, while small farmers could not afford to take the economic risk.

In the meantime, Rome had to turn to southern Gaul and Spain to replace the wine from the "vine-covered hills whose liquid produce is famous in every land and ennobles tipsiness" (Pliny the Elder, *Historia Naturalis* 3.60). The area the volcano had devastated was part of Campania, which was also Rome's most important nearby source of olive oil, wheat, sheep, pigs, and fish (Allison 2002, 110–114). The imports of these products from Gaul to Rome rose sharply.

The land recovered its agricultural richness: as Cassius Dio observed 150 years later, "The elevated parts of this mountain [Vesuvius] are clad in many trees and vines . . . " (*History of Rome*, 66.23), but the buried cities were not restored. It was not until after 1,000 CE that a town named Resina arose, unsuspecting that Herculaneum lurked under its foundations. Cities on the northwest side of the bay, however, soon removed the lighter ash falls that had occurred there and revived as centers of commerce and pleasure. The emperor Hadrian had a resort on the coast of the Bay of Naples but spent little time there; he had a more lavish one at Tivoli and traveled constantly throughout the empire (Scarth 2009, 85).

Vesuvius was not finished. It erupted again in 172 while Marcus Aurelius was emperor, and at least eight more times up to the year 1139 CE, when there was a spectacular eruption with fountains of molten lava, mentioned among others by the Englishman John of Salisbury, then Bishop of Chartres. Then there was a long period of almost non-interrupted quiet until December 15, 1631, when a major eruption killed more than 3,000 villagers and rained ash as far as Istanbul (see, e.g., Dobran 2006). After that, there followed a series of over 20 important eruptions, averaging 13–14 years apart, the last of which occurred on March 1944 during the allied campaign in Italy in the Second World War (see Fig. 7.14), damaging much of an airbase near Pompeii, destroying at least 80 airplanes on the ground, wiping out several villages and killing 28 people (Chester et al. 2007).

The quiescent period since then has lasted 68 years at this writing (2012). In the crater and nearby, there are hot vents of steam and gases that have a sulfurous smell, and sulfur deposits as well, often noted by mountain climbers and confirming that the volcano is still active, but they are seldom seen from afar. I flew over Vesuvius in 1959 and have visited Naples, Herculaneum, Pompeii, and Sorrento several times since and, from that distance, have seen no smoke or steam rising from the volcano. Eruptions occurring in the past after long inactive periods have usually been the most destructive ones, and another eruption is inevitable, according to volcanologists.

About 3,000,000 people live in the possible danger zone around the mountain, going about their daily lives without being preoccupied by the thought of an eruption, except for the few who have the responsibility of preparing disaster plans (Lancaster 2005). Humans are powerless against volcanoes, so the plans have to involve relocation outside the danger area or evacuation before or during an eruption. The Italian government has endorsed both approaches. Relocation is unpopular; the amount offered as a subsidy is small, and only 5,697 families applied in the first 2 years, a number smaller than those who have moved to the slopes of Vesuvius, many illegally, and occupy homes that may not meet

Fig. 7.14 The eruption of Vesuvius in 1944 (Source: USAAF during World War II)

building standards. In 1995, the Italian Civil Protection Agency approved a Vesuvius evacuation plan that assumes a warning of about 2 weeks before an eruption on the basis of seismicity, ground deformation, geochemistry of gas, and gravitometry. These factors are all recorded by the Vesuvius Observatory, founded in 1841 on the mountain by Fernando II, King of the Two Sicilies, as the world's first scientific volcano observatory. The building on Vesuvius is now a museum, while the work of the volcanologists has been moved to Naples. The evacuation plan defines a red zone containing a number of villages around the volcano, with a total population of almost 700,000, to be evacuated by bus, train, and boat to other parts of Italy in advance of an eruption. The plan has been attacked and its implementation stymied by bitter political controversy. A counterplan called Vesuvius 2000 was prepared at a conference of scientists and experts and described the government plan as inadequate, which of course it could well prove to be in an actual event (Dobran 2006). Meanwhile, real estate promoters and others with development interests tell people that Vesuvius is extinct. Scientists, gathering information from benchmarks, gravity stations, seismic stations, tidal gauges, and leveling lines for surveillance of changes and having detected a huge pool of magma under the mountain, disagree.

7.4 Conclusion

The ancient response to disaster in the cases examined here was for the most part uninformed, chaotic, and inadequate. Knowledge of the true causes of disease and volcanic eruptions did not exist. The assignment of responsibility to the gods was only an admission of ignorance, and this was tacitly understood by our learned philosophical eyewitnesses if not by the general public at the time. In spite of their undeniable intelligence and inquisitiveness, Greeks and Romans of the educated classes found it challenging or impossible to explain many natural phenomena. (Vittori et al. 2007, 52)

The victims were caught unaware, although in both cases, there were warnings that were not heeded because they were not comprehended: the approach of the plague from Egypt was ignored, and the earthquakes that preceded the eruption could not be distinguished from those that are commonly felt in the Mediterranean region.

During the actual event, social cohesion broke down, and most individuals tried to save themselves and perhaps also those closest to them without concern for the larger community and also without knowing what was the best course of action. Thucydides believed that care for others and for society provided the cohesion necessary for the state and that war and the plague dissolved this social glue for most people. Pliny reports that those around him when he fled from his uncle's house were disoriented, panicked, and willing to follow anyone who looked as if he knew what he was doing, whether this was true or not. The fact that he tries to portray himself as calm in the midst of storm only protests his own disorientation. His uncle had been calm indeed, but calmness after he had landed at Stabiae only led him to his death.

In the aftermath, those in positions of leadership tried to reestablish the body politic and their own positions at its head, with success that was well intended and at least partially successful. Pericles gave a speech that rallied the people around him after some initial disgruntlement but of course could not stem the plague, which killed him. The pestilence ran its course but weakened the military strength and leadership of Athens. Titus, who had shared imperial power with Vespasian for about 9 years, became sole emperor only 2 months before Vesuvius blew its top. He organized relief efforts intended to prevent anarchy in an essential part of Italy, but full restoration proved impossible, and he perished 2 years later, when power was seized by Domitian, a man ill suited to wield it.

These ancient case studies are worthy of careful study in the modern world, where a rapidly growing and crowded human population offers increasingly fertile ground for the mutation and spread of new diseases analogous to AIDS, SARS, Ebola, and bird flu. Imagining the people of modern Naples trying to cope with a new Plinian eruption offers a horrifying prospect, in which one wonders whether or not our increase of knowledge has improved our social wisdom and ability to cope. As the Roman poet Statius (*Silvae* 4.4) warned, "This summit does not cease its mortal threat."

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Chapter 8
Provisioning Capacity: A Critical Component of Vulnerability and Resilience Under Chronic Volcanic Eruptions

Graham A. Tobin and Linda M. Whiteford

Abstract Using the cascade of effects model, this chapter discusses the impacts chronic hazard conditions can have on environment, economy, social capital, and health. In particular, this chapter investigates these impacts through the lens of provisioning capacity in order to understand the vulnerability and resilience of the populations. Looking specifically at two separate sites in Ecuador that are chronically affected by an active volcano, researchers used questionnaire surveys, key personnel interviews, focus groups, and health records to study the impacts of this hazard including personal experience, damage/loss, perceptions, provisioning, and health. Results show a direct line of impact from the volcano to provisioning capacity and to health, showing that an increased ability to provide food led to better health and a reduced perception of risk. The authors argue this can ultimately mitigate individual vulnerability and facilitate community resilience. In this chapter, provisioning capacity relates to a household's ability to provide itself with adequate food and water and can be seen as both a measure of vulnerability and resilience and an influence on associated outcomes such as physical and psychological health. Included in this measure are variables related to both capacity (at the time of the survey) and a perceived change in capacity over the impact period. The authors conclude with an assessment of the model employed and recommendations for future changes to the model to make it more responsive to temporal as well as spatial changes occurring at the level of the population being studied during an ongoing disaster.

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K. Pfeifer and N. Pfeifer (eds.), *Forces of Nature and Cultural Responses*,
DOI 10.1007/978-94-007-5000-5_8,

Keywords Chronic disaster • Volcanic hazards • Provisioning capacity • Cascade of effects • Ecuador

8.1 Introduction

In this chapter, we look at how provisioning capacity can impact household vulnerability and resilience under chronic hazard conditions. The availability of adequate food supplies and safe, potable water are obviously essential to any disaster recovery; ongoing disaster conditions however can exacerbate losses and put access to such resources at great risk. To illustrate the interplay of provisioning and disaster impacts, then, we employed a "cascade of effects" framework, incorporating many of those environmental, political, economic, and social forces that ultimately shape vulnerability. The study was conducted in Ecuador around the active volcano Mount Tungurahua where we have been working for the last 12 years (see, e.g., Tobin and Whiteford 2002a, b, 2004; Whiteford and Tobin 2004, 2007, 2009).

Access to adequate food and water has been addressed in different disaster contexts, and there is a constant fear in some parts of the world of inadequate supplies. For instance, U.N. FAO (p. 1, 2012) reported that in the Sahel, "More than 16 million people are facing food insecurity and more than one million children under the age of five are at risk of severe malnutrition." This crisis has emerged due to complex emergencies involving drought and human conflict. The effect of food insecurity can have spiraling impacts that permeate throughout the socioeconomic system and generate precarious conditions. Indeed, if the disaster is ongoing, as associated with some volcanic activity, then the cascade of impacts may be particularly devastating. For instance, environmental pressures, created by natural disasters, can generate economic challenges that ultimately disrupt social networks and increase social and physical vulnerability.

Specifically, this chapter addresses various aspects of human vulnerability and resilience in chronic disaster conditions in Ecuador by looking at access to food and water. Mount Tungurahua has erupted frequently since 1999, having a profound impact on both the physical landscape and the human environment, the repercussions of which are discussed here. To set this in context, we provide a brief literature review of some of the classical articles on vulnerability and resilience, outline a simple theoretical framework, introduce the study sites, and describe the methods undertaken in the research. The results are broken into two sections, a section describing the findings regarding disaster impacts and responses and an analytical section that examines relationships among variables based on the theoretical framework. Conclusions and recommendations follow outlining some lessons learned from this work.

8.2 Resilience and Vulnerability

In addressing resilience, attention has been given to the contextual conditions of society, notably to structural issues associated with vulnerability and marginalization (Wisner et al. 2004). Considerable research has examined how macrolevel forces, particularly global economic systems and political structures, influence microlevel systems (political, economic, etc.), social behavior, and a community's interaction with its environment (e.g., Adger 2006). Moreover, Farmer (2003) employed the concept of "structural violence" which refers to the idea that larger historical trends in conjunction with the current capitalistic global market system result in economic inequalities. These inequalities directly impact health and well-being, often limiting basic human rights. The poor, by the very nature of their limited resources, are exceedingly vulnerable to all types of insults, including the effects of natural disasters, human-induced disasters, and exposure to disease. Research has shown that groups that are socially, economically, or politically separated from the mainstream of society tend to experience disproportionately high impacts of natural hazards. For instance, Oliver-Smith (1994) identified structural imbalances rooted in historical processes as a major factor in creating a human-environmental relationship that predisposed some populations in Peru to increased devastation.

Vulnerability, therefore, depends upon preexisting conditions of material and social life, not merely the geophysical event itself. In this respect, human vulnerability to disasters is portrayed by Wisner et al. (2004) in terms of a "pressure and release" model in which underlying factors and root causes embedded in everyday life give rise to dynamic pressures that affect particular groups and lead to unsafe conditions. Attempts to quantify vulnerability provide comparable indices, and map vulnerability levels have met with mixed success and raise criticisms particularly regarding appropriate weighting of different factors (Bankoff et al. 2004; Cutter et al. 2000; Mustafa et al. 2011).

Disasters can also act as catalysts, accelerating the rate at which adjustments in social and political institutions occur. Such changes can be progressive and beneficial to affected communities, while others can result in continued or increased political and economic oppression of previously vulnerable groups (Oliver-Smith 1996). Closely related to this is community resilience, which is dependent on preexisting social, economic, and political conditions as well as post-disaster responses, relief efforts, mitigation strategies, and longer-term rehabilitation programs. Certainly, the socioeconomic impacts can be long term as shown by Lynham and Noy (2013) with coastal disasters in Hawaii (see Chap. 6 in this volume). Vulnerability and forces that exacerbate or ameliorate vulnerability, as discussed by Wisner et al. (2004), are integral to community resilience and hence require investigation and understanding (Boyce 2000; Dibben and Chester 1999). Uneven development can also engender different recovery dynamics as shown by Hutanuwatr et al. (2013) in Chap. 5 of this volume. Furthermore, ongoing disaster conditions, such as volcanic eruptions, can multiply hardships many times over for populations facing adversity on a daily basis.

Research into volcanic disasters has supported these findings. For instance, Chester (1993) showed that, in addition to economic and demographic factors, deep-seated historical, cultural, and social characteristics are also important in determining disaster impacts. Rees (1979) pointed out that volcanic ash often requires fertilizers before corn will produce; thus, additional costs may make farming uneconomical for small farmers in underdeveloped areas. In the Mexican community that Rees examined, farmers whose cattle died as a result of ashfall also lost the means to plow their land. In addition, the disruption caused by volcanic disasters can lead to social changes. Blong (1984), from his analysis of eruptions of Mt. Lamington (Papua New Guinea, 1951), Paricutin (Mexico, 1943–1952), Tristan da Cunha (1961–1962), and Niuafo'ou (Tonga, 1946), recognized that volcanic eruptions hastened social change in these resource-poor countries.

Gaillard and Dibben (2008) provided an edited collection of papers on volcanoes and their impacts in a special issue of the *Journal of Volcanology and Geothermal Research*. In particular, Cashman and Giordano (2008) reviewed the literature regarding volcanoes through human history and provided a useful assessment of anthropological perspectives. Kelman and Mather (2008) discussed how communities might live with volcanoes under different scenarios, while others looked at perception issues (Chester et al. 2008; Barberi et al. 2008; Carlino et al. 2008). The health component of disasters has been the focus of attention with researchers addressing both physical and psychological ailments (Noji 1997; Norris 2002). As far as volcanoes are concerned, studies have been undertaken into physical impacts (Buist et al. 1986), respiratory illnesses (Baxter et al. 1999; Horwell and Baxter 2006), children (Forbes et al. 2003), and psychological stress (Shore et al. 1986). These studies demonstrated how volcanic activity can have severe deleterious economic and social impacts on communities, how ashfalls can seriously affect health, and how effects are not evenly distributed among populations. As with many disasters, the young and the elderly are often more harshly impacted than other members of society.

Research also suggests that turning to personal social networks to complement help provided by institutions may enhance individual and group recovery from disasters (Ibañez et al. 2004; Hurlbert et al. 2001; Murphy et al. 2010). Disaster victims, for instance, often rely on family, friends, and neighbors for aid and emotional support immediately following a disaster. Hobfoll et al. (2002) argued that community recovery depends somewhat on individuals feeling that being part of a strong network can help them overcome adversity (see also Kadushin 2012; Reissman et al. 2004). Not only are networks important for individual well-being, but their study also demonstrated the linkages that exist between the daily lives of individuals and households and the political economy of regional, national, and international activities. When faced with considerable and immediate needs following a disaster, people often look to different components of their social network for particular support. For example, Unger and Powell (1980) found that families faced with stress looked to different categories of people for various kinds of aid (Schweitzer et al. 1998). Nevertheless, under chronic conditions, this support may weaken as victims' needs grow and support fatigue sets in, thus reducing

typical interactive social activities that function to replenish and invigorate social ties. Furthermore, people may be relocated and hence removed from networks and no longer able to provide sustenance. In this respect, Masten and Obradovic (2008) recommended that recovery policies to promote resilience adopt a local scale within the broader context.

These disaster impacts can be compounded by other factors such as limitations on the access to provisions and resources. Without adequate supplies of food and water, for instance, vulnerability can be increased and health threats heightened, and under chronic disaster conditions, preexisting difficulties can be particularly devastating. Dilley and Boudreau (2001) looked at food security and vulnerability in Tanzania and recommended identifying the underlying causal factors for vulnerability and food insecurity prior to any shocks to the system. However, policies addressing food shortages typically fall short of intended goals. In chronic conditions or protracted crises, for example, Flores et al. (2005) showed that agencies responding to crises tended to favor short-term over long-term action. Haen and Hemrich (2007) examined food security and natural disasters and stressed the need to integrate risk management with food security and poverty reduction. While policy choices were important in this regard, they also pointed to political will and public versus private responsibility as important factors that affect success. The World Food Programme now considers these ongoing issues through its protracted relief and recovery operations (see, e.g., p. 1 WFP 2012) recognizing that "A protracted crisis disrupts food production and destroys the foundations of people's livelihoods, eroding the social fabric of families and communities." Adequate provisioning, then, is critical to recovery and sustainability. Thus, provisioning provides the lens through which we examined disaster impacts in a chronic context.

8.3 Theoretical Framework

One goal of our ongoing research has been to explore how chronic exposure to disasters has a cascading effect on the health and well-being for people living in exposed communities (Tobin and Whiteford 2007; Tobin et al. 2010). In the chronic exposure and health model (Fig. 8.1), we suggest that chronic events will have a cascading effect as impacts deepen and create heightened problems throughout society. For instance, Mount Tungurahua, which initially erupted in 1999, has continued to erupt with varying degrees of intensity creating problems for surrounding communities through periodic ashfalls, mudslides, and lahars along with the ongoing threat of a total collapse of the volcano. The effects of this exposure are long term in nature with significant structural devastation, yet aid and support from the government are extremely limited. For this reason, devastation of continual exposure with its compounding effects may be more detrimental to a community than a single, destructive natural disaster. Indeed, such chronic events may eventually trigger additional negative consequences that permeate throughout society (Whiteford et al. 2002; Whiteford and Tobin 2009).

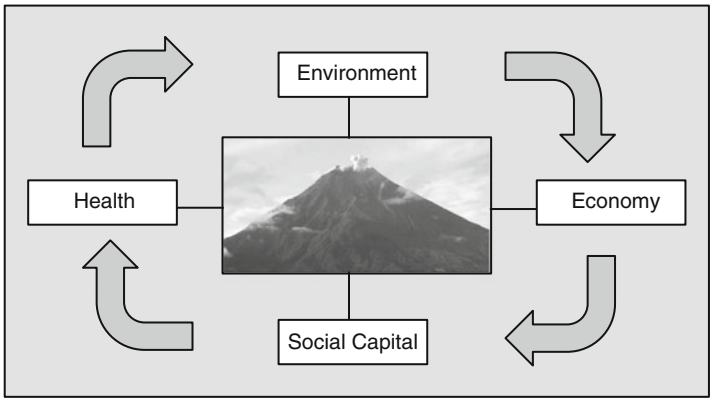

Fig. 8.1 Cascade of effects (Source: Created by Tobin and Whiteford)

In this study, environmental damage, such as to agricultural production, from ongoing volcanic activity leads to economic deprivation, social disruption, and health problems such that the impacts of many "small" events build on each other and lead to a breakdown of community life. Any lack of food and potable water will serve to intensify such conditions further compromising health, limiting economic activities, and disrupting social networks.

8.4 Study Site

This chapter focuses on two neighborhoods of Baños (El Recreo and El Fundación) and two villages in Quero Canton (El Santuario and Gualacanga San Luis); all located around the volcano, Mount Tungurahua in Ecuador. The volcano has been active since 1999, after about 80 years of acquiescence, and eruptions have occurred with great frequency and with varying degrees of intensity (Fig. 8.2).

Periodic ashfalls, mudslides, lahars, and pyroclastic flows are common, and there remains the ongoing threat of a total collapse of the volcano (Whiteford and Tobin 2009). Damages have continued to mount over the years, and several people died from pyroclastic flows in 2006. Agricultural activities around the volcano have been decimated by ashfalls, and this has had repercussions on the local economy. Potatoes, a basic carbohydrate for local populations, are especially vulnerable to ashfalls, and such crops are now limited to sheltered slopes. Farmers have replaced potato crops with onions, which seem to be hardier with respect to ash, but these prices have fallen by over 50% due to a glut in the market. Similarly, many small animals, such as rabbits and guinea pigs, raised for personal consumption as well as market and which often formed the basic sources of protein, have died from eating food and grasses contaminated with ash. Such activity has disrupted local business and appears to have compromised health of individuals (Tobin et al. 2005).

Fig. 8.2 Tungurahua, August 2006 (note pyroclastic flow) (Source: Photographs were taken by Graham A. Tobin)

The volcanic eruptions have precipitated several evacuations of these communities, some long term, which have led to high stress levels associated with leaving homes, possessions, livelihoods, friends, and familiar surroundings (Whiteford et al. 2010). As a result, many individuals have experienced a decline in their health. These physical, economic, and emotional losses have been exacerbated by a loss of faith in local and national political leadership and by a national economy in disarray (Whiteford and Tobin 2004).

8.4.1 Baños

Baños, with a population of approximately 12,000, is a market town and tourist center in the heart of Ecuador (Fig. 8.3). There were approximately 140 dwellings in El Recreo neighborhood and a further 15 selected from the El Fundación neighborhood included in the study sample. Baños is a picturesque community, temperate in climate, and surrounded by mountains, waterfalls, and hiking paths. In addition to tourism, the economy relies greatly on agricultural activities with crops of potatoes, onions, tomatoes, and beans as well as livestock. Many small agricultural communities and peasant farmers scattered around the slopes of the volcano supply the surrounding markets. The economy of Baños, however, has

Fig. 8.3 Baños with Mount Tungurahua in background (Source: Photographs were taken by Graham A. Tobin)

been severely impacted by the eruptions of Mount Tungurahua and by the military-enforced evacuation of the town in 1999. This operation was not popular but was deemed by the civil defense to be the best way at that time to ensure the safe relocation of residents. The town has not totally recovered from the evacuation, and many residents have still not returned. At the time of the evacuation, some families were housed in shelters for nearly a year, while others broke down military barricades and marched back into their community (Tobin and Whiteford 2002a; Whiteford et al. 2010). Our studies showed that those families who returned were generally better off financially and health-wise than those who remained in the shelters. Over the years, tourism has declined significantly, and agricultural crops have been destroyed by ashfalls. However, this should also be placed in context, since Ecuador was at this time undergoing a severe financial crisis with an annual inflation rate exceeding 90% and political chaos at the national level (Lane et al. 2004).

The volcano hazard remains a constant threat. There have been several major explosive eruptions, notably in August 2005 and August 2006, and Mount Tungurahua provides residents of the town with regular reminders of its deadly potential. The town itself does not often experience significant ashfall due to the local topography and prevailing winds, but the periodic steam and ash columns rising over the city and the sound of explosions within the crater make the volcano threat impossible to ignore – Baños sits right at the base of the volcano.

8.4.2 Quero

Quero Canton, located northwest of Tungurahua, has a population of approximately 16,000 people, half of whom are dispersed throughout the county. The community of El Santuario has a population of approximately 400 with 92 families, while Gualacanga San Luis has nearly 1,000 residents and 186 families. The primary economic base is agriculture, although leather goods and tourism are growing activities. Quero communities are subject to similar difficulties to those of Baños, but problems in Quero are intensified due to periodic heavy ashfalls. Crops have been damaged, particularly potatoes, as have stocks of domesticated animals used to provide meat and milk to families. In 2006, due to the ash, onions were the only field crop grown with success having replaced many of the potato fields. Onions have now been grown for a number of years because they are more tolerant of the ashfalls. However, market prices for onions have declined and both money and food are now scarce. Some beans are also grown, but commercially it is onions that have been most productive. Many residents voluntarily evacuated on several occasions, following recommendations made by local authorities and the geophysical institute, during particularly periods of heavy ashfalls. As noted by one man from Quero in 2005 (all translations by the authors),

> We lost everything . . . potatoes, beans . . . now there is nothing. We had damaged roofs and with my money we had to try and fix it because it was so bad . . . and now we are not able to buy the chemicals [pesticides and fertilizers] that we need. So, every year we just continue to lose. Also, we have to buy food for the cattle. Before they would eat the grass without problems, and they were healthy. We did not have to buy them anything.

While all of Quero Canton was affected by the volcanic activity, the two communities included in this study, El Santuario (Fig. 8.4) and Gualacanga San Luis, were particularly impacted. Both communities depended almost entirely on agriculture for their livelihoods before the reemergence of the volcanic activity and consequently experienced severe setbacks over the years as the ash has taken its toll of the crops and animals. These were poor communities prior to the eruptions, and prevailing conditions only served to make the situation even more arduous for residents. At the time of our research, ash remained a constant feature of the two settlements.

8.5 Methods

Primary data were collected through (1) in-depth interviews with public officials, (2) focus groups, and (3) a structured questionnaire survey of the communities. In addition, geological information on Mount Tungurahua from the Ecuadorian Geophysical Institute, medical records from the Ministry of Health, census records, and archival data were examined to place the research in a broader context. Full approval for the research was obtained through the University of South

Fig. 8.4 El Santuario, Quero Canton (note onions in foreground) (Source: Photographs were taken by Graham A. Tobin)

Florida's Internal Review Board and from the communities in Ecuador. Support for the research was provided by the Global Center for Disaster Management and Humanitarian Action at the University of South Florida.

8.5.1 Interviews with Public Officials and Religious and Community Leaders

Qualitative data were obtained from community leaders, provincial governments, health authorities, and local leaders from Baños and Quero (including elected officials, church leaders, and community organization leaders) on various occasions in February, April, July, and August of 2004. These took the form of structured interviews with selected leaders. These data were used to support the structured questionnaire.

8.5.2 Focus Groups

In May 2004, we facilitated six focus group discussions, two consisting of a total of 17 women and one of 8 men in El Santuario and two groups of women

totaling 21 individuals and one group of 5 men in Baños. The questions focused on nutrition, evacuation experiences, women's health, men's health, children's health, stress, and losses (economic, family, property, etc.). The discussions were tape recorded and transcribed by an Ecuadorian assistant and then translated into English. This information was used to frame the further development of a culturally and linguistically appropriate questionnaire that was later administered in the same communities.

8.5.3 Questionnaire Development, Sampling Design

The questionnaire was developed to measure the effects of living in chronic disaster areas. The survey comprised 75 structured questions focusing on nutrition, food and water security, loss experiences, and health and emotional stress characteristics associated with ash and evacuation. In addition, questions on social capital dealt with community participation, feelings of trust and safety, and proactive actions in a social context. The questionnaire was composed in English and then translated by Ecuadorians to ensure that the language would be clear and culturally specific. A pilot survey was undertaken to test the clarity and appropriateness of each question and the flow of the overall questionnaire and to determine the efficacy of the questionnaire in gathering valid information from respondents.

A combined US-Ecuadorian team, comprised of eight for Quero (two US and six Ecuadorians) and six for Baños (two US and four Ecuadorians), conducted the surveys in July and August 2004. Before the surveys began, an orientation and training session was held with team participants to explain the purpose of the research and to standardize the surveying process. Team meetings were held daily to debrief about any difficulties being encountered, to assess progress, and to anticipate any further problems we might face.

Similar sampling strategies were employed for the communities. Using maps generated from earlier field work, each community or neighborhood was divided into discrete blocks of roughly equal size, and then each team member was assigned one block with guidelines to survey at every second or third dwelling depending on community size. The exception was El Santuario where, because of its small size, surveyors went door to door. The surveys were conducted through personal contact, meaning face-to-face surveys with the respondents in their own homes with each questionnaire lasting approximately 40 min. Surveys were restricted to respondents with the following: (1) a minimum of 5-year continuous residence in the community, (2) between the ages of 18 and 60 years, (3) considered the household decision-maker, and (4) fluent in the Spanish language. Overall, 242 surveys were successfully completed: 126 in Baños and 116 in Quero. The overall rejection rate based on viable households was 4.7%, and there was a 1.07 to one ratio of males to females.

As far as we could tell, demographic characteristics of the sample respondents compared favorably to the official data for small communities in Ecuador. Respondents' ages ranged from 17 to 65 (mean 38.9 years in Baños and 36 in Quero); males made up 52% of respondents in Baños and 47% in Quero; over 80% were

married or in a civil union, and over 70% had lived in their community for more than 15 years. The average household size was 4.4 in Baños and 5.2 in Quero. Education levels varied between the communities, an indication of the differences in their economic patterns and available resources. In Quero, <2% of respondents had completed secondary school and none had had any higher education. Results were mixed in Baños, though even here, <12% percent had a higher education degree. In addition, respondents were asked to report on family health data; this resulted in data on 518 individuals in Baños and 567 in Quero. Many questions were asked and not all are reported here; for a fuller account, see Tobin et al. (2005, 2010) and Whiteford and Tobin (2004, 2009).

8.5.4 Geophysical Data, Archival Research, and Medical Record Reviews

Secondary data were collected from various sources including the Ecuadorian Geophysical Institute, the Ministry of Health, regional clinic records, census records, and newspapers. National and canton records were accessed to determine evacuation-related decisions in relation to the volcanic activity, and medical records were reviewed to track the frequency of hospital attendance and visits preceding and following the evacuations. Various diseases were considered to compare local and national statistics for specific diseases. For a detailed account, see Tobin et al. (2005).

8.6 Research Findings

The research findings are divided into two sections, descriptive results and analysis, and are presented using the cascade of effects framework with each section including data on environmental, economic, social capital, and health impacts (Fig. 8.1). The first section describes the outcomes of the surveys and categorizes how the eruptions have affected households in each community. The second section takes an analytical approach looking at these traits through the lens of provisioning and access to resources.

8.7 Descriptive Results

8.7.1 Environmental Impacts

The survey data show that virtually all respondents had been affected by volcanic activity particularly with ash, although there were differences in the extent of these experiences. In Quero, ash was cited as an almost daily occurrence by 93% of

Table 8.1 Volcanic activity: damage and losses by household

Damage or loss	Baños		Quero	
	Count	%	Count	%
Agricultural losses: plants	43	34.1	112	98.2
Agricultural losses: animals	35	27.8	105	92.1
Equipment losses	12	9.5	23	20.2
Problems related to work	79	62.7	93	81.6
Credit problems	41	32.5	53	46.5
House damage	30	23.8	107	93.9
Property damage	43	34.1	16	14.0

participants, whereas less than a third reported daily exposure in Baños. Forty-one percent in Baños reported weekly ashfalls. As shown in Table 8.1, volcanic activity has taken its toll on households, although those in Baños have experienced far less physical damage to their homes and/or crops than Quero residents.

In Quero, where the primary occupation is agriculture, 98% reported loss of plants, and another 92% lost animals to ashfalls. The ash killed most small animals kept by the residents. In light of these numbers, it is not surprising that 82% of participants indicated they had had work-related problems. These losses are ongoing as the volcano continues to erupt and conditions have gotten worse. In Baños, it is the same picture, while only 29% of respondents reported work-related problems as a result of the volcano in 2001; this figure had risen to 63% in 2005, which suggests that the disaster conditions were getting worse and being felt throughout much of the community.

The differences in the two communities' exposure and losses are reflected in respondents' perceptions of the volcanic risk and impact (Table 8.2). While most participants in both Quero (88%) and Baños (68%) believed that the volcano was a danger to those who evacuated, Baneños expressed less concern than Quero residents. Only 17% said they were "very worried" about the volcano, and 39% considered the volcano a "high risk." In Quero, more respondents expressed worries about the volcano; 83% were "very worried," and 82% believed the volcano to be a "high risk." Perception of health risk also differed, with only 58% of Baños participants but 98% of those living in Quero stating that the volcano presented a risk to his or her health. In addition to experience and exposure, these perceptual differences might also reflect differential access to resources.

There is, however, a marked difference between the quantitative and qualitative responses; in Baños higher levels of perceived risk were noted, especially by women. This was especially apparent from the focus group data which showed that women appeared genuinely concerned about the volcanic activity and impacts it could have on their children. This presented a quandary though which was well expressed by a Baños woman, "I wanted to leave before the evacuation. I was so frightened. I was ready to leave even if I had to go far away. But leaving was worse than staying." Staying in Baños, therefore, presented a challenge and raised fears, but at the same time, the evacuation shelters were often perceived as being far worse than staying in their homes and being exposed to an explosion. Indeed,

Table 8.2 Perception of the volcano

		Baños		Quero	
Concern		Count	%	Count	%
Worried about the volcano	Very worried	21	16.7	95	83.3
	A little worried	41	32.5	16	14.0
	Not worried	64	50.8	3	2.6
Have the eruptions affected your family	A lot	70	55.6	106	93.0
	A little	30	23.8	8	7.0
	No	26	20.6	0	0
Danger now	High risk	49	38.9	93	81.6
	Moderate risk	45	35.7	18	15.8
	No risk	32	25.4	3	2.6
The volcano is a risk to your health now	Yes	73	57.9	112	98.2
The volcano is an obstacle for earning a living	Yes	52	41.3	108	94.7
The volcano has affected your ability to secure loans	Yes	72	57.1	104	91.2
The volcano has caused damage to your house/property	Yes	36	28.6	109	95.6
The volcano was a danger for those evacuated	Yes	85	67.5	98	87.5
	Don't know	7	5.6	11	9.8

the experience of living in the evacuation shelters had repercussions on respondents particularly associated with the lack of what they saw as effective and responsible planning. A Baños man remarked, "Yes, the evacuation was necessary, but they [the authorities] failed to plan very well for what would happen to people once they were evacuated." A second man said that, "My mother died after the evacuation of a heart attack. She never recovered from her pain of the losses she suffered because of being forced to leave her home." Thus, experience of the volcano took various forms associated not only with direct and immediate losses but also with evacuation concerns and the long-time repercussions as the disaster conditions persevere.

8.7.2 Economic Impacts

Ash exposure, damages, and work patterns all affect a household's ability to provide for itself, while the quality and quantity of food and water in turn influence health, thus shaping levels of vulnerability. Again, community differences in exposure, impact, and economic patterns are reflected in the responses.

The survey data revealed that over half of respondents in both Baños (64%) and Quero (91%) reported difficulty finding enough food every day for their families, although 79% of those in Baños eventually succeeded in finding sufficient daily food (Table 8.3). Only a third of those from Quero said the same. The situation

Table 8.3 Provision of food

		Baños		Quero	
Provisions		Count	%	Count	%
Sufficient food daily	Yes	100	79.4	38	33.6
It is difficult to obtain food everyday	Yes	80	63.5	103	91.2
Change in your capacity to obtain food	Better	8	6.3	3	2.7
	Same	63	50.0	7	6.2
	Worse	55	43.7	103	91.2

had changed over the previous 5 years, with 44% in Baños and 91% in Quero reporting that their capacity to obtain food had gotten worse. Again, this suggests that food production had declined at least in those areas most impacted by the ash or alternatively that residents no longer had the necessary resources to purchase such supplies. Whichever the scenario, the long-term effects of the volcano were being felt by many in both communities. Baños respondents generally had more resources than those in Quero and hence, at first, could withstand the periodic disruptions more readily. However, as the disaster continued, even Baños residents were experiencing more and more difficulties.

It was also significant that women in Baños were more likely than men to report difficulties in obtaining food daily, which may reflect the cumulative effects of the emergency as women struggled to care for children, reassure elderly parents, and yet live within an ongoing disaster. Virtually everybody in Quero experienced food problems, with 91% citing a decreased capacity in obtaining food, so differentiating between the sexes was not possible. However, the high level of impact illustrates the degree to which the volcano has negatively impacted agriculture.

Daily and weekly consumption rates of common foods, especially of those containing protein, were significantly lower in Quero than Baños. A majority of Baños participants reported that they ate beans, grains, potatoes, fruits and vegetables, and milk on a daily basis; those in Quero reported that they ate only potatoes, bread, or rice daily. Aside from beans and milk, most foods containing protein were eaten only on a weekly basis in Baños, and just 14% reported eating pork even that often. In Quero, while some got weekly protein, the majority did not. Guinea pigs, once a common household food source, had not survived the repeated ashfalls and were less accessible as they were no longer raised at home, but rather were purchased at the market, and hence were eaten on a weekly basis by only 6 out of the 242 respondents.

Respondents procured their food by buying and raising or as gifts from friends or family members, each of which might indicate different levels of vulnerability. Gifts of food might point to solid social networks, buying might indicate continued cash flow, and raising might show productive land. However, the data must also be looked at in relation to consumption patterns. For instance, 63% of Quero participants said they bought pork, but only one person actually ate it on a weekly basis. Similar difficulties arise with the suggestion that social networks are evidenced through gifts of guinea pigs in Baños. Only one individual in Baños ate guinea pigs on

a weekly basis, though 15% reported receiving them as gifts. It should be noted that guinea pigs are traditional celebration foods in much of the highlands of South America, eaten to mark the birth of a child, the homecoming of a labor migrant, and all birthdays, anniversaries, or other such occasions. The loss of the affordable availability of this food source marks more than a dietary change; it marks a loss of traditional identity. In both communities, it has become customary to buy food rather than to raise or receive it as a gift, though in Quero, raising chickens (35%) and milk cows (40%) remained relatively common. These sources of protein were also consumed somewhat regularly. Deteriorating agricultural conditions appeared to have impaired the ability of households to raise their own food.

Most of the water used for drinking and cooking in both Baños and Quero came through pipes connected to local tanks, although access remained an issue. Many houses in Quero also relied on tanks to collect rainwater. In Baños, 13% of respondents reported that they "always" or "almost always" had difficulty obtaining water, whereas 52% of those in Quero reported problems. While Quero respondents had more difficulty in obtaining water, 69% of them described their perception that the water was safe. In contrast, only 19% of those in Baños perceived that their water was safe and clean.

8.7.3 Social Capital

Questions were asked to elicit information on social capital in the communities. However, it was apparent that in many cases, support was generally limited because everybody was in the same situation. Those with social networks extending outside the disaster zone were sometimes fortunate to report support was available. For example, some residents of Baños evacuated to family and friends in the larger regional city of Ambato or the farther away national capital of Quito. This was not an option for everyone and many residents were relocated to the shelters provided by the national government. While evacuation may be necessary to prevent casualties, evacuations also disrupt social networks, work and economic patterns, and provisioning capacities and can exacerbate stress. Within the cascade model, we see how people were being continuously affected by a multiple range of disaster-related injuries to their economic well-being, to their sense of being able to take care of themselves and their families, and to their own personal agency to protect where they live and what they eat.

Each community had evacuation experience, though under very different circumstances. Baños was evacuated only once at the time of this study, although there have been subsequent evacuations. In 1999, the town was forcibly evacuated with residents escorted out by the military; 46% of the respondents did not go willingly. The residents were given little notice and were not allowed to take their animals, either larger livestock like cattle or smaller household animals like chickens, rabbits, or guinea pigs. Residents tried to sell their larger animals, but the returns were

low and many were taken advantage of by business people taking advantage of the circumstances. The situation was summed up by a Quero woman:

> ... business people came during the ash and took advantage of us during that time. We were selling everything, losing everything ... and now it is much more expensive. If you sold three cattle then you would not even have enough money to buy back one today. They [businessmen] took advantage of us because we didn't know what was happening with the volcano.

Because the city was barricaded, the majority (58%) of Baneños were away from their homes for at least 6 months. The overall shelter experience was not positive and many vowed not to evacuate again. As put by one Baños woman,

> The shelters were very, very stressful. No privacy, just a curtain between you and the next family and you never know how that family was going to be. There were rapes, people were sick, they were crowded together. For my mother it was very stressful – even living together in our family group ... during the evacuation they had no work, no income. It shamed her ... she didn't want to ask us for money ... she went without it [her diabetes medicine] when it ran out.

Those in Quero have had shorter, though somewhat more frequent, voluntary evacuations. Almost all (89%) of the 75% who indicated that they evacuated one or more times did so voluntarily. As is evidenced in statements made by respondents, issues associated with the involuntary evacuation had less to do with the military (as was the case in Baños) and more to do with local and family issues. Over half (55%) of those who evacuated the first time were gone for <1 month. The average time away for the second evacuation was slightly longer.

During the eruptions and evacuations, residents of both Baños and Quero received different levels of assistance, including food and shelter as well some remittances from overseas. In Quero, 82% of the community's respondents indicated that they had received help of some sort. The central government (32%) was the most commonly cited source of aid. Other sources (18%) and religious groups (11%) also provided aid to more than 10% of participants in Quero. In Baños, foreign individuals and family members were the most common source of aid. However, only 10% received aid from family members, and some of these family members lived abroad. The fact that 69% of Baneños reported receiving no help at all and most of the help that was received came from overseas may indicate poorly developed local social networks and a government not prepared to deal with evacuation. Quero received most of its assistance from the national government, which might point to the more limited local resources and social networks of its residents.

8.7.4 Health Perceptions and Complaints

The majority of participants from both Baños (82%) and Quero (98%) were worried about their health (Table 8.4). However, only in Quero did the majority identify

Table 8.4 General health

		Baños		Quero	
		Count	%	Count	%
Worried about your health	Yes	103	81.7	112	98.2
Health change in the last 5 years	Better	8	6.3	3	2.6
	Equal	81	64.3	14	12.3
	Worse	37	29.4	97	85.1

a distinct negative temporal trend with over 85% believing that their health had grown worse in the last 5 years. (The 5-year period was used based on the eruption history of Tungurahua at that time.) The majority of those in Baños (64%) reported no change in health over the eruption period. However, even if the survey results suggested no change in health status, in personal interviews people said that while their health had not suffered due to the volcano, their lives had deteriorated because of the cumulative effect and the loss and uncertainly associated with evacuation and relocation.

The most frequently reported illnesses over the weeks preceding the survey were cough, flu, and sore throat in both communities. However, in Quero, nearly 90% of respondents also reported irritated eyes or vision problems, which would appear to be associated with ash. In general, Quero respondents reported much higher levels of illnesses than those in Baños. One Quero man reported:

> I have felt a big change . . . in respiratory problems especially. And how would you say . . . it is chronic . . . it stays with us the whole time and it affects us a lot, and it does the same to the kids . . . sore throats. I had to go to a doctor in Ambato because my throat was so inflamed . . . he said it was because of the ash. I also suffer from problems with my eyes and lungs. They had to give me medicine but it always comes back.

This is fairly typical of the physical health issues faced by those living in areas that frequently experience ashfalls. Data obtained from the Ministry of Health in Ecuador showed that the number of hospital consultations grew, especially for children under five, and incidence diseases such as upper respiratory tract infections, pneumonia, and tuberculosis all increased after 1999 (Tobin et al. 2005). Young children are particularly susceptible to respiratory illnesses associated with ash because their lungs are more vulnerable. This reversed a trend of improving health in the previous 10 years or so. However, while mortality rates remain high in Baños and Quero cantons, in comparison with national norms, overall health status was not specifically worse. Controlling for size, national statistics for Ecuador showed mortality rates of 456 per 100,000 compared to 468 for Quero and 707 for Baños cantons (Tobin et al. 2005).

Respondents also reported symptoms of stress. A majority of Quero respondents, for example, reported problems; 75% reported sleeping less, 68% ate less, and 80% were more nervous than before the volcano began erupting. There seemed to be less of an impact in Baños where the data showed 34, 16, and 45%, respectively. Again, the greater wealth in Baños may help mitigate the effects of the disaster allowing the residents there more options on how to cope and thus reducing stress.

These descriptive statistics provide a valuable picture of how the volcano impacted the residents living around Tungurahua. Clearly, experiences differed, varying between those in Baños living at the base of the volcano but not in the direct ashfall area and those in Quero who received substantial amounts of ash. Not only had the volcano brought about differential economic impacts, but perceptions and attitudes of the residents toward the ongoing disaster also differ. We now analyze these findings in the light of provisioning through the cascade framework.

8.8 Analysis and Discussion: Provisioning Capacity

Provisioning capacity relates to a household's ability to provide itself with adequate food and water and can be seen as both a measure of vulnerability and resilience and as an influence on associated outcomes such as physical and psychological health. Included in this measure are variables related to both capacity (at the time of the survey) and a perceived change in capacity over the impact period. The provisioning capacity extant in the study communities and its association with vulnerability and resilience was examined through the cascade framework – environment, economic, social, and health traits (see Fig. 8.1). Provisioning variables used in analysis were sufficient daily food, difficulty in obtaining sufficient daily food, water source perceived as safe, problems obtaining water, and a worsening of the capacity to obtain sufficient daily food. Correlations between variables were examined using standard Spearman's rank or Pearson's product moment statistical tests, with only relationships significant at the 0.05 level reported.

8.8.1 Provisioning and Environment Impacts

The destruction and losses caused by volcanic activity are directly related to provisioning capacity at the household level as shown in Table 8.5. For example, in Baños, those respondents who reported damage to plants, loss of animals, and equipment also experienced problems obtaining food on a daily basis, a situation that became worse over the years of our study. There was also a negative relationship with acquiring sufficient daily food suggesting that this was a continuing problem. Similarly significant relationships with plant losses and work-related issues were found in Quero, although here daily food was not problematic. It is apparent from these relationships, however, that perturbations to the agricultural system have generally had a negative impact on the ability of respondents to feed their families and importantly that the struggle to obtain nutrition has worsened over the years.

Experience with evacuations also showed an interesting relationship with provisioning especially in Baños. In this study, those who made a decision to evacuate seem to have been less impacted by the trials of relocation than those forced unwillingly from their homes. There is, for instance, a negative correlation between

Table 8.5 Provisioning and environmental impacts

		Baños		Quero	
Damages	Provisioning	Corr.	Sig.	Corr.	Sig.
Plants losses	Sufficient daily food	−.212	.017	.194	0.39
	Food difficult to obtain daily	.244	.006	–	–
	Obtain food worse over the years	.244	.006	.252	.007
Animal losses	Food difficult to obtain daily	.213	.017	–	–
	Obtain food worse over the years	.312	.000	–	–
	Water never a problem	−.189	.034	–	–
Equipment	Obtain food worse over the years	.260	.003	–	–
House damage	Water never a problem	–	–	−.189	.044

voluntarily evacuating and obtaining food getting worse over the years ($p = -0.247$; sig. 0.005). It is possible these individuals had more resources or perhaps, in deciding to evacuate, had enacted a plan and had not been taken by surprise. Regardless, these individuals had some semblance of control. Similarly, those who evacuated for a year had fewer problems obtaining food on a daily basis ($p = -0.186$; sig. 0.037). It may be that these individuals had greater resources before the eruptions or were able to establish themselves in a new setting, ensuring a return on their terms, rather than one prompted by need. In Quero, those who did not evacuate experienced more problems obtaining daily food ($p = -0.192$; sig. 0.042). However, this applies only to a very small number of respondents who had not evacuated.

The environmental impacts were widespread and ongoing and consequently had a worsening effect on provisioning. This is evident also from an examination of respondents' perceptions of risk. In Baños, a perceived higher risk was positively correlated with greater frequency of ash exposure, while those respondents who had sufficient food did not perceive the volcano as dangerous ($p = -0.222$; sig. 0.013) or as a significant risk to health ($p = -0.236$; sig. 0.008). In contrast, those whose experience in obtaining food had gotten worse had the opposite perceptions and saw the volcano as dangerous ($p = 0.182$; sig. 0.038) and a risk to health ($p = 0.264$; sig. 0.003). In Quero, similar correlations did not exist, although such relationships were unlikely in Quero because 93% of those surveyed experienced ash on a daily basis. Those in Quero, therefore, were more heavily impacted by ash and, as predicted, perceived the risk from the volcano to be higher than did those in Baños. However, Quero respondents who had sufficient daily food did not view the volcano as a risk to their health ($p = -0.189$; sig. 0.045), whereas those who had food problems saw the volcano as a health risk ($p = 0.194$; sig. 0.039).

8.8.2 Provisioning and Economic Capital

The economic repercussions of the eruptions have been widespread and have deepened over the years with agricultural losses mounting and various markets

Table 8.6 Economic capital and provisioning

		Baños		Quero	
Economic capital	Provisioning	Corr.	Sig.	Corr.	Sig.
Difficult to get loans	Obtain food worse over the years	.277	.002		
Own land	Obtain food worse over the years	−.316	.010		
	Sufficient daily food	.445	.000		
	Food difficult to obtain daily	−.436	.000		
	Water always and problem			.188	0.48
Credit problems	Water always problem			−.226	.015
	Water never problem			.254	.006

threatened, such as for potatoes and onions. The association of such losses with increasing difficulties in providing food is apparent and can be seen in various economic indicators. Take for example land ownership. While owning land could be regarded as a short-term liability in some locations hard hit with ash, in Baños it is a benefit, since the provisioning capacity of those whose land is held within the family seems to have been little affected. Owning land was negatively correlated to both current food difficulties and a decreased ability to obtain sufficient food over time (Table 8.6). In fact, there is a relatively strong positive relationship between owning land and having sufficient daily food. In contrast, land ownership was not a significant variable in Quero since most people owned or shared land with family.

The ability to provide sufficient food may also explain the negative association between land ownership and the belief that the volcano was a danger to those who evacuated. Though owning land had a negative correlation with the perception of help, it could be that those owning land did not seek outside assistance; they may instead be providing it. No relationship was found between any of the economic variables and mitigation strategies. However, a majority of respondents in both Quero (91%) and Baños (57%) indicated that it was difficult to get loans because of the volcano threat.

8.8.3 Provisioning and Social Capital

While social networks can affect disaster recovery, our analysis showed few significant correlations of social capital indices to outcome variables. Females in both communities were more likely to report difficulties obtaining sufficient food daily; in Baños, the elderly were significantly worse off with regard to food, while in Quero, household size was correlated with a declining capacity to provide food. The number of residents in households was also associated with non-evacuation, so taken together, these relationships may indicate a limited resource base which constrains action and increases vulnerability. In Quero, large households may not serve to expand social networks as they appeared to in Baños where family members had access to jobs through tourism, a source of income not available in the more

Table 8.7 Demographics and provisioning

		Baños		Quero	
Social capital	Provisioning	Corr.	Sig.	Corr.	Sig.
Female	Sufficient food daily	−.181	.042	–	–
Elderly	Obtain food worse over the years	.187	.036	–	–
Female	Sufficient food daily	–	–	−.232	.013
	Obtain food worse over the years	–	–	.269	.004
	Water always problem	–	–	.209	.026
Number in house	Obtain food worse	–	–	.219	.020
	Safe water	–	–	.252	.007

traditional farming community of Quero. Though household size was positively correlated to help from family and friends (Table 8.7), they play a limited role in overall assistance. No significant relationships were found between demographics and perception of the volcano.

In Baños, being married and having a spouse who worked away from the home resulted in higher negative perceptions of aid from local, provincial, and national levels. However, this division within the family may have increased the household's social networks and resources and hence enhanced resilience. The importance of family and friends in providing assistance was evidenced by a strong correlation to general help and further explains the association of help and household size mentioned above.

8.8.4 Provisioning and Health

To test for health outcomes, several indices were formulated from the questionnaire data to represent individual physical health, family health, and individual psychological stress. Data were gathered on over 500 individuals in each community, and factor analysis was used to identify symptom groupings and scales. The final individual physical health index consisted of three equally weighted variables: sore throat, irritated eyes, and congestion, all of which were among the top ten complaints of both respondents and spouses. A family health index consisted of the same variables used in the individual health index. The psychological stress index was based on behavioral changes and non-gender-specific physical changes that might indicate stress. The final scale included changes in sleep patterns, increased crying, increased nervousness, changes in appetite, and changes in weight. All were weighted equally and added. Cronbach's alpha was used to test for validity of these indices with acceptable scores of 0.73 for physical health but slightly lower for stress (0.64). A high index score represented relatively worse health.

The relationships between provisioning capacity and physical and psychological health in both communities were varied. The highest correlation, found in both Baños and Quero, was between decreased ability to obtain enough daily food

Table 8.8 Provisioning and physical health

		Baños		Quero	
Provision	Health	Corr.	Sig.	Corr.	Sig.
Obtain food worse over years	Health worse	.381	.000	.218	.021
Water perceived safe	Health index	–	–	.232	.037
Water always problem	Family health	–	–	−.392	.001
	Health index	–	–	−.328	.003
Food difficulties	Health worse	–	–	.305	.001

Table 8.9 Provisioning and psychological health

		Baños		Quero	
Provision	Psychological health	Corr.	Sig.	Corr.	Sig.
Obtain food worse	Change in appetite			.263	.005
	Change in weight	.215	.016	.380	.000
	Stress index	.307	.000	–	–
	Change in crying	.215	.016	–	–
Sufficient food	Change in appetite	–	–	−.212	.024
	Depression	–	–	−.293	.004
	Increased conflict	–	–	−.205	.029
Food difficult to obtain daily	More nervous	.229	.010	–	–
	Stress index	.249	.005	–	–
	More nervous	.192	.031	–	–
Water always problem	Change in sleep	–	–	.312	.001
	Change in appetite	–	–	.195	.038
	Change in weight	–	–	.193	.040
Water never problem	Change in sleep	–	–	−.377	.000
	Change in appetite	–	–	−.254	.006
	Change in weight	–	–	−.222	.017

and worsening physical health (Table 8.8). We can see that, in Quero where 69% considered their water safe, water perceived as safe was correlated with poorer health, whereas when finding water was considered problematic, health indices for individuals and families were lower. It may be that the confidence in their water sources was unwarranted. Those who consider finding water to be "always" problematic may be more discriminating in their chosen sources. This juxtaposition might also point to a key mitigating factor in improving health outcomes.

There were several significant correlations between provisioning capacity and psychological variables (Table 8.9). Both variables, difficulties in obtaining food daily and a decreased capacity to do so over time, had a positive association with the psychological stress index suggesting a relationship between reduced provisioning capacity and increased psychological problems. In Quero, a reduced capacity to supply food was also positively correlated to stress factors such as changed appetite and weight, though changed weight may simply be due to limited caloric intake. In Baños, we see higher levels of stress associated with reduced food availability.

While somewhat limited, these results emphasize the importance of provisioning capacity. While they vary between communities, each variable representing sufficient food or water was negatively correlated to stress and depression. In addition, those who had sufficient food daily had greater faith in the local government. This category, therefore, might better illuminate issues of resilience and vulnerability than other outcomes alone.

8.9 Conclusions

This chapter examined how individuals' experiences, characteristics and attitudes, and social support mechanisms mediate impacts of exposure to chronic volcanic disasters while controlling for access to food resources. The research was conducted in several Ecuadorian communities located on the slopes of Mount Tungurahua, including Baños, and two settlements in Quero. These communities have been subjected to frequent volcanic activity since October 1999. The objective of the research was to understand the roles of provisioning in the context of chronic natural hazards in order to reduce human vulnerability and enhance community resilience. It was hypothesized that provisioning capacity would be measurably expressed in physical and psychological health outcomes, during times of crisis, and thus impact both vulnerability and resilience. The work was guided by the cascade of effects framework, describing how ongoing events can lead to a downward spiraling of negative impacts.

The consequences of reduced provisioning, that is, being unable to provide sufficient food and sustenance for one's family, are critical elements which can exacerbate problems for already vulnerable populations. Indeed, given the situation in and around Mount Tungurahua, with the repeated ashfalls and threat of significant eruptions, it was expected that this would be an ongoing, daily concern in both Baños and Quero. Three findings stand out:

- Chronic ashfall damaged crops and reduced land productivity, resulting in a failing agricultural industry. In addition, many individuals had not returned to their homes. This disruption of economic and social networks, in conjunction with constant exposure to ash, may have led to negative health outcomes particularly among the younger population.
- The ability to provide food was associated with better physical and mental health, improved perception of authorities and community leaders, and reduced perception of risk. This suggests that the ability to provide (having access to a reasonable level of resources on a day-to-day basis) was a key factor in the mitigation of the negative outcomes in chronic hazard environments.
- Women in both communities were less likely to report having adequate food than men. This outcome echoes findings from other hazard studies that suggest women are often more vulnerable than men because of the roles they have in society. The significance of this finding is abundantly clear; inequities in the distribution of

resources are harmful to society at large and may injure the very population that is usually responsible for tending to the children and older adults.

In our research, the cascade of impacts, environmental, economic, social, and health, were certainly interrelated, and as the disaster progressed, so the situation for many residents has become decidedly more precarious. Losses have mounted and the impacts are now felt throughout many spheres. This chapter suggests that disaster research should adopt a comprehensive outlook in developing mitigation plans to address these relationships especially in chronic disaster environments. And, given the dynamic nature of chronic hazards and if community resilience is to be fully understood, it is also necessary to examine how impacts cascade among the different components of the system.

If provisioning capacity is considered an economic consequence of disaster, the cascade of effects framework is also supported, though the interactions among social capital, economic, and health consequences and environmental impacts were not always established. Nevertheless, the impact of volcanic activity on the social and economic systems is evident, and relationships with health problems have been supported elsewhere. While causality between provisioning and health still needs to be affirmed in this study, it is not inconceivable that the interplay of decreased economic resources and provisioning capacity, decreased health, and lack of social capital, illustrated in this chapter, would lead to a decreased ability to cope.

In conclusion, these findings suggest that further attention should be given to understanding the relationships among social support networks and health and well-being. The model itself is too static, describing a somewhat linear approach that does not necessarily reflect actual relationships; it fails in some ways to capture any changing socio-environmental conditions. In addition, a hypothesized relationship of how social support and individuals' attitudes mediate the effects of natural hazards on health and well-being suffers from similar structural problems. Thus, given the dynamic nature of chronic hazards, it is necessary to examine how impacts cascade among the different components of the system if community resilience is to be fully understood.

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Section 4
Hurricanes and Floods

Chapter 9
Jamming with Disaster: New Orleans Jazz in the Aftermath of Hurricane Katrina

Bruce Boyd Raeburn

Abstract While storms such as the Hurricane of 1915 and Betsy (1965) occasioned major damage and dislocations for many New Orleans residents, Hurricane Katrina in 2005 was the first such event to receive international media coverage as it was happening. Televised reports emphasized the misery of black refugees massed at the Convention Center and Superdome: depictions of New Orleans as "third world," deviant, and unworthy of salvation revealed the negative underside of the exoticism that had fueled the city's cultural tourism industry for centuries. Yet, the resilience of jazz musicians and concomitant festival traditions (Carnival, "second lines," "jazz funerals," and New Orleans Jazz and Heritage Festival) became the city's barometer for recovery. Seven years later, one can offer some tentative conclusions about the impact of Hurricane Katrina on the fortunes of New Orleans jazz musicians. In time, positive media coverage surfaced in Spike Lee's film "When the Levees Broke" and David Simon's HBO series "Tremé," providing New Orleans musicians with national exposure and, in some cases, substantial revenue. Moreover, an amelioration of the factionalism that had plagued the New Orleans brass band scene for at least three decades prior to Katrina has led to a renewed sense of community among these musicians. Fears that the city's jazz culture would not survive have abated. Increased visibility, combined with the psychic and material impact of private sector aid to musicians, has given New Orleans jazz musicians new opportunities for growth and hope for a better future. In fact, many writers now feel that Katrina has ushered in a renaissance for New Orleans jazz, an awakening based in catharsis and a renewed commitment to a cultural environment that posits music as necessary to existence.

Keywords Hurricane Katrina • New Orleans • Jazz • African-Americans • Cultural tourism

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K. Pfeifer and N. Pfeifer (eds.), *Forces of Nature and Cultural Responses*,
DOI 10.1007/978-94-007-5000-5_9,

Jazz emerged in the early twentieth century from a culture that had long employed music to mitigate a harsh and disaster-prone environment. It was evident in masked balls staged during cholera and yellow fever epidemics in the 1830s (in which active ballrooms sometimes served as makeshift hospitals); in weekly Sunday ring shouts in Place Congo (1817–1845) designed to relieve the pressure of urban slavery while also satisfying the city's penchant for escapism and spectacle; and in the proverbial brass band funeral parades that sought to affirm life in the face of death as the departed were escorted to the aboveground gravesites commonly referred to as "cities of the dead." As an African-American vernacular dance music rooted in the experience of the city's underclass, jazz drew on all of these musical practices, developing its identity as an accessible and necessary form of pleasure within a continuum of community-based festival traditions representing a discrete regional cultural reality.

While earlier storms such as the Hurricane of 1915 and Betsy (1965) occasioned major damage and dislocations for many New Orleans residents, Hurricane Katrina in 2005 was the first such event to receive widespread international media coverage as it was happening, and the images that were televised were extremely selective, focusing primarily on the misery of black refugees massed at the Convention Center and Superdome: depictions of New Orleans as "third world," deviant, and unworthy of salvation in the media revealed the negative underside of the exoticism that had fueled the city's cultural tourism industry for almost two centuries. Yet, and almost by default, the resilience of jazz musicians and concomitant festival traditions (Carnival, "second lines," and "jazz funerals") became the city's barometer for recovery, both at home and in the eyes of the world (see pp. 813–814, Raeburn 2007 and pp. 593–595, 599, Porter 2009).

Hurricane Katrina made landfall on August 29, 2005, as a Category 3 cyclone with winds of 127 mph and a tidal surge that surpassed 35 ft in some areas. The failure of key floodwalls along canals fed by Lake Pontchartrain and on the Industrial Canal was colossal by any standard and caused the inundation of 80% of the city. Although a mandatory evacuation order for Orleans Parish was in effect from August 27, approximately 100,000 residents were trapped within the city limits during the week of August 29 through September 4. If one counts flooding in the surrounding parishes of Jefferson and St. Bernard, 40% of a total population of 988,182 lived within flooded terrain by September 8, and in Orleans Parish the total exceeded 60%. Richard Campanella, whose work affords perhaps the most incisive accounting of Katrina's impact and demographic implications, states: "The repopulation of postdiluvian New Orleans defies easy measure… Most observers generally agree that the summer 2005 Orleans Parish population of between 450,000 and 455,000 dropped to nearly zero immediately after the flood, then rose to roughly 100,000 by the year's end, to 200,000 on the first anniversary of the storm, 300,000 on the second anniversary, 320,000 on the third anniversary, and around 340,000 by summer 2009" (p. 168, Campanella 2010; for time-lapsed maps illustrating neighborhood flooding in stages, see http://www.nola.com/katrina/graphics/flashflood.swf). By February 23, 2006, the storm-related body count was approaching 900, and it would eventually climb even

higher, making Hurricane Katrina one of the most lethal disasters in American history (see http://www.dhh.louisiana.gov/offices/publications/pubs-192/Deceased%20Victims_2-23-2006_information.pdf).

As self-appointed pundits and politicians debated whether or not New Orleans was worthy of reconstruction, residents who had been subjected to mandatory evacuation pondered personal futures and the logistical issues related to rebuilding lives as well as property. In the Crescent City, citizens affiliate and identify by neighborhood, which is also how bands, social aid and pleasure clubs, and Black Indian gangs are organized. After so much of the city flooded in the wake of Hurricane Katrina, the primary question in the minds of most people who valued or understood New Orleans culture was whether the constellation of neighborhoods such as Tremé, the Lower Ninth Ward, the Seventh Ward, Central City, and Algiers that had nurtured jazz and the city's other indigenous musical cultures (and that had therefore bequeathed to the nation its "great American art form") could survive intact, or would these "cultural wetlands" disintegrate, forcing musicians who had been dispersed to lose their sense of connection and find more profitable opportunities elsewhere? Such issues pertain perhaps more to the spiritual state of the city's post-Katrina population than to its material infrastructure, rendering them that much more nebulous and inscrutable, but 6 years after the fact, one can offer a few tentative conclusions about the impact of Hurricane Katrina on the fortunes of New Orleans jazz musicians and their response to the situation because there is a growing consensus among scholars and writers about the trends that have emerged in that time (see especially Porter and Watts 2013).

Due to the traumatic legacy of slavery, the disillusionment of Emancipation and Reconstruction (bookended locally by the race riot of 1866 and the "Battle of Liberty Place" in 1874), and the psychic and material damage inflicted by a federally authorized Jim Crow segregation from 1896 that continued to plague social relations well after 1954 (when it was officially dismantled but not eradicated), many African-American and Afro-French Creole residents of New Orleans were systematically excluded from the American Dream of economic opportunity, upward social mobility, and a sense of personal security. They were relegated instead to lives of desperation, albeit mitigated to some extent by the richness of the musical culture and social networks they created in spite of adversity, as a means of coping with it. Thus, many of the problems related to housing, gainful employment, working conditions, and social services for jazz and other musicians in New Orleans that have been discussed in the aftermath of Hurricane Katrina existed prior to the flooding that destroyed much of the city, but there is little doubt that the scenario became much worse following the annihilation of key residential neighborhoods and the implosion of the tourist economy that sustained many musicians.

The dispersal of musicians accompanying evacuation of the city and questions about tracking their return led to the realization that adequate statistical information was simply not available, making it difficult to ascertain the magnitude of the cultural disaster. Since the storm, the actions of corporations (both commercial and nonprofit), private sector volunteers, and local institutions such as WWOZ radio and Local 174–496 of the American Federation of Musicians have addressed the

need to define the musical community of New Orleans more effectively, and it is now possible to speak with greater precision about how many musicians live and perform there. Yet ironies abound. Habitat for Humanity's Musicians Village, a concept developed in December 2005 to deal with postdisaster housing shortages, initially excluded the very people it was designed to help because many African-American brass band musicians lacked bank accounts, tax returns, and the credit histories needed to meet eligibility requirements (during the past 4 years, credit remediation programs have improved the situation significantly). Such endemic infrastructure problems cannot be solved overnight, but bringing hidden service economies and invisible labor to light is an important beginning in addressing these issues.

Moreover, despite the glut of early media attention, not all the results of the disaster were negative. In time, positive media coverage could be seen in projects such as Spike Lee's "When the Levees Broke" (HBO, aired 2006), "If God Is Willing and the Creek Don't Rise" (HBO, aired 2010), and the David Simon series "Tremé" (HBO, aired 2010–11), which gave New Orleans musicians increased national exposure and, in some cases, provided a large infusion of revenue at a critical time in the city's recovery. There also seems to have been an amelioration of the factionalism (traditional versus modern) that had been a constant presence in the New Orleans brass band scene for at least three decades prior to Katrina, leading to a renewed sense of community among these musicians, whose dedication to New Orleans jazz has become more ecumenical in direct proportion to the threat of extinction. Thus, while some New Orleans jazz musicians may have fewer jobs and make less money per engagement than before Katrina, fears that the city's jazz culture would not survive have abated. Furthermore, the visibility that Katrina conferred upon New Orleans jazz musicians, combined with the psychic and material impact of private sector aid to musicians through the efforts of the Grammy Foundation's Musicares, Bob Ezrin's and the Gibson Guitar Foundation's Music Rising, and the New Orleans Musicians Clinic, sustaining belief in the value of New Orleans music and culture, has given New Orleans jazz musicians new opportunities for growth and hope for a better future. In fact, Katrina may have ushered in a renaissance for New Orleans jazz, an awakening based in catharsis and a renewed commitment to a cultural environment that posits music as necessary to existence, but this phenomenon did not reveal itself immediately.

In the first 2 years following the disaster, predictions concerning the future of New Orleans musical culture tended toward the pessimistic. In a book titled *Why New Orleans Matters*, written within 2 months of the flooding, the writer Tom Piazza feared that a neoliberal agenda for reconstruction of destroyed neighborhoods would yield an ersatz jazz playground for tourists: "If you thought the contracts for Baghdad were fat, wait until you hear the cash registers ringing for Jazzworld" (D-1, Larson 2005). In July 2006, Howard Reich, the jazz critic for the Chicago *Tribune*, declared that "the cradle of America's artistic identity might never recover its vitality" (Reich 2006). The following February he was quoting Stella Baty Landis, the owner of Sounds Café and an organizer of Silence Is Violence (a response to the murders of Hot Eight snare drummer Dinerral Shavers in December 2006 and filmmaker Helen Hill in January 2007), under the rubric

"a culture's sad finale?": "I feel that the city that existed pre-Katrina is done, and that its culture is not going to suddenly reappear, no matter how hard we fight for it . . . My hope is very long-term and itself kind of abstract, but it's that the kernel of New Orleans, that essence of New Orleans that is deep in our soul and thick in the air, will give rise to something, eventually, newly wonderful" (Reich 2007; for Silence Is Violence, see also pp. 311–314, Berry 2009).

Yet Landis was about to embark on a novel experiment that Katrina made possible—a series of hosted sessions at Sounds Café in which the clarinetist Dr. Michael White, a scion of traditional jazz, was joined by members of the Hot Eight Brass Band, led by the sousaphonist Benny Pete, a band which was part of the progressive "new wave" of brass bands that had been spawned by the popularity of the Dirty Dozen Brass Band in the 1980s and the rise of the Rebirth Brass Band (and many others) shortly after (for detail on Sounds Café sessions, see pp. 319–323, Berry 2009). The Hot Eight was there to learn about the "passing on" of a tradition with which they had hitherto been unfamiliar, intended as a means of restoration and recovery, and to promote healing as well as growth. The band had experienced two murders of band members (one by the New Orleans Police Department) prior to Hurricane Katrina, plus Shavers' subsequent death. Then one of their trumpeters, Terrell "Burger" Batiste, lost both legs in April 2006 after being hit by a car during his Atlanta evacuation. (He continues to perform in a wheelchair.)

Hot Eight's interest in connecting to the traditional brass band repertoire was not the only dynamic at play at Sounds Café. Dr. Michael White had lived a block away from the London Avenue Canal breach, and he lost everything that he could not take with him when he fled, including 50 vintage instruments, numerous unique interviews with pioneer jazz musicians, more than 4,000 LPs and CDs, and reams of sheet music, including his own compositions in manuscript (Spera 2005). He evacuated to Houston to care for his mother and his aunt but commuted regularly to New Orleans to perform and eventually to resume teaching at Xavier University, where he lived in a FEMA trailer (pp. 820–822, 826–827, White 2007). Following the storm, he became an eloquent spokesman for traditional New Orleans jazz musicians in numerous media interviews and lectures. So did the banjoist and bandleader Don Vappie, who was the subject of Glen Pitre's 2006 PBS documentary "American Creole," a film that presented a similar account of disruption and survival (p. 817, Raeburn 2007). Yet even before Katrina, White had been contemplating new avenues for musical exploration. During a fellowship residence at Studio in the Woods in 2004, he had begun to move beyond his staunch adherence to traditional jazz and expanded his vision of the city's indigenous music heritage to include Caribbean beguines and calypso, modern jazz, rhythm and blues, and hip-hop, all of which served as inspiration for the resulting CD, "Dancing in the Sky" (Basin Street Records, released 2004). In other words, before the Hot Eight Brass Band was moving in his direction, White was already gravitating toward their eclectic, experimental approach. And although this shift began before Katrina, it was accelerated and deepened by the clarinetist's Katrina-related experiences, helping to heal the divisions that had created dissension within the brass band community before the storm.

Prior to Katrina, the brass band scene in New Orleans had been factionalized along "traditionalist" and "modernist" lines, generating acrimonious debates about authenticity, instrumentation, repertoire, and performance style. As a participant in these discussions, Dr. Michael White was in a position to comment upon them and with a remarkable degree of equanimity given his traditionalist orientation: "During the middle and late seventies, several new younger brass bands emerged to fill in the community void as traditional groups on the street became rarer and rarer. The ranks of younger players were filled with musicians who rarely interacted with older players and had little, if any, contact with or 'apprenticeship' in the authentic traditional New Orleans style. Since a once strong high school band tradition was beginning to decline, fewer younger players had training or development before becoming professional. Characteristic of many younger groups, which grew to dominate the streets by the early eighties, were unison section playing, 'riff tunes,' simplified harmonies, reduced numbers of keys, faster and more prominent rhythms, and smaller groups of about eight musicians. Instrumental shifts were also seen: the clarinet virtually disappeared, and the tuba and drums developed a more dominant role with rhythm and blues overtones. The overall sense of pride, professionalism, and seriousness gradually gave way to street clothes, baseball caps, and tennis shoes. Mixing all the musical elements around them—reggae, rhythm and blues, bebop, free jazz, high school band music, Mardi Gras Indian chants, current radio hits, and television themes—the younger brass bands brought a freshness and creative excitement to the streets that had been missing in the older traditional bands. Commercialism and the generation gap were the underlying causes of the older bands' dwindling repertoires, stagnation of styles, and a lack of new songs in the traditional groups" (p. 89, White 2001).

After the disaster, a more expansive and ecumenical vision of the jazz tradition began to develop among many brass band musicians, driven by an unavoidable contemplation of fate and identity that the storm set in motion for all evacuees. During their respective evacuations, New Orleans residents yearned to "get their lives back," yet not all were in a position to do so. Therefore, individuals did what they could. As early as February 2006, members of the Soul Rebels, a brass band whose 1998 CD "No More Parades" was designed to proclaim the band's renunciation of "second lines" and social aid and pleasure club work in order to position itself more effectively as a hip-hop act, were commuting weekly (at a financial loss) from exiles in Houston and Baton Rouge to perform for local audiences at Bon Ton Roulé on Magazine Street (see p. 6, Spera 2011). Lumar LeBlanc, the band's snare drummer, felt that regaining contact with the band's local audience was important, even though its promotional strategy prior to Katrina had relied increasingly on national touring: "We've committed ourselves to our [local] fans, and we'll do it as long as we physically can" (quoted pp. 39–40, Tolliver 2007). Prior to Katrina, the band was doing what it could to distance itself from the brass band tradition; afterward, it sought to reestablish continuity to a historic tradition that seemed to be imperiled. The band still prefers club work to street parades, although a "Bless You Boys" commercial for WWL-TV celebrating the New Orleans Saints' 2010 Super Bowl victory shows them on Bourbon Street

surrounded by a "second line" (as well as assorted cheerleaders), so they are still employing the marching band trope when it advances their career goals but only rarely.

The catharsis among New Orleans brass band musicians catalyzed by Hurricane Katrina and its salutary effects in unifying that community since 2007 is only one aspect of what appears to be a broader shift in musician attitudes about how music and social activism can blend to promote political awareness and inspire agency in a postdiluvian New Orleans. This has been a primary theme in recent books about musicians surviving disaster, especially Keith Spera, *Groove, Interrupted: Loss, Renewal, and the Music of New Orleans* (2011); John Swenson, *New Atlantis: Musicians Battle for the Survival of New Orleans* (2011); and Eric Porter and Lewis Watts, *New Orleans Suite* (2013), all of which argue that, rather than facing extinction, New Orleans musicians have used the disaster to reorganize, clarify priorities, and invigorate their art with new meaning.

As Harry Shearer affirms in his preface to *Groove, Interrupted*, New Orleans musicians should be regarded as "neither heroes nor victims. They are extraordinarily gifted members of a unique music culture, their world flooded away in a historical instant—family splintered, neighborhood rubbished, support system shattered—and . . . they are, each at their own speed, in their own way, doing what New Orleanians have always done: getting the groove back" (x, Spera 2011). Spera provides moving accounts of the experiences of many of New Orleans's jazz icons, including clarinetist Pete Fountain and trumpeter Terence Blanchard, whose 2007 CD "A Tale of God's Will (A Requiem for Katrina)" he describes as "the most intelligent, articulate and elegant musical expression of the tragic events and aftermath of August 29, 2005" (p. 108, Spera 2011).

Yet Spera also illustrates how fixation with Hurricane Katrina's impact can divert our attention from the host of challenges that have routinely afflicted many New Orleans musicians and from the historical forces that have contributed to those challenges. In his testimonial to the Rebirth Brass Band, he depicts leader and tuba player Philip Frazier as contending regularly with arrests of band members (including his own); the murder of his wife's son, James Tapp Jr. (better known as the rapper Soulja Slim); the premature death or injury of colleagues from violence and assorted health issues; and, finally, a stroke in December 2008 that almost ended his musical career. By comparison, Hurricane Katrina had barely caused Rebirth to break stride. One of the band's trumpeters, Shamarr Allen, became a focus of media attention because he lived in the devastated lower Ninth Ward, and his celebrity became a distraction and a reason for leaving, but otherwise, the band concentrated on business as usual, returning to perform in New Orleans in October 2005, despite the dispersal of several key members to distant locations, and by November, Frazier had returned to his damaged home in Gentilly (pp. 248–260, Spera 2011).

While Spera's narrative mostly highlights the experiences of New Orleans musicians who have already achieved fame (Aaron Neville, Allen Toussaint, Fats Domino, Mystikal, Juvenile), Swenson's *New Atlantis* presents a chronological memoir tracing the trials and tribulations of a cross section of the author's local network of musical friends and acquaintances from Katrina through 2010, ranging

from homegrown heroes such as Malcolm "Dr. John" Rebennack and the bassist George Porter Jr. (whose granddaughter Katrina wanted to change her name after the storm) to less well-known and more recent arrivals such as the vocalist Shannon McNally, whose musings on New Orleans as "the Constantinople of the New World" provide a sense of what attracts people to the place: "The energy that's trapped here, that lives here, is very unique, and it's very powerful . . . Everything is exaggerated, the poverty is exaggerated, the brutality, the music, the food. If you're a person whose senses are acute, there's no way of getting around it. You just feel it" (p. 20, Swenson 2011). Once again, the emphasis is on the metaphysical as intrinsic to the cultural terrain—"spirit tides" that animate the actions of the living.

Swenson's book opens with discussion of blues guitarist Tab Benoit's Voice of the Wetlands recording project at Mark Bingham's Piety Street studio in January 2005, an initiative employing music to promote awareness of wetlands conservation that predated hurricanes Katrina and Rita (see also p. 816, Raeburn 2007). Among the all-stars who performed on the recording were Dr. John, George Porter Jr., drummer Johnny Vidacovich (of Astral Project), percussionist Cyril Neville, guitarist Anders Osborne, and Monk Boudreaux of the Wild Magnolias, and the music developed spontaneously, with Porter serving as the ad hoc music director. As Dr. John described the process "Ain't nobody tryin' to be a front man. It's just everybody bein' part of a band. Everybody's a piece of somethin'. Chunks of it got written right in the studio . . . Dat's what you call community skull arrangements. Dat's where the music of New Orleans all came from, everybody working in unison to do somethin'. That's where the whole thing came from" (p. 9, Swenson 2011).[1] The "Voice of the Wetlands" CD was released on September 29, 2005, by which time Hurricane Katrina had already stolen its thunder, but it nevertheless serves as an example of politically conscious agency by New Orleans musicians prior to the storm.

Indeed, although Eric Porter's *New Orleans Suite* (with photographs by Lewis Watts) presents a hopeful vision of a post-Katrina musical renaissance in the benefit concerts, CD projects, and related media initiatives that resulted from the dislocations associated with the aftermath of the flooding, it is important to remember that New Orleans musicians have had recourse to such measures in dealing with social and economic problems for many years. Aaron Neville and Allen Toussaint's New Orleans Artists Against Hunger and Homelessness concerts were inaugurated in 1985 and eventually took shape as a nonprofit corporation addressing the needs of homeless people through a variety of concerts and fund-raisers. The New Orleans Jazz and Heritage Festival Foundation has similarly sought to filter money from the production of the annual "Jazz Fest" back into African-American communities citywide, sponsoring neighborhood "mini festivals"; providing grants to composers, musicians, and other culture bearers; and underwriting lectures on aspects of New

[1] "Skull" arrangement and "head" arrangement are interchangeable terms denoting the working out of repertoire collectively in advance during rehearsals and then memorizing the parts agreed upon or assigning opportunities for improvisation once the basic structure of the piece is in place.

Orleans culture and history. Yet Porter is certainly not mistaken in arguing that Katrina served as a catalyst for a general awakening of political consciousness within the New Orleans musical community.

In a chapter titled "Reconstruction's Soundtrack," Porter interprets the meaning of the various tribute and benefit concerts, theme-oriented recordings, and related "incantations" occurring in the aftermath of Hurricane Katrina, envisioning the movement as symbolic of the possibilities of multiracial democracy in practice (for further exposition of progressive and regressive aspects of jazz culture in New Orleans, see also pp. 595–597, 600–605, Porter 2009). He is particularly interested in exploring the role of New Orleans musicians as politically self-aware "healers" in recording projects undertaken by the New Orleans Social Club ("Sing Me Back Home," recorded by a superstar lineup of New Orleans musicians while in evacuation in Austin, Texas, in 2006), Terence Blanchard (the aforementioned "A Tale of God's Will," recorded in 2007), the Dirty Dozen Brass Band (an updated, Katrina-inspired remake of Marvin Gaye's seminal "What's Going On" album from 1971, recorded in 2006), and the Preservation Hall Jazz Band (their 2010 "Preservation" CD, a collaboration across genre boundaries with numerous guest artists, such as Tom Waits, Dr. John, Steve Earle, Pete Seeger, Merle Haggard, the Blind Boys of Alabama, and Ani DiFranco). Porter finds hope in such stories, a counterpoise to his rather negative reading of the treatment of creolized, diasporic populations (African-Americans and Hispanics especially) that produce New Orleans culture in earlier chapters about the New Orleans Jazz and Heritage Festival and the "biopolitical" implications of neoliberal visions of reconstruction that cast musicians in the role of service workers bereft of health care, retirement plans, and decent wages (see also pp. 597–598, Porter 2009). Unlike Spera and Swenson, Porter is a trained scholar who offers an outsider's perspective on post-Katrina New Orleans, which not only enables him to more easily place relevant issues in a broader national and global context but also removes him from any vested interest in addressing the conflicts associated with racial, aesthetic, or neighborhood boundaries throughout the city. While his commitment to the creolized, diasporic communities of culture bearers in the city is unequivocal, his equanimity in approaching the issues that have confronted them in the past and that continued after Katrina is laudable, as is his celebration of New Orleans musicians who maintain hope through pursuit of their craft and the struggle for a better future.

Porter's critique of neoliberal agendas conforms to similar arguments made by George Lipsitz, who has been writing about New Orleans culture bearers, including jazz musicians, for 30 years. In "Learning from New Orleans: The Social Warrant of Hostile Privatism and Competitive Consumer Citizenship," Lipsitz clarifies the intrinsic conflict between those who make New Orleans culture and those who would seek to manage its reconstruction:

> From the perspective of the richest people, the richest corporations, and the most powerful politicians and media outlets in our society, New Orleans must be rebuilt for the convenience of investors, entrepreneurs, and owners. From this vantage point, the black residents of the city who suffered so terribly during and after the hurricane are not people who have problems, but instead they are the problems. In the wake of the devastation caused by

> Hurricane Katrina and his own administration's maliciously incompetent relief efforts, President Bush outlined a program of legalized looting to enable corporations to profit from the misfortunes of poor people . . . an excuse for an exercise in social engineering and an opportunity to implement the free market fundamentalism that is not yet politically palatable in the rest of the country. The President ordered the suspension of laws that require affirmative action in hiring and contracting, mandate environmental protection, and prescribe paying the prevailing union scale and minimum wage for federally-funded rebuilding projects. Bush offered lavish tax breaks to corporations by making the entire Gulf Coast a taxpayer-subsidized "enterprise zone," and he even exploited the emergency as an opportunity to advance his schemes to undermine public education by using taxpayer money to support vouchers to send children to private schools. (pp. 451–452, Lipsitz 2006)

What Lipsitz and Porter both emphasize is that whether Katrina is characterized as a natural or a man-made disaster, the true threat to the survival of New Orleans's African-American musicians, i.e., the systematic exclusion and dispossession of these people under a neoliberal agenda, predates the storm and continues to inhibit solutions to fundamental issues related to provision of basic infrastructure: education, economic opportunity, adequate housing, and security, all of which pertain to cultural production. As Lipsitz argues, "the most important social mobilization of our time was not the civil rights movement of the mid-20th century but rather the counterrevolution that emerged against it through resistance to school desegregation, fair housing, and progressive taxation and eventually coalesced into a social warrant for competitive consumer citizenship" (p. 454, Lipsitz 2006). Thus, as Lipsitz reminds us, "the pleasures of New Orleans come from a crucible of undeniable pain . . . The organized abandonment of poor and working-class black people in New Orleans prior to the hurricane had left them vulnerable to the effects of flooding . . . [yet] the black working class in New Orleans has long refused to concede that white property is more important than black humanity" (p. 460, 464, Lipsitz 2006).

Occasionally, however, although exceptional, the post-Katrina interaction of corporations and New Orleans jazz musicians does not lead to negative consequences. On October 23, 2010, Red Bull, a "power drink" company that sponsors extreme sporting events to promote its product, staged the "Red Bull Street Kings Brass Band Blowout," featuring battles under the Claiborne Overpass (a site of high cultural significance that amplifies sound dramatically) among the Free Agents Brass Band, TBC (To Be Continued), the Stooges Brass Band, and the Soul Rebels. The prize was three days at the Red Bull recording studio in Los Angeles, plus an oversized champion's belt reminiscent of the World Wrestling Federation trophy. One might assume that Red Bull's interest in having its wares associated with brass band jazz musicians valiantly fighting to survive in a seemingly postapocalyptic urban environment not only conformed to their brand's established devotion to extreme challenge situations but also stemmed from a blatantly commercial desire to bask in the afterglow of charity work among a group of unfortunates with high media visibility. Yet the company's efforts to present a spectacle that would accurately represent the New Orleans brass band tradition of "cutting contests" were nevertheless sincere.

Interestingly, Red Bull's Brass Band Blowout project team, led by Field Marketing Manager Scott Lopker, spent over a year conducting research on the history of "cutting contests" in New Orleans jazz at the Hogan Jazz Archive at Tulane University in preparation for the event, including a final meeting with the author (acting in his capacity as curator of the archive) to discuss "authenticity issues" on August 4, 2009. The extent to which Red Bull was willing to go to create an event that would have credibility within the New Orleans brass band community was actually quite remarkable, and judging by local responses afterward, the company succeeded. At the conclusion of the Red Bull Blowout, trombonist and host Glen David Andrews felt that "the true winners were the people of New Orleans . . . because we showed that violence has nothing to do with second lines." As another observer commented, "[the Brass Band Blowout] was a beautiful event, and a perfect example of how an international corporation can come to New Orleans and stage an event that properly celebrates and promotes our local culture" (both as quoted in Berman 2010).

The final round was a showdown between the Free Agents and the Stooges, with the crowd of spectators favoring the Stooges and the panel of judges concurring. Yet the decision was controversial and sparked a vendetta that played out for weeks afterward. There were complaints that the Stooges had arrived at the competition wearing T-shirts juxtaposing their name with the Red Bull company logo and had more than the permissible number of players on stage. Lack of clarity regarding the judging criteria further complicated matters. The Stooges had a well-deserved reputation for inciting "humbugs" with other bands, including challenges to the Rebirth Brass Band that had occasioned fights during the Big Nine annual "second line" in the lower Ninth Ward in 2009. When members of the Stooges appeared at a later Free Agents show carrying the oversized victory belt that they had won at the Brass Band Blowout, it was interpreted as a provocation. Walter "Whoadie" Ramsey (sousaphonist and leader of the Stooges) recalled the incident: "I watched one guy grab the belt and stomp on it. He was so upset. I guess he thought we would be upset, too. The belt was just a gift, it's not that serious. When he saw it didn't bother us, he realized 'Wow I'm tripping. It's not that serious.' It kinda broke the ice to mend the situation" (Cotton 2010).

The Stooges were formed in 1996, and according to Ramsey, they have become "the most sought after, most controversial and most competitive band on the brass band scene," dominating the parade market with performances at a majority of "second line" parades during 2010. "Just like their namesake [the Three Stooges], the band is known and adored for clowning during the shows, mugging at the audience, group dancing, inciting passionate city ward call and responses . . . We have band members 17–33 years old. To have that group together, young and old, the fun is what makes it work." Ramsey studied at New Orleans Center for the Creative Arts and is the grandson of a member of the Dirty Dozen Brass Band, and despite his seemingly aggressive approach to marketing and penchant for hokum, he is, in fact, employing a promotional strategy fusing art and entertainment that can be traced back to the earliest traditional jazz bands. Ramsey's response to the hard feelings following the band's Red Bull victory was candid: "Those guys didn't

understand this was a competition. I'm very competitive. I'm gonna out-think, outplay y'all 'cause that's what I do. I was kinda disappointed 'cause the Rebels are a great band. They shoulda made round two. Not to take away from the Free Agents, but the Free Agents don't know how to catch an audience. TBC, too. Sounding good is one thing, getting the people into it is another . . . it's about being an entertainer" (all as quoted in Cotton 2010).

As Jason Berry affirms in his epilogue to the new edition of *Up from the Cradle of Jazz: New Orleans Music Since World War II* (2009): "The history of New Orleans in the wrenching aftermath of Hurricane Katrina can be telegraphed in one sentence. Politics failed, culture prevailed" (p. 293, Berry 2009). Indeed, in Berry's accounts of the post-Katrina fortunes of New Orleans musicians, one witnesses the same endurance, strength, and persistence that inform the narratives of Spera, Swenson, and Porter, illustrating the myriad of strategies that musicians used to "get their lives back" after Hurricane Katrina but all united by one basic theme: tradition matters. Yet for New Orleans musicians, this is business as usual. The pragmatic interplay of ideas that Dr. John described in crediting "skull arrangements" for the musical (if not financial) success of the Voice of the Wetlands recording project in 2005 is the very same as the "head arrangements" that drove an evolving template of improvisational performance practices merging amateur and conservatory traditions in early New Orleans jazz a century before. As the drummer Johnny Vidacovich (also from the VOW session) told Sam Charters after the disaster: "Tradition can be a verb. It isn't over yet. It hasn't become history yet" (p. 181, Charters 2006).

In his work with the Hot Eight at Sounds Café in 2007, Dr. Michael White went even further in situating jazz at the center of New Orleans music traditions: "Jazz can teach us about history. We learn where we come from and how we can become better people if we understand our ancestors . . . There is a parallel to democracy. Democracy is about the freedom to create, to participate as an individual with the group. Self-worth. Respect for others. Team work. Learning about one's traditions and ancestors . . . Katrina taught us that we have something important. But people don't realize that the only thing created here that had any impact on the world was traditional jazz. That's what put New Orleans on the map" (quoted on p. 322, Berry 2009). While the eminently successful New Orleans hip-hop artists associated with Cash Money might well gainsay the exclusivity of such claims, it should be remembered that New Orleans jazz has informed and influenced virtually every indigenous local music that followed it, including rhythm and blues (e.g., the pianist Professor Longhair), rock and roll (the guitarist Earl King and the drummer Earl Palmer), and hip-hop (especially with regard to the fusion of traditional parade beats and rap motifs in "bounce").

The improvisational ethos basic to jazz—especially the traditional format of "collective improvisation" that was its first iteration—mandates the reconciliation of individual freedom with communitarian responsibilities, prioritizing in favor of the community. The sound of the band becomes more than the sum of its parts, and as the trumpeter Sam Morgan told his sidemen in the 1920s, "who fall down, stay down." To be a part of a community, one must contribute. In the aftermath of Hurricane Katrina, New Orleans jazz musicians drew on the familiar techniques

that had nourished and sustained their musical traditions for more than a century, whatever their respective stylistic preferences. Every story of hardship and resilience was different, but the opportunity to reflect upon what mattered most in one's life during evacuation, to activate a renewed commitment to an endangered community in returning to the city, and to draw deeply from within in dealing creatively with a complex and daunting situation required a set of skills with which most New Orleans jazz musicians were already familiar. For better or for worse, Katrina forced all New Orleanians (and the people who care about them) to stand up for the city through concerted, if frequently messy, action.

As it happened, despite the detractors, New Orleans found that it had many friends. The National Academy of Recording Arts and Sciences Musicares program acted quickly to restore instruments to the musicians who had lost them and, with further impetus from the Gibson Guitar Foundation's Music Rising initiative in 2006, helped to provide instruments for more than 4,500 musicians within a year of the flooding (for details see http://www.grammy.org/musicares.html and http://www.musicrising.org/about). Music Rising underwrote similar programs for New Orleans churches and cultural organizations in 2008, followed by a major grant to build a Gulf Coast music curriculum (jazz, rhythm and blues, zydeco, Cajun) at Tulane University in 2010. Following the storm, the New Orleans Musicians Clinic, which had hitherto sought only to address musician health issues, expanded operations to become a clearinghouse for donations to culture bearers, sponsoring after-hours concerts at clubs such as Snug Harbor, assisting with housing issues, and advocating broadly on behalf of jazz musicians, Black Indians, and the social aid and pleasure clubs that underwrite "second line" parades (for services provided by the New Orleans Musicians Assistance Foundation, see http://www.nomaf.org/index.php). Sweet Home New Orleans, a nonprofit established solely to enable the repatriation of New Orleans residents, collected statistics on the return of culture bearers and posted them periodically on the Internet (www.sweethomeneworleans.org). What began as disparate individual initiative worked its way to collaborative action, with additional sustenance provided by the Tipitina's Foundation and the New Orleans Jazz and Heritage Festival Foundation. And, as we have seen, even Red Bull managed to contribute in its own small way to recovery, largely because it took the time to familiarize itself with the ways and means of the brass band community and remained sensitive to its need for respect, if not so much to its economic needs (3 days in a recording studio is not much of a prize). Yet other corporate entities have done much more.

David Simon's "Tremé" series for HBO has not only provided an engaging representation of the contemporary music scene in post-Katrina New Orleans, casting it as an essential indicator of recovery, it has put large amounts of money directly into the pockets of New Orleans musicians, who serve the series both as actors and as composer-performers (standard fee for use of a song is $10,000). Jazz musicians such as the trumpeter Kermit Ruffins and the pianist Tom McDermott have abiding roles that span multiple episodes, and they deliver credible performances as themselves. "Tremé" has the further benefit of being controversial, which means that it generates heated discussion of issues related to the past and

future of New Orleans but always with culture bearers (jazz musicians, brass band musicians, street musicians, and Black Indians) at the center of attention.[2] The series foregrounds traditional jazz heritage in its interrogation of "authenticity" issues, while also deferring judgment—it is presented appropriately as an ongoing issue intrinsic to innovation within the tradition. While one can occasionally criticize the series for its sometimes naïve earnestness in pursuit of these goals, it is also possible to enjoy it for its layers of irony, as when the "real" DJ Davis (Rogan) stands behind Steve Zahn, who plays DJ Davis in the series, as Zahn attempts to engage the English rock star Elvis Costello in conversation while trumpeter Kermit Ruffins (with whom Costello is completely absorbed) performs onstage. Rogan surveys the action mysteriously, stealing the camera with an imagined bubble caption that screams, "It's really ME! I'm DJ Davis!" The contrast between Davis Rogan's situation in the fall of 2005, at which point he was an unemployed refugee from a devastated town that he dearly loved, and his present celebrity as a minor cast member (and major character) in "Tremé" should give us pause and remind us that life is about transformation and the choices we make in the face of adversity (for further detail on Rogan's saga, see pp. 22–23, 46–47, 88, 215–216, Swenson 2011). "Reversal of fortune" does not begin to describe it. Reiterating Harry Shearer's comment, "Tremé" presents the post-Katrina population of New Orleans as "neither victims nor heroes"—they are everyday people attempting to cope with a bad situation by supporting each other and having as much fun as they can on the side.

The New Orleans jazz tradition and its implications for the resuscitation of community life are central to recovery and restoration strategies in post-Katrina New Orleans, but embedded within that heritage is another thread that is also worthy of closer attention. In his interview with Charles Henry Rowell on August 31, 2006, Louis Edwards, a highly regarded novelist and an associate producer with Festival Productions (the company that puts on the New Orleans Jazz and Heritage Festival), pondered the symbolic value of the "jazz funeral":

> There is tragedy in the world, but many times out of tragedy comes great joy. In a way, it's what the jazz funeral is about: the great New Orleans tradition of mourning or ritual mourning. You know we have that in the underpinnings of our culture. I can't think of another city better equipped emotionally to handle this death—this kind of devastation—because of the way we handle death on a daily basis. Look at the jazz funeral and the way that New Orleanians have historically managed mourning. You find that we deal with it artfully and forthrightly. From the dirge to the lively celebration that ends the jazz funeral, you find a people that are tremendously resilient. Resiliency is actually built into the culture. (p. 1303, Rowell 2007; for further elucidation on the symbolic potency of jazz funerals, see pp. 25–32, Piazza 2005)

[2]This observation is based on anecdotal information obtained by the author in 2010–2011 in conversation with various New Orleans musicians and scholars, including drummer Bob French, clarinetist Evan Christopher, pianist Tom McDermott, guitarist Tony Green, trumpeter Irvin Mayfield, Dr. Christopher Dunn, and Dr. Felipe Smith. For further opinion on the series, see a special issue of *Television & New Media* 13/3 (May 2012) devoted to HBO's "Tremé."

Edwards observes that "Katrina was a plot-propelling incident for those of us who survived," an event that created new possibilities not only at Jazz Fest 2006 but also for the population in general subsequently, and he concludes on a hopeful note: "I'm optimistic that the passion for New Orleans by New Orleanians is something that cannot be defeated" (p.1305, Rowell 2007). In the final analysis, it is this passion, a commitment to living with intensity, regardless of the challenges, that explains the sense of urgency and agency that informs the actions of so many musicians in post-Katrina New Orleans.

Jam sessions are always about new possibilities, and as outlined at the beginning of this essay, New Orleans musicians have been jamming with disaster for centuries. Every jam session is predicated on the notion that there will be unexpected surprises, which is endemic to any process of creative expression, and if the experience ultimately encompasses (and reconciles) the full spectrum of human emotion from joy to sorrow (and back again), that, too, is a desired result because like the music that conveys the message, the feeling generated is what gives it value. By affirming life through music, New Orleans jazz musicians will always find hope in disaster.

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Chapter 10
Two Floods Compared: Perception of and Response to the 1682 and 1715 Flooding Disasters in the Low Countries

Adriaan M.J. de Kraker

Abstract On 26 January 1682 and again on 3 March 1715, parts of the coastal lowlands of the Netherlands in the southwest were flooded. Both flooding disasters were caused by a storm surge, and in both cases, largely the same areas were flooded. Because these events occurred within a time interval of 33 years, documentary evidence of the 1715 flooding makes numerous references to the 1682 flooding. It not only allows us to learn about the causes and extent of both flooding disasters, but also enables us to study what the contemporaries of 1715 had actually learnt from the 1682 disaster. In particular, we look at how the measures taken after the first flood and those taken in 1715 differed. Furthermore, we need to have an insight into the perception of both flooding events: Had the perception in 1715 really changed? Moreover, is there a difference in the perception of people if we distinguish them into different social classes? Or is perception based on different people just having different kinds of responsibilities? And what about people who were mere victims of these flooding events?

Keywords Flooding • Storm surges • Weather extremes • Perception • Low Countries • Dike building and maintenance

10.1 Introduction

The coastal lowlands of the Low Countries are characterised by a long-standing record of flooding events. The oldest recorded flooding dates back to 838 (Gottschalk 1971, p. 34) and the most recent flood in the Netherlands took place in 1953, whilst in Belgium there was a flood near Antwerp in 1976. The sixteenth

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K. Pfeifer and N. Pfeifer (eds.), *Forces of Nature and Cultural Responses*,
DOI 10.1007/978-94-007-5000-5_10,

century stands out as the century with the highest number of flooding events. It was common practice for these disasters to be mentioned in chronicles, but more relevant are the numerous administrative documents on the causes, scales and measures taken to re-embank lands hit by flooding. Whilst the sixteenth-century flooding events have been studied thoroughly, the seventeenth century seems to be a quieter period until all of a sudden in 1682 a disastrous flood occurred and again, 33 years later, a second flood hit the same area. This makes these two flooding events interesting to study; it allows us to make a comparison between a number of related aspects. The key question here is whether in 1715 they had learnt anything from the previous flood disaster and, if so, what? In order to answer this question, we need to study risk management and understand how the coastal lowlands were protected against flooding and also learn what changes were made during those intervening years. Furthermore, we need to have some understanding of how contemporaries of 1715 perceived such flooding disasters. Therefore, a knowledge of several factors that determine perception is required. But first, we must look into the causes and consequences of the flooding events and put them into a wider spatial and temporal context.

10.2 Flood and Weather Data of 1682 and 1715

There are numerous accounts of both the 1682 and the 1715 flood. In this section, two detailed descriptions will be given and discussed along with the context of the weather events of the months preceding the flooding events:

> [1682] On 26 January 1682 there was a big tempest with a high flood which according to reports coming out of Antwerp was never heard of before. It very vehemently flooded the polders of Kallo with an area extending as far as the Vlaemsche Hooft. Thanks to their high sea walls only Verrebroek, Schoor and Beverenpolder managed to keep dry. Meanwhile the wider area looked like a deluge with only dead people, animals, grain, household goods, barns and stables floating in the water in such large numbers that it was hard to describe. Damage was estimated at several millions and thousands of people were ruined [...] Officials who visited the disaster area were told stories of people fleeing to roof tops of houses and barns and stables, who could only be rescued by using rowing boats. However, many rowing boats did not venture into the flooded area at all because of fear of being shipwrecked, as the tempest lasted for several days. Therefore many starved on rooftops or suffered other inconveniences. In the town of Antwerp the flooding caused extremely large damage to storehouses of merchants leading many to the brink of bankruptcy. In the main church of Antwerp the flood piled tombstones one on top of the other causing graves to collapse. In the cemetery of the Vlaemsche Hooft corpses were even lifted up from their graves ... [1]

> [1715] Yesterday afternoon there was a severe storm blowing from northwest and a very extraordinary high tide, even higher than the 1682 flood, when we had a large scale flooding. Several polders in our district were flooded such as Clinge, Cambron, Namen,

[1] Municipal Library at Kortrijk, ms. 175, fol. 460.

> Speelmanspolder, Wilhelmuspolder near Walsoorden and Ser Arendspolder and others were flooded such as Klein Kieldrecht, Dullaert, Langendam etc. in which inundation and flooding have been largely caused by breaching the Clinge sea wall at several spots...[2]

From the two descriptions of the extreme weather events of 1682 and 1715, it becomes clear that a heavy gale along with a high springtide was the main cause of the large-scale flooding in the southwestern Netherlands and adjacent Flanders (Antwerp). Whilst the 1682 flood, happened in midwinter and the storm was seen to last longer than one day, the 1715 flood occurred on 3 March, whilst the storm lasted barely one day. This difference in duration actually implies that during the 1682 flood, there must have been three or at the very least two successive springtides funnelling water to extreme heights in the estuaries of the southwestern Netherlands. Fortunately, the winter of 1682 was rather mild; so at the time of the flooding on 26 January the weather was mild, which would have caused less suffering for those unfortunate enough to lose their homes. It was only by the end of that month that frost set in, interrupting shipping on the canals for no more than a week. March 1715 was mild too and frost had lasted barely 2 weeks in January, and so there would have been no further suffering from cold either. Both accounts go on to give details of the damage caused, especially of the areas flooded and material damage done to buildings. The 1682 account gives information about regions affected further north in Holland, whilst the 1715 account gives more details on the damage inflicted on the fortification of Hulst, the town located within the flooded polders. Details on specific damage and human suffering in 1715 are not given in the account.

Documentation on the weather conditions prior to the flooding of 1682 is available from the dairy notes of Claes Arisz Caescooper (1669–1729)[3] a miller and shipowner who lived north of Amsterdam. January of that year was a mild winter month. On 13 January, the wind was blowing from the south, turning west during the afternoon. This continued the next day, whereafter the weather improved. This storm caused damage in Holland and on the isle of Texel. On 21 January 1682, another storm arose from the west which caused barges in Holland to stay in their harbours. On 24 January 1682, there was a full moon, and two days later there was a springtide, whilst there was a northwesterly gale blowing. This was the third storm during that month and again caused barges to remain in their harbours. Damage was also inflicted on sea walls in Holland.

There is more information about the prevailing weather conditions in 1715. According to the diary of Caescooper, the temperature in January 1715 barely fell below freezing and the first half of February was very windy, changing into a storm between 10 and 12 February. Then some days of frost followed. March began rough with a storm blowing from the west to the northwest, which continued the next day and also saw rain. On 20 March, there was another storm, but the register of observed wind direction at Bilderdam clearly specifies that this storm began two days later, the reason for which remains unclear.

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[2] Zeeland Archives (Middelburg), Hulsterambacht, no. 24. Resolutions magistrate 1715.

[3] Regional Archives (Haarlem), Honig Collection, no. 125, diary Caescooper (Buisman 2000, 622).

Fig. 10.1 Southwestern Netherlands mapped by Johannes Bleau, mid-seventeenth century. The different colours refer to different administrative areas. *Red* is the province of Zeeland with its capital city Middelburg on the island of Walcheren. North is the island of Schouwen and Duiveland with the town of Brouwershaven. East is the island of Tolen (Tholen) and south of Schouwen is the small island of North Beveland. The *yellow-orange* areas are the islands of Goeree and Over-Flackee (Overflakkee) located north of Zeeland. Niervaert or Clundert is east of Willemstad. The *green* area down below separated from Zeeland by the Western Scheldt is Zeeland Flanders with its towns of Hulst, Axel, Ter Neuse (Terneuzen), Aardenburg and Sluis. *Bottom right* on the west bank of the river Scheldt are the villages of Verrebroek and Callo, and on the east bank of the river is the town of Antwerp (mentioned in 1682) (Source: Taken from collection "Stitching Land van Axel", Axel, Netherlands)

A report from the island of Schouwen and Duiveland (Fig. 10.1), made by the officials of the local water boards, gave the following information about the weather conditions (Kool-Blokland 2003, 90). Several days before 3 March 1715, a strong south to southwesterly storm had risen, pushing the incoming tidal water to extreme high levels. Two days before new moon, the storm all of a sudden changed from a southwesterly into a northwesterly dangerous springtide, pushing incoming tides to an even higher level, which observers had never witnessed before.

It will become clear that both flooding events took place during heavy gales occurring at the same time as a springtide thus right after a new or full moon. These are conditions which often create storm surges (De Kraker 2006).

10.3 Consequences, Risk Management and Measures Taken

Both storm surges caused large-scale damage to sea walls, sluices and the dune areas in the southwestern Netherlands and adjacent Flanders. In many areas, this kind of damage was so huge that it caused large-scale flooding. In harbour towns, the storm surges caused damage to groynes[4] and piers, whilst at sea, dozens of ships were lost, as happened in 1534 when 40 herring boats were shipwrecked (Buisman 1998, 441).[5] Moreover, the strong winds also caused damage to high buildings and to windmills in particular. The way the sea defences were built and in particular the height of their top levels tell us already a lot about risk management.

Late medieval and early modern sea walls were constructions that were solid enough to withstand average floods and even spring floods during the stormy winter season. The baseline of dikes usually ranged from 20 to 30 m, whilst they had top levels of 3.5–4.0 m. The main body of a dike was built of fine clay. The gentle seaward slope was reinforced with a double layer of sods. Twice a year this slope was further protected by putting bundles of wicker or a straw mat on it which were fastened onto the sods with bands tied to short wooden posts. The first round of maintenance, the summer upkeep, occurred in spring and the second one, the winter upkeep, occurred in autumn. As the storm season began in autumn, a thicker straw mat was fastened onto the seaward slope of dikes during the second upkeep. If damage occurred into the layer of sods, this needed to be repaired within three tides. If large-scale damage occurred, this could even lead to an extra round of maintenance. The steeper, landward slope was covered with a single layer of sods. If rough tides caused gaps in the wicker bundles or straw mats on the seaward slope, even the sods on the steep slope could be washed out. Under these circumstances, fast repairs needed to be carried out. Therefore, officials were required to be present on dikes during tempests in order to undertake immediate action. However, if the springtides were accompanied by gale force of 8 or more, water could be pushed over the top level causing gaps on the landward side. Depending on the duration of the storm, such circumstances could easily lead to the collapse of the dikes and, subsequently, flooding.

Apart from the technical aspects of sea walls and their maintenance, there was another kind of reducing risk. If salt marshes became silted up high above mean tide, they automatically could be embanked; this was how the process of embankment

[4]Groynes are low walls built out into the sea to prevent it from washing out sand.

[5]Royal Library Albert I (Brussels), ms 17,243, fol. 83ro. This storm occurred on Saint Martin (11 November 1534).

was continuously happening. As each next embanked polder faced the sea directly, the older polders became further inland areas and eventually became completely cut off from the sea, and as a result of this, their dikes lost their original function as a sea defence. But these old dikes were never removed, and using them as pasture and roads, they could still function as a sea wall during flooding of the polder positioned in the front and thus confine the area of flooding. Therefore, this kind of compartmentalization of a coastal landscape was by far the best option for confining floods to smaller areas. Besides, it often happened that newly embanked areas had to abandon their first dike by building a secondary or reserve dike right behind it. Such a secondary dike was another dike built on the inland side at some distance from the sea wall which functioned as a reserve dike in case of collapse of the sea facing dike.

Harbour towns were faced with damage to piers, groynes and even their docks. Most of these constructions were made of wooden posts driven into the ground and lots of heavy planks. Piers and groynes could also be filled with earth and stones. When a gale was blowing at springtides, these constructions could easily give way under the pressure of the battering incoming waves. We do not know if the physical presence of officials at spots at risk in harbour towns was required, but it is known that day labourers could be summoned to assist in preventing flooding during extreme weather conditions. Usually, church bells were rung or fires were lit on top of flat church towers to warn neighbouring communities of the danger that lurked on the coast.

As soon as town authorities and water boards had a clear picture of the damage caused by a big flood, they usually started writing letters to higher authorities such as the provincial government telling them the nature and extent of the flooding and the kinds of measures already under way. Initially, water boards were not entitled to any kind of help because according to customary law each polder had been embanked at their own risk. They only required the permission of the count of Flanders, who usually granted it on certain conditions from which he benefited in terms of a modest land tax and a whole new farming community settling the new lands. Those who actually ventured to embank a salt marsh enjoyed all the benefits of the new lands in terms of crop return. On the other hand, those who embanked also had to maintain their own dikes. If the new embankment proved to be a failure, for instance because of the expense of dike maintenance, they could use the right of abandonment, which usually led to the flooding of the embankment. Nevertheless, a lot of requests asking for financial assistance were granted by owners of neighbouring polders, because they would suffer the consequences of higher dike maintenance in the future if the flooded ‘forelying’ polder would not be re-embanked, since their secondary dike would then become the first sea defence again. According to customary law, owners of such polders were legally obliged to contribute to particular costs, such as the initial adjacent embankment and the building of a sluice if they also made use of it. Flooding of a polder and its re-embankment were considered a similar circumstance in which neighbouring polder owners might contribute to the overall cost of the works undertaken. Other requests asked for direct help from the provincial government by way of a tax reduction for

a number of years. Such kinds of requests were made during the largest floods and if flooding was caused by warfare. In coastal Flanders, many such requests were granted during the sixteenth-century flooding events, for instance in 1509 and 1530, when polder owners were granted up to 25% of tax reduction. There is only one exception to this rule, when in 1494 a large new ring dike was built to re-embank lands that had flooded after 1488 and the count of Flanders asked the Estates of Flanders to contribute a large sum of money, which they did (De Kraker 1997, 28–29).

In 1682, officials of areas hit by the flooding informed the provincial government. The report was sent only three days after the disaster had hit the island of Tholen, painting a picture of its rural communities in complete disarray.[6] Two breaches in the dike had caused the flooding of the polders surrounding the small town of Tholen. People had left the flooded lands and had taken refuge in the town. From the town walls, dead cattle as well as barns had been seen floating by. Moreover, in the villages and hamlets on the island, many houses had been destroyed causing people to flee elsewhere. Finally, there was damage to the fortification of the town. The report did not give numbers of casualties or the extent of material damage.

Other reports were more detailed, such as the report sent to the Estates of the province of Zeeland by Heerder about the damage caused to the island of North Beveland (Table 10.1).[7] Seven out of 13 polders had been flooded, totalling 1,061 ha, or 24%, of the surface of the island under water. This report was sent on 20 February 1682, which implied that three polders had already been repaired, whilst four others remained inundated, totalling 549 ha, or 12%, of the surface of the island. Although damage to crops of certain polders is mentioned, there is no mention of buildings destroyed or other kind of material damage. Only three people died in the flood. The report goes on complaining of how hard it was to hire day labourers to carry out the necessary repairs and also that there was a shortage of dike materials because everywhere the demand for these materials was high (Fig. 10.2).

Some reports asked for some kind of direct assistance. One such report was for the polder of Walcheren on the island where the provincial capital was. This request also initiated the delicate discussion about who could be held responsible for the flooding (Hollestelle 1996, 73–74).[8] Tenants of the Nassau manors in the polders in the Hulst area, of which 15 (6,440 acres) had been flooded, asked their landlord for a reduction of the yearly rent. In half of the polders, the whole year's rent of farmers, already taken, was repaid (De Kraker and Bauwens 2000, 24). The owners of the flooded areas also requested the government for a remittal of their yearly tax.[9]

[6]Zeeland Archives (Middelburg), Estates of Zeeland, no. 1297. Letter of 29 January 1682 by Johan van Vrijberghen.

[7]Zeeland Archives (Middelburg), Estates of Zeeland, no. 1297. Heerder, most probably the local sheriff or chair of the largest local water board, was authorised to report to the provincial Estates of Zeeland.

[8]Zeeland Archives (Middelburg), Polder van Walcheren, no. 199. February–March 1682.

[9]National Archives (The Hague), Nassause Domeinraad, no. 41 (res. 2 March 1682).

Table 10.1 The damage of the 1682 flood on the island of North Beveland

Name of polders	Hectares	Kind of damage
1. Kampensnieuwland	n.d.	Flooded through two breaches but repaired within 8 days
2. Wissekerkepolder	512	Flooded 10 days
3. Oweleck	169	Flooded through 30 breaches
4. Layeplate	168	Flooded and probably lost
5. Polder Oud-'sGravenhoek, combined with		Flooded
6. Oudnoord-Beveland	1,706	Damage to dikes
7. Alteklein	9	Flooded, but no breaches, dry again within 6 days
8. Catspolder	65	Flooded through five breaches and all crops destroyed
9. Fredericxpolder	451	Not flooded
10. Geersdijkpolder	256	Not flooded
11. Cortgenepolder	239	Not flooded
12. Nieuw-'sGravenhoek	138	Flooded
13. Nieuwnoord-Beveland	447	Not flooded
14. Nieuw-Wissekerkepolder and Outcampen	200	Not flooded
		Other consequences of the flood
		Three children drowned
		Few cattle drowned
		No data on buildings
Total	*4,360*	

Source: Zeeland Archives (Middelburg), Estates of Zeeland, no. 1297

On the island of Schouwen and Duiveland, the sea damage was caused by two breaches in the sea defence on the eastern part of the island (Kool-Blokland 2003, 87–88). An area around the fishing town of Brouwershaven was also completely flooded. Although only a few people were drowned, the number of drowned animals, such as horses, cows, pigs and sheep, was significant. Attempts by the local water boards and districts to plea for financial assistance from the provincial government failed (Kool-Blokland 2003, 88–89). Apart from the ordinary and necessary repairs, no extra measures were taken at this time.

Besides the report sent from North Beveland and one on the situation on the island of Schouwen and Duiveland, there is a report from an area south of Axel, written many decades after the flood, which gave the following account: 'the general high flood of 26 January 1682 caused the drowning of many of my neighbours, in the parental house of my father's side fourteen people had fled to the living room above the cellar during the night and standing in the water which reached as high as their shoulders they died from fear and cold, forty cows and horses had tried to stay alive swimming around the house until they drowned completely exhausted'(De Vleesschauwer 2012, 45). This account clearly demonstrates that in spite of the mild winter, there may have been more severe conditions existing at that time than most

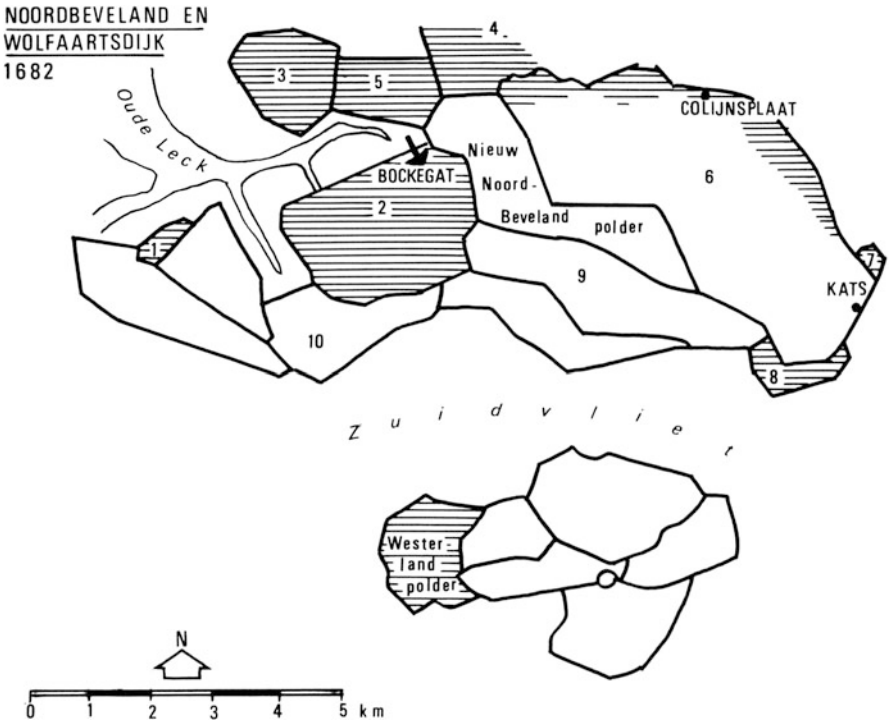

Fig. 10.2 The island of North Beveland and the impact of the 1682 flood. Polders *shaded* were flooded and are listed in Table 10.1 (Source: Taken from M.E.K. Gottschalk, Storm surges an river floods in Netherlands, the period 1600–1700 Assen 1977, 316)

reports allow us to believe. Why this report was written remains unclear; however, the person who wrote it became a member of the local water board where this document was kept amongst the records of the board.

In terms of consequences and measures taken afterwards, there were similarities but also significant differences between the 1682 and 1715 flooding events. Again the officials of the areas hit by flooding informed the provincial government of the bad news. However, in their letters, they often referred to the 1682 flooding and the number of storms that had preceded the 1715 storm surge. This means that contemporary officials in 1715 still had a fair knowledge of the 1682 flooding 33 years before and were therefore able to make comparisons. But unlike damage experienced in 1682, the damage caused in 1715 was different because it was partly caused by storms that hit the area earlier in 1714. Especially the storms of 26 February 1714 and 4–7 March 1714 and a gale on 12 February 1715 were partly held responsible for the wide-scale damage in March 1715. As a result of these preceding storms, by March 1715 a number of weak spots in dikes had already been repaired. The storm surge of 3 March 1715 undid most of these repairs, and many of the repairs carried out right after the flooding were again seriously hampered by

the storm of 4 April 1715. For many contemporary officials in 1715, all of these preceding and succeeding storms made the circumstance in spring 1715 even worse than it really was.

A report from the Klundert area (Clundert on Fig. 10.1) states that houses that were washed away by the flood of 7 March 1714 were again washed away by the flood in March 1715. Of some houses, only parts of the walls remained erect.[10] Tenants of some polders flooded at St. Maartensdijk on the island of Tholen (Tolen on Fig. 10.1) asked their landlord for remittance of rent for a 3-year period. They only got a quarter remitted.[11]

A report from the island of Schouwen and Duiveland, in which the weather conditions have already been discussed, also made several comparisons between the 1682 and 1715 floods. The dike breached again in 1715 at the same location as it did in 1682 causing flooding of a large part of the island. For the second time, the area suffered from the penetration of sea water and was flooded. In the town of Zierikzee, water flowing from the harbour penetrated cellars of houses in the old town and then headed straight towards the new town areas washing out the pavements from the streets (Kool-Blokland 2003, 90–91). Most interesting is the comparison of the highest water levels recorded. In 1715 water was recorded 32.4 cm higher than 1682 and even 55 cm higher than All Saints Flood of 1570 (Kool-Blokland 2003, 89).

Surprisingly detailed are the requests made from the district of Hulst (Hulsterambacht). The aim of the requests was to obtain remittance of annual taxes. In order to demonstrate the damage sustained, inventory lists of all the damage in each of the polders were made (Table 10.2). From this it becomes clear that actually nobody drowned during the flood and apparently no animals seem to have lost their lives. This implies that flooding had not completely taken the inhabitants by surprise and so they must have been able to drive their animals to safety on top of secondary dikes or one of the polders further inland that had remained dry.

The biggest damage was the loss of crops, especially wheat and barley which were the main crops grown in the very fertile soils of these commercially exploited lands. Also rape seed being a winter crop was destroyed. There was also damage to orchards. This must have been a rough guess because real damage can only be assessed during late spring and summer when fruit trees bear fruit. The kind of damage caused also depends on the duration of the flooding. This also largely applies to pastures where the damage had been assessed. Damage to buildings usually refers to barns that can be lifted by water and moved; so they have to be rebuilt. Damage to dikes usually consists of breaches and as a result of this the washing away of earth, often also of the landward slopes of a dike if water merely overflows its top level. Sluices can be damaged too by a strong current of water that needs to discharge from flooded polders. Such currents destroy sluice doors and are often erosive underneath sluices as well, leading to a dislocation of the sluice floor and possible future malfunctioning, because on the one hand such a sluice

[10]National Archives (The Hague), Nassause Domeinraad, no. 74, res. 15 April 1715.

[11]National Archives (The Hague) Nassause Domeinraad, no. 74, res. 1 May 1715.

Table 10.2 Damage assessment of the 1715 flood in the district of Hulst

	Langendam		Kruispolder		Dullaert		Cambron		Kieldrecht		sArendsp.		Klinge	Stoppeldijkp.
Kind of damage	ha	guild.	ha	guild.	ha	guild.	ha	guild.	ha	guild.	ha	guild.	guild.	guild.
Size	470		670		555									
Winter crops	268	3,600	30	298.4	278	3,421	100	12,150						206
Summer crops	156	1,575	35	154	223	2,000	40	5,220	92	820	20	2,640		
Clover							27	1,980	36	320				
Pasture	34	125	20	54.35	55	182.1								
Orchards		225				900								
Buildings		800				750		4,600						252
Dikes, sluice		320		266.7				12,000						756
Stored grain								3,000		30			27,056	
Soil damage							268	20,400						
Total		6,645		769.75		7,253		59,350		1,170		2,640	27,056	1,214

Source: Zeeland Archives (Middelburg), Hulsterambacht, no. 589
1 guilder = 20 shillings = 8–10 days of labour

leaks fresh water during the dry season and salt water during high tides. Stored grain in barns can be completely washed away if barns are lifted and destroyed, but what was more likely to have happened was that the grain merely became wet and rotted. Finally, there is the fact that soil damage caused by erosion and deposition of fresh sediments could be valued in money in 1715 looks like quite a modern response to flood damage. This sort of damage which affects the soil content in terms of degrading fertility and changing hydrology has only been assessed for the Cambronpolder. This polder was embanked in 1709 and bordered directly at the sea and therefore faced flooding directly (De Kraker and Bauwens 2000, 27).

Some requests demonstrate that lessons from the past actually had been learnt, for instance concerning indirect damage caused by salinity. One such request, asking for tax reduction, was made by the landowners of several polders around Terneuzen. Some polders were flooded in 1682 but reclaimed again. At that time, the owners had been allowed remittance of taxation for 2 years, but since then the soil had remained brackish for some years. As a result, the 1715 request could be sustained by extensive evidence of financial losses suffered since 1682.[12] Apart from again requesting a remittance, the landowners now decided to raise the top levels of their dikes, which they had not generally in 1682. Strongly convinced of the need for changing dikes, most water boards with sea walls only reluctantly took such a decision because such a drastic measure was very expensive (Kool-Blokland 2003, 92; De Vleesschauwer 2012, 44–47, 53–56). It also implied that top levels of sea walls had been too low for a number of decades, resulting in risks of flooding that could have been avoided if the top levels had been raised as suggested above. In fact it goes on to show that top levels of dikes were already too low in 1682, and as a result, the risks of flooding then were already too high. The main reason for this is a lack of funding by landowners. It needs to be said that most embankments were investments in that they claimed land that could be used as arable land. As long as prices of grain were high, such investments were relatively safe, but as soon as prices for wheat and other commercial crops dropped (1650–1740), profits for landowners and farmers dropped accordingly, and as a result of this, saving on dike maintenance was a logical solution (Van Cruyningen 2005/2006; De Kraker 2011).

In other areas hit by the 1715 flood, such as the isles of Goeree Overflakkee and the Polder of Namen, things became still worse. On Goeree Overflakkee, the remaining dikes and sluices in the flooded lands were again hit by storms in the next 2 years. Consequently, reclamation of these lands had to be postponed until a committee for re-embankment was formed in 1717–1718 and paved the way for large-scale re-embankment.[13] The worst kind of measure taken was the abandonment of a flooded area. This happened, for instance, at the Polder of Namen on the banks of the Western Scheldt. Although this polder flooded in 1682 too, it was re-embanked at high costs within a few months. Re-embankment after the

[12]Zeeland Archives (Middelburg), Estates of Zeeland, no. 1927, requests sent from Terneuzen (March 1715).

[13]Regional Archives of Goeree Overflakkee (Middelharnis), Commissie Herdijking 171–1737.

1715 flood appeared to be too high a financial burden at this time (De Kraker and Bauwens 2000, 25–26). In fact the landowners simply followed the medieval custom of abandoning the lands on which they were unable to maintain the sea walls.

Finally, looking at the measures taken by the provincial government and the national government in The Hague, it becomes clear that initially they allowed tax reduction, but the provincial government went a major step beyond. Across the province of Zeeland, the number of polder landowners and in particular their water boards asking for financial relief had increased dramatically over the years (Hollestelle 1996, 74). Most polders of these begging water boards faced the risk of flooding. This was often the combined cause of erosive channels approaching the baseline of their sea walls and extreme weather events such as gales and storm surges. As a last resort before abandoning their lands, the polder boards turned for help to the provincial government, which began to implement new legislation on this issue. Nevertheless, it took almost a century before new regulations became effective. By 1791 the provincial government issued a regulation for these calamitous polders (De Kraker and Bauwens 2000, 62–69; De Vleesschauwer 2012, 82–83). It allowed them to apply for financial assistance on a number of strict conditions. One such condition was that the provincial government had to examine the records of the applying polder board, and in so doing it lost control over its finances. And because the neighbouring polders always had to contribute a fixed taxation per acre to a calamitous polder, which strongly opposed the principle of each polder defending its own dike, it took so long to implement the new regulation. During the French occupation of the Low Countries (1795–1813), the policy, as applied to calamitous polders, was further developed into a set of detailed regulations, and in 1871 calamitous polders became a separate category of polders. By then, risks were shared by a much larger area surrounding the calamitous polder as well as financial relief which was given by both the provincial and national governments. After the 1953 flood, the large-scale reorganisation of water boards spread the risks even further. Today, there is only one water board in the province of Zeeland left, whilst there were still over 300 in 1900.

10.4 Perception of the Floods

In order to understand how the 1682 and 1715 floods were perceived, there is a need to elaborate a bit on the background in general as well on particular factors that determined the way contemporary people perceived extreme weather conditions.

One factor that has an influence on perception is the natural environment in which people that were faced with flooding lived. These are the coastal lands protected by brittle sea walls that can be breached any moment during the storm season. People living there were well aware of the danger of flooding and tried to reduce the risks to the minimum as outlined above.

This awareness of the risk of flooding could be strengthened by the frequency of flooding. The higher the frequency of such disasters, the higher the awareness and

accordingly the more appropriate the measures that could be taken. In this respect, the sixteenth century still remains the outstanding century during which some areas were faced with as many as six flooding events (1509, 1511, 1530, 1532, 1552 and 1570) (De Kraker 1999, 2006).

If flooding occurs more often, people tend to compare floods especially in terms of the highest water levels reached. Such comparisons often result in a kind of grading of flooding events because there will always be one which had the highest water levels or lasted longest or caused the largest-scale flooding. In order to measure heights, flood marks were installed at big sluices and bridges. As far as the six flooding events of the sixteenth century are concerned, we now know that the 1530 and 1570 hazards stand out as the megaflooding events whilst the other four were of a similar magnitude but slightly less severe at least in terms of the number of areas flooded (De Kraker 1997). A comparison of the floods of 1682 and 1715 clearly demonstrates the use of such flood marks, but this has a much longer history. During the 1682 flood, Gabbema (Gabbema 1718) says water stood 9–10 feet high (2.5–2.80 m) on the wharfs of Antwerp, which seems to be extremely high, whilst at Dordrecht, levels reached ten thumb (0.25 m) higher than the St. Nicolas flood and 3–4 ft (0.75–1.00 m) higher than the 1421 flood. Details on the level the flood reached in 1715 have already been discussed. So installing flood marks as evidence of public awareness goes straight back to the early fifteenth and sixteenth centuries; for example the 1530 flood, observed at Antwerp, was estimated to have reached one foot higher than ever before.[14] It also demonstrates that flood marks had become a part of the collective memory in coastal lands, especially in the larger ports such as Antwerp and Dordrecht. In spite of the reference to flood marks, many contemporaries still used the expression 'never seen before . . . ' or 'never heard of before . . . ' (Table 10.3, no 1). These expressions are mostly sheer rhetoric and were also used to describe other extreme weather events (Pleij 1988, 55).

Another factor that determines perception of the event lies in the terminology used to describe the event. A number of different quotations describing both extreme weather events have been summarised in Table 10.3. It follows that normally a standard set of terms was used. Terms such as high, latest, extraordinary, severe and flood, storm, tempest, sea storm and/or wind are most commonly used. This practice already goes back to the late fifteenth and sixteenth centuries and was more common for administrative sources rather than narrative sources (De Kraker 1999, 2005). Comparing the 1682 and 1715 quotations shows that the set of quotations from 1715 have begun to be used as a set of standardised items: storm, flood and inundation. This seems reasonable within the context of the many storms that hit the area from 1714 onwards; the March 1715 storm was only one of them but unfortunately the severest one. Here, without any doubt, the high frequency of the storm events (1713–1715) has also contributed to the use of a standardised set of terms.

Closely connected with terms used in written reports is the source: who is talking or writing about the event and what is the interest of the source (Rohr 2007, 52–53;

[14]Royal Library Albert I (Brussels), ms II-1593, 5–6.

Table 10.3 Quotations of the 1682 and 1715 floods

Quotations 1682	*Source*
1. High flood never heard of before	ZA Polder Walcheren, no. 199
2. The last high flood	ZA Polder Walcheren, no. 199
3. In the storm	RAG Water board St. Maartensdijk, no. 69
4. In the extraordinary storm/high flood	RAG Water board Molenpolders, no. 17
5. Inundation	RAG Water board Weijpolder, no. 15
6. Big and excessive tempest	NA Bruges Vrije van Bruges, no. 106
7. The tempest and high sea	Municipal Archives Bruges, barges
8. The extraordinary flood	ZA Water board Poortvliet, no. 88
9. Severe storm and high flood	ZA Water board Oude Kraaijerpolder, no. 37
Quotations 1715	*Source*
10. Severe storm	ZA Water board Scherpenisse, no. 134
11. High flood	RAG Water board Dirksland, no. 79
12. Inundation	RAG Water board Galathepolder, no. 20
13. Latest storm	NA, Nassause Domeinraad, no. 74, (res. 15 March 1715)
14. The severe storm wind and extraordinary high flood	ZA Staten van Zeeland, no. 1297, (letter 29 January 1682)
15. Severe storm from NW and a very extraordinary high flood, even higher than the 1682 flood	ZA Hulsterambacht, no. 24, (res. 4 March 1715)

ZA Zeeland Archives, *RAG* Regional Archives of Goeree Overflakkee (Middelharnis), *NA* National Archives (The Hague)

Lamarre 2005, 10–20). All quotations listed in Table 10.3 come from administrative sources, mainly from water boards or officials of local governments.

On the one hand, these people are used to dealing with such events; they want to undertake action fast, and so they do not make too much fuss about it. On the other hand, if they ask for assistance, they undoubtedly would want to describe how bad their situation actually was and that they were in desperate need of aid. This would imply a representation of the situation in excessive negative terms. In a lot of such cases, they would add, for instance, 'never heard or seen before' (quotation 1). In some cases, they would refer to God, which the water board of the polder of Walcheren actually did in 1682. The reason is clear: if God is responsible for the disaster, the water board certainly was not and therefore could not be blamed for overdue maintenance as well. Usually, this led to long-term quarrels between local authorities, such as the water boards, and the provincial government without anyone taking adequate measures.

The latter leads us to religion as a determining factor for perception (Rohr 2007, 62–64; Mauelshagen 2009). Divine Punishment or the Last Judgement are expressions that are used less frequently than often presumed. This very much depended on the fact who the person behind the information was and what the purpose of his writing was. In fact in the late seventeenth and early eighteenth centuries, Low Countries religion only plays an important role amongst strict Calvinists. Unlike the Christmas flood of 1717 that devastated the coastal lands of

Northern Germany (Jakubowski-Tiessen 1992; Hagen 2005, 65–75), the 1682 and 1715 floods in the study area did not cause thousands of casualties. As only a small number of people drowned, hardly any sermons were held in the Low Countries, unlike those held after the floods of 1634 (Allemeyer 2006, 293–318) and 1717 in Northern Germany. Moreover, there are hardly any quotations that refer to Divine Wrath or to the Biblical Deluge. Only the first extended quotation of the 1682 flood coming from Antwerp refers to a deluge, but this term is used to underline the large-scale devastation of the event; there is no further mention of God intervening or His Punishment.

An outstanding example of religious perception of flooding and floods is perhaps Jacob van Oudenhoven, a Calvinist minister, who published a book on floods (Oudenhoven 1682). Surprisingly enough the description of the 1682 flood takes up <10% of his book. In the introduction, Oudenhoven explains the chief aim of his book which he dedicates to a Haarlem magistrate who said: 'In all countries we find the Hand of God responding to sins with his plagues . . . using the elements of climate . . . .' In the Low Countries, the most important element God uses is water, but this has been enclosed by man through embankment. As a result of this, God punishes through floods. And because people tend to forget easily, Oudenhoven gives a survey of historic floods as a mirror for people to keep on following the good faith or repent. It therefore comes as no surprise when he starts his survey with The Deluge. Oudenhoven lived in or near Haarlem, where his book was published. His writing in the form of books or more usually pamphlets must be seen in the tradition of evangelising the Gospel. Most of the authors were actually vicars, and indeed, Oudenhoven was such a vicar.

Other intellectuals writing about causes of flooding did not refer to Divine Intervention but rationally analysed all possible causes ranging from changes occurring in estuaries and tides, to neglect of upkeep of sea defences caused by warfare, quarrelling amongst water boards, removal of secondary dikes and other possible causes, which Oudenhoven does not mention explicitly (Gabbema 1718).

Finally, weather extremes and in particular flooding events could also be perceived differently per social class. However, the various social classes involved in or hit by flooding were mostly farmers, landowners and day labourers working on farms and living in hamlets and villages that were flooded. Judging from the documentary evidence of both floods, mainly the landowners and farmers can be traced, through their influence in the water boards. Their chief aim was applying for financial assistance from higher authorities and neighbouring polders, as has been described. If landed property was spread out in several polders or in even wider areas, they could benefit from this, because flooding, for instance, generally was limited to polders that bordered directly onto the sea and some in the vicinity. There is no evidence from the poor classes hit, but judging from the many reports, those hit by flooding could not apply for any kind of help, except for getting relief provided by charity institutions or perhaps the church of their parish.

10.5 Conclusion

In this chapter, the 1682 and 1715 floods were compared questioning whether contemporaries of 1715 have learnt anything from the first flood. Both floods hit the coastal lands of the southwestern Low Countries and led to a large-scale flooding of roughly the same embanked areas. Although probably over 20,000 acres were flooded and the material damage (sea walls, buildings and crops) in those areas must have been very high, the number of casualties was fortunately very low. Whilst in 1682 no drastic measures were taken other than conventional repairs of sea walls and sluices, the 1715 flood compelled water boards to change the construction of dikes by raising their top levels by 0.3–0.5 m. Whilst both flooded areas asked for remittance of rent and taxation, which was usually granted for 1–3 years, in 1715 financial requests went one step further. In 1715 landowners and water boards knew the damaging effect brackish water had on the fertility of the soil leading to years of low crop yields after 1682; so many polders asked for extra financial assistance. This in turn led to the gradual implementation of new regulations in coastal management and water management, becoming really effective only as late as 1791. Thus, the 1715 flooding and its aftermath were dealt with more efficiently: damage was assessed more precisely, dike building strategy was changed, and new legislation came into being. From a comparison of the two flood disasters in terms of perception, the following may be concluded. Most likely due to the natural environment of the coastal lowlands, which were always at risk of flooding during the storm season, contemporaries have perceived the flooding events remarkably objectively, almost dealing with them as their daily business. Moreover, the flood of March 1715 cannot be detached from the large number of severe storm events that took place in quick succession in a short span of time (1713–1715), of which the last in March 1715 was the most destructive. There is hardly any doubt that the poor classes suffered most from both floods. Day labourers and small peasants had little resources to rely on generally being confined to small areas, whilst big landowners had widely distributed assets which were seldom hit all at the same time.

Acknowledgements Thanks to Dr. Sjoerd Kluiving, Institute for Geo- and Bioarchaeology (IGBA), VU University, Amsterdam, and Mr. Roger Pendery (Terneuzen) for their advice.

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K. Pfeifer and N. Pfeifer (eds.), *Forces of Nature and Cultural Responses*,
DOI 10.1007/978-94-007-5000-5,