Accepted Manuscript

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PII: S0377-0273(15)00061-X
DOI: doi: [10.1016/j.jvolgeores.2015.03.004](https://doi.org/10.1016/j.jvolgeores.2015.03.004)
Reference: VOLGEO 5503

To appear in: *Journal of Volcanology and Geothermal Research*

Received date: 19 December 2014
Accepted date: 4 March 2015

Please cite this article as: Chester, David, Duncan, Angus, Kilburn, Christopher, Sangster, Heather, Solana, Carmen, Human responses to the 1906 eruption of Vesuvius, southern Italy, *Journal of Volcanology and Geothermal Research* (2015), doi: [10.1016/j.jvolgeores.2015.03.004](https://doi.org/10.1016/j.jvolgeores.2015.03.004)

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March 3 2014

Human responses to the 1906 eruption of Vesuvius, southern Italy

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1. Introduction

Vesuvius located near to the city of Naples in southern Italy (Fig.1), is one of the world's most celebrated and dangerous volcanoes, erupting frequently during historic times and manifesting all the principal styles of activity. With a basal diameter of 12 km and rising from the Mediterranean shore to a height of 1281 m, its flanks support a population of around 600,000 people, with some 3 million being in range of its eruptive products (Kilburn and McGuire, 2001, pp. 23; Guest et al., 2003, pp. 25). In addition to its fame and danger, Vesuvius is also one the most intensively studied volcanoes. Accounts of eruptions date from classical times and correspondence between Pliny the Younger and Tacitus in 79 CE¹ constitute the first reliable reports of an eruption and its impact on the surrounding region, with Pompeii and Herculaneum being just two of many settlements destroyed. Study of Vesuvius has also advanced scientific knowledge more generally and the mountain has been one of the 'cradles' of volcanological enquiry, evidenced by the creation of the world's first dedicated observatory in 1841.

A principal finding of the United Nations *International Decade for Natural Disaster Reduction* (IDNDR) which framed disaster research in the 1990s, was that successful mitigation occurs when two conditions are fulfilled: first, the physical processes controlling an eruption are understood and, secondly, that policies of civil defence are, not just in place, but take into account details of place, culture and society (Peterson, 1996). The IDNDR was succeeded in 1990s by the *International Strategy for Disaster Reduction* (ISDR) (United Nations, 2014) and its agenda,

¹ In recent years and for reasons of inclusiveness the abbreviation CE (i.e. Common Era) has replaced AD (i.e. *Anno Domini* – of the Christian era). BCE (i.e. before the Common Era) is used in place of BC (i.e. before Christ).

especially following the publication of the *Hyogo Framework for Action*², became highly ‘incultured’. An understanding of place and culture is now viewed as being vitally important in developing policies of risk reduction. *Vulnerability* is the extent to which a society suffers damage from volcanic activity and is governed both by the nature of the eruption and the characteristics of the society affected, whereas *resilience* is a society’s ability to resist and recover (Gaillard, 2007, pp. 522-3; Manyena et al., 2011), the severity of disaster depending upon the balance between these two characteristics (Chester et al., 2012, pp. 77). Within the context of Hyogo, studies of historical disasters are important for a number of reasons (Bankoff, 2012, pp. 39-40) many of which are relevant to the historical eruptions of Vesuvius.

1. The ways in which people have coped with past eruptions may challenge assumptions that present-day approaches are always the best (i.e. potentially valuable forms of indigenous coping may be uncovered).
2. An appreciation of historical eruptions may show how responses are not isolated incidents, but processes represent a continuum of occurrences and responses to them.
3. Knowledge of how societies have reacted to past eruptions provides valuable information on culture and, more specifically, on aspects of vulnerability and resilience within the region of Vesuvius. The study of past eruptions may identify areas, economic activities, populations and types of building that are particularly at risk.

Although some aspects of culture are long-standing, the prime example being the framing of disasters within the prevailing religious culture of southern Italy (Chester et al., 2008 - see section 5.1), in general more recent historical eruptions

² The *Hyogo Framework for Action 2005-2015* was promulgated following the World Conference on Disaster Reduction that was held in Japan in January 2005. It effectively strengthened the focus on society and culture already present within the *ISDR*. A revised blueprint will be published in 2015 (United Nations, 2006, 2014).

have the greater potential to inform policies of hazard risk reduction because aspects of society that were important then may still be relevant today.

Three eruptions have occurred on Vesuvius since 1900 that have affected people and their activities: 1906; 1929 and 1944. The 1929 eruption was small-scale and affected a limited area with lava reaching the village of Terzigno (Fig. 1), and this was followed by lava fountaining and sustained seismic activity. The 1906 and 1944 eruptions were far more serious, with lava flows and pyroclastic deposits causing deaths, injuries and major destruction. Although studied extensively from a volcanological perspective both at the time and subsequently (see references in: Guest et al., 2003; Chester et al., 2007; Scandone et al., 2008; Scandone and Giacomelli, 2013), it is only in recent years that attention has focused on human impact, with major studies being published on the 1944 eruption by Pesce and Rolandi (2000) and Chester et al. (2007), and on 1906 by Avvisati and Casale (2006). Studying the effects of the 1906 eruption is possible because of the availability of: newspapers of record both on-line³ and re-published (De Lucia et al., 2006); contemporary published accounts some of which have also been re-issued; reports that were formerly only available from archives⁴; newsreel films/still photography⁵ and ephemera including postcards (Marasco, 2014d). This allows the in-depth study of human impacts to be carried out in considerably more detail than was the case even a few years ago. In

³ In addition to materials in Italian newspapers, English language newspapers of record carried detailed – often daily - accounts of the 1906 eruption. Many research libraries have direct access to such sources or, alternatively, individual subscriptions may be purchased. Examples include: the *New York Times* (<http://www.proquest.com/products-services/pq-hist-news.html>) and *The Times (London)* – The Times Digital Archive (<http://gale.cengage.co.uk/times.aspx/>).

⁴ A major source is an account prepared by Lt. Col. Sir Charles Delmé-Radcliffe, the British military attaché to the Italian government (see section 5.2). Until a few years ago this account was only available archivally (Delmé-Radcliffe, 1906), but was re-published with an introduction in 2007 (Chester and Duncan, 2007). Another important source is Ricciardi (2009), which reproduces contemporary notes, letters and telegrams.

⁵ Much material is available on: (<http://www.vesuvioweb.com/it/>). The present paper is illustrated by photographs first published by H.J. Johnson-Lavis (1909) and not widely reproduced for more than a century.

some cases the effects of the eruption may now be monitored on a day-to-day or even hour-by-hour basis and it is data from these sources which are reported and analysed in this paper.

Before describing and analysing human responses it is necessary to discuss two contexts: the singularity of the region in which Vesuvius is located and the volcanological characteristics of the 1906 eruption.

2. The Naples Province in 1906

Italian unification occurred in 1861 and the *Kingdom of the Two Sicilies* with its capital in Naples was incorporated into the *Kingdom of Italy*. For administrative purposes Vesuvius became part of the *Provincia di Napoli* (Naples Province)⁶, which at the time of unification was the home of 951,000 people. By the time of the 1906 eruption this figure had risen to around 1.2 million (Anon, 2014a), but this was not matched by any gains in prosperity and, in common with much of the rest of the Italian south, the *Provincia di Napoli* was mired in poverty. Following unification the economic situation of the Italian south worsened, contrasts with the north of the country widened and, although the relative importance of the causes are debated (Eckaus, 1961), the principal reasons were: a decline of fledgling manufacturing industries particularly in the city of Naples once protective tariffs had been removed after 1861; a lack of government directed development in the south, with manufacturing and agricultural investment growing rapidly in the north and closer ties between northern Italy and the major industrialised powers of Germany, France and the UK (King, 1987, pp. 9-12.). For the region of Campania which includes Naples Province: index values of per-capita income fell from 96 in 1861 to 91 (Italy as a

⁶ The boundaries of the *Provincia di Napoli* changed on several occasions in the twentieth century. They were, however, unchanged from 1861 to 1926.

whole 100); in 1861 the south contributed 40% of the nation's wealth (i.e. value added), by 1901 this had fallen to about 30% (Rinaldi et al., 2011); in 1905 some 12% of northern agriculture was irrigated, the figure in the south being less than 2% and the impoverished agricultural sector in the south became even more unproductive, increasing its share of the working population from 54% in 1871 to over 60% on the eve of the First World War without any concomitant increase in output. Over the same time period, industrial employment in the south fell from 24%, to under 22% of the workforce (King, 1987, pp. 10-11). One manifestation of poverty and stagnation was a major flow of migrants to other European countries and especially to the USA, and between 1880 and 1914 some 7 million Italians emigrated many of whom came from the south (King, 1987, pp. 10-15).

The plight of the Naples Province was not just economic, but in common with the rest of the south was social as well. In the years before 1914, illiteracy rates in the south were nearly 60%, many farmers especially those with small plots and/or insecure tenancies lived at a subsistence level and infectious diseases killed many people every year⁷ (King, 1987; Snowdon, 2002). Although organised crime was present in the form of the notorious *Camorra*, the reputation of the region as one mired in delinquency (Chester et al., 2007) has been questioned by some contemporary historians with John Dickie arguing that 'the concept of the south was (re-invented following unification) and a massive accretion of real and symbolic problems rapidly began to shape that concept as a national concern' (Dickie, 1999, pp.143). Views were moulded by northern ruling elites and frequently involved overstated views of the south as a region devastated by organised crime (Dickie, 1999, pp. 146).

⁷ Major cholera epidemics affected Naples in 1884 and 1910-11 (Snowdon, 2002).

Politically the early years of the twentieth century up to the First World War were dominated by governments led by Giovanni Giolitti (1842-1928), who served as Prime Minister for most of the period⁸. Known as the *Giolittian Era* (Bosworth, 1983; King, 1987), these were years of economic advance in Italy as a whole – though not in the south – and progress was secured by monetary stability, protectionism and government support for industry. The *Giolittian Era* was one in which Italy was on the cusp of modernity, with interventionist policies touching more aspects of everyday life for the first time (e.g. support of low income housing, old age and disability pensions and support of workers' cooperatives) and, as will be discussed in section 5.2, this progressive political climate meant that responses to the 1906 emergency involved the State to a much greater extent than had been case in previous eruptions. In responses to the 1906 eruption both *pre-industrial* and *industrial* features may be recognised.⁹

3. The 1906 eruption

3.1 The historical eruptions of Vesuvius

The 1906 event was preceded by over 1,800 years of recorded volcanic history, with the 79 CE eruption being, not only the first recorded event, but also the most explosive (Scandone et al., 1993). Before 79 CE Vesuvius was not recognised as active and between 79 CE and the 472 CE (*Pollena*) eruption there are few records of

⁸ Giolitti served as Prime Minister from: 15/5/92 - 15/12/93; 3/11/03 - 12/3/05; 29/5/06 - 11/12/09; 30/3/11 - 21/3/14 and 15/6/20 - 4/7/21. The Prime Minister at the time of the eruption was Sidney Sonnino who only served from February 8th to May 29th 1906. He was in every sense a politician of the *Giolittian Era*, and Giolitti himself returned to government after May 29th (Anon, 2014d). Italy was a constitutional monarchy and the King at the time of the eruption was Victor Emmanuel III, who reigned until 1946.

⁹ The terms *pre-industrial* and *industrial* were introduced by Gilbert White (1974, pp. 5) to describe characteristics ways in which human responses are related to level of economic development. In *pre-industrial* societies the emphasis is focused on responses that are, *inter alia*: predominantly locally-based, involving a wide range of actions; which are flexible and emphasise harmonisation with nature, action being taken by individuals and/or local groups. In contrast, *industrial* responses involve: the State to a much greater degree; emphasise technological control over nature and adopt more uniform responses (see also Chester et al., 2005)

activity, but by using the documents which are available together with archaeomagnetic dating and tephrostratigraphic data (Rolandi et al., 1998; Cioni et al., 2008), Principe et al. (2004) were able to produce a chronology of eruptions from 79 CE to 1631. Between 79 CE and 472 CE, there was a major eruption in 203 CE, plus a number of smaller events, but there was no evidence of lava having been erupted from locations outside the Monte Somma caldera (Fig. 2). From 787 CE to 1571 (Brown, 2012) activity was marked by mixed explosive and effusive eruptions and a number of lava flows reached the sea, but after 1571 there was a prolonged period of quiescence and the inhabitants of the region once again forgot that they were living on an active volcano, their reverie being disturbed by the large sub-plinian eruption of 1631 which killed around 4,000 people (Rosi et al., 1993). There followed a well recorded phase of continuous summit activity until 1944 (Chester et al., 2007). This was dominated by strombolian activity, with eruptions involving: lava being emitted from the upper flanks of the volcano, from time to time flowing over the crater rim; and occasionally from parasitic cones that developed on fractures located on the middle flanks, which produced flows that reached inhabited areas (Brown, 2012). In all cases eruptions were usually accompanied by explosions and fire fountains. A number of workers, such as Alfano and Freidlaender (1929) and more recently Carta et al. (1981), have recognised cyclicity in this eruptive behaviour with episodes of mild strombolian activity and lava effusion ending with violent *final* eruptions followed by several years of repose. Arrighi et al. (2001) in a detailed study of violent strombolian/subplinian eruptions since 1631, showed that not all violent eruptions were followed by periods of repose and many eruptions identified as *final* did not show evidence of phreatomagmatic character required by the cyclic activity model. Scandone et al. (1993) and Arrighi et al. (2001) question the existence of cycles of

activity. Further research by Scandone et al. (2008, pp. 169) enabled them to argue ‘that major eruptions do not represent the culmination of a period of activity’.

Scandone et al. (2008, pp. 169, 172) propose that the eruptive behaviour of Vesuvius between 1631 and 1944 is characterised by the following states: (1) normal strombolian activity; (2) slow lava effusion and (3) rapid discharge of lava followed by violent strombolian eruptions (paroxysms) sometimes followed by periods of repose. States 1 and 2 may occur simultaneously and occur for years as persistent activity. State 3, violent strombolian eruptions or paroxysms, last from hours to days and are characterised by either major explosions or eruption of high velocity lava flows which may reach the lower flanks of the volcano. These are followed by high lava fountains which, if the eruption rate is sufficiently high, may lead to crater collapse sometimes accompanied by phreatomagmatic activity.

3.2 Events of 1906

The 1906 eruption was observed by scores of reporters and many scientists, who included five leading geoscientists of the day: Raffaele Vittorio Matteucci¹⁰, the Director of the *Osservatorio Vesuviano*; Giuseppe Mercalli¹¹; the doyen of French volcanologists, Antoine Lacroix¹² and two anglophone expatriates, Henry Johnston-

¹⁰ Raffaele Vittorio Matteucci (1846-1909) was a distinguished geologist, volcanologist, who authored two major works on volcanology: *Fisica delle lave fluenti* (1898) and *État actuel des volcans de l'Europe méridionale* (1899) (Anon, 2014g).

¹¹ Giuseppe Mercalli (1850-1914) a priest/scientist, who as well as devising the earthquake intensity scale that carries his name, was also at the University of Naples from 1892. From 1911 to 1914, when he was killed in a house fire, he was Director of the *Osservatorio Vesuviano* (Anon, 2014b).

¹² Antoine Lacroix (1863-1948) Professor of Mineralogy at the *Jardin des Plantes* in Paris (from 1893) and Director of the mineralogical laboratory (from 1896) at the *École des Hautes Études*. He is best known for his research on the Martinique eruption of 1902. Later he was president of the volcanology section of the *International Union of Geodesy and Geophysics* (IUGG) (Campbell-Smith and Margerie, E. de, 1952)

Lavis¹³ from the UK and the American Frank Perret, who worked with Director Matteucci at the observatory during the eruption.¹⁴ Only Matteucci, Mercalli and Perret were directly involved in handling the emergency (Ricciardi et al., 2006).

The eruption of 1872 produced lava that covered, respectively, around a third and a quarter of the villages of Massa di Somma and San Sebastiano (Fig. 2) and ended with strong explosive activity in the central crater (Palmieri, 1873). During this eruption explosive activity caused damage to cultivated land and housing. Nine people were killed and eleven were injured (Ricciardi, 2009). The latter part of the 19th century and the beginning of the 20th century was characterised by slow effusion of lava from the summit cone. This changed in April 1905 with more explosive activity developing in the summit cone punctuated by a phase in which small volumes of lava were erupted (Mastrolorenzo et al., 1993). The 1906 eruption began on April 4th with the volcano erupting a column of dark ash and on the night of 4th/5th lava began to be erupted from a vent at 800 m asl on the southern side of the cone (Mercalli, 1906; Perret, 1924). Between April 5th and 7th lava vents opened along a 2000 m long fracture (Acocella et al., 2006) downslope to the south, and also to the east down to a height of 600 m (Mastrolorenzo et al., 1993). The easternmost vent, Bosco Cognoli, was erupting lava on April 6th at a velocity of 6 ms⁻¹ (Perret, 1924). During April 6th and 7th lava reached to within 500 m of Boscotrecase and a flow to the east stopped just short of Terzigno (Fig. 3, 4 and 5). On the evening of April 7th, Perret describes great geyser jets and activity building to a condition of extraordinary violence accompanied by continuous seismic activity. Perret describes the fountains

¹³ Henry Johnston-Lavis (1856-1914) was a medical practitioner and volcanologist who was Professor of Volcanology at the Royal University of Naples from 1892. Johnston-Lavis published extensively on Vesuvius and its eruptions (Kirk, 2014).

¹⁴ Frank Alvord Perret (1867-1943) was an American inventor and engineer who worked with Thomas Edison and retired to the Neapolitan coast in 1903 because of ill-health. He subsequently studied Vesuvius in particular the eruption of 1906 (Hoffer, 1982).

as having trajectories inclined to the NE and depositing large quantities of tephra on the towns of Somma Vesuviana, Ottaviano and San Giuseppe (Fig.1). This accumulation of tephra caused roofs to collapse including that of the church of San Giuseppe which led to more than 100 people being killed (Scandone et al., 2008, see section 4.1). Fresh outpouring of lava on the night of the 7th/8th sent a flow through the outskirts of Boscotrecase (Oratorio district) on the 8th and this was travelling so quickly that it killed several people who were unable to escape (Scandone et al., 2008, see section 4.1). The flow cut the Circumvesuviana railway in two places and came to a halt just short of Torre Annunziata. Vigorous fountaining ceased at 3.30 am on April 8th (Bertagnini et al., 1991) leading to what was described by Perret as the 'intermediate gas phase' and by the afternoon a column with a height of 13 km had been generated. It is thought that the vigorous discharge of the eruptive column caused an in-rush of air from all sides of the volcano and windows which faced away from the crater, were broken in Ottaviano and San Guiseppe (Hobbs, 1906). The products of activity, that followed the changes that occurred in the early hours of Monday morning, showed hydromagmatic features. The 'increase in the degree of fragmentation of the juvenile component together with the marked increase of the lithic component...emphasise the repeated occurrence of magma-water interaction' (Bertagnini et al., 1991, pp. 517). In phase 3 the gas/pyroclast column was characterised by huge quantities of steam and a high lithic/juvenile ratio and Bertagnini et al. argue that this resulted from hydromagmatic activity through interaction with the geothermal system. After the April 8th activity declined, but large volumes of grey ash were erupted from the central crater and the direction of tephra dispersal moved to a more westerly direction reaching Puglia. Ash was also, deposited to the east on Capri, Ischia, Pozzuoli and Naples (Bertagnini et al., 1991;

Mastrolorenzo et al., 1993 – Figs. 6 and 7). The eruption ended on April 21st according to Mercalli (1906).

Destruction continued after the eruption finished. Heavy rainfall on April 27th/28th, on the night of May 17th/18th and on May 20th/21st, led to re-mobilisation of unconsolidated tephra mantling the flanks of the volcano as lahars (Mercalli, 1906). These damaged bridges on the Circumvesuviana railway, caused further devastation to agricultural land and badly affected several villages (Scarth, 2009, Table 1, Figs. 1 and 3).

Details of the eruption are summarised in Table 1 and the extent of its eruptive products are illustrated in Figures 2 and 3. Although Table 1 is self-explanatory in the main, one point requires further discussion. Although the table makes some mention of earthquakes, volcanic tremors were a frequent occurrence with felt earthquakes being experienced: over a wide area on April 5th (Anon, 1906a); on April 7th, from Boscoreale along the coast to the southeast for a distance of 24 km (Anon, 1906b); on April 8th, a strong earthquake was felt at the summit at 12.37 h followed by seismic swarms (Mastrolorenzo et al., 1993, pp. 220) and in Naples windows were broken and walls cracked (Anon, 1906c); on April 9th, when a seismographic record, presumably from the observatory is noted (Anon, 1906d) and on April 10th, when Nola, Somma and Ottaviano were affected (Anon, 1906e). Apart from broken windows, cracked walls and the shock caused to the inhabitants on April 8th, volcanic earthquakes do not appear to have been a major cause of damage during the 1906 eruption (see section 6), although Hoffer (1982, pp. 173) claims that the Monte Oliveto market collapse (Table 1) was hastened because its structure was weakened by seismic activity.

4. The Extent of the Losses

Inaccurate reporting is a problem which has dogged attempts to reconstruct the impacts of eruptions, both generally (Tanguy et al., 1998) and more specifically in the context of the Italian volcanoes (Duncan et al., 1996; Chester et al., 2007). Eyewitness accounts are often exaggerated, or even false and this is reflected in contemporary newspaper reports, especially those close in time to the events being described. For instance, one account in the *New York Times* dated April 9th (Anon, 1906c, pp. 1) describes events on March 8 (Table 1) and contains three exaggerated statements: ‘no trace remains of Boscotrecase’; Torre dell Annunziata is almost surrounded by lava and the observatory had been destroyed. Fortunately there are usually many observations of the same events and these may be compared to correct or eliminate inaccuracies and, furthermore, newspapers of record frequently correct initial statements in later reportage.

Following the 1906 eruption a prestigious Central Relief Committee (*Comitato Centrale di Soccorso*) was established under the chairmanship of the Duca d’ Aosta¹⁵ which took great care to enumerate the deaths, injuries and damage to land, property and economy. Later its findings were published (Anon, 1908a) and it is these data, together with information in Anon (1906f), Delmé-Radcliffe (1906), Sabatini (1906), Nazzaro (1997), Avvisati and Casale (2006), Marasco (2014 a-g) and the other sources noted below, which form the basis of the summaries presented in sections 4.1 and 4.2.

4.1 Deaths, injuries and homelessness

Some 216 people were killed by the effects of ash, lapilli and asphyxiation, 112 were seriously injured and around 34,000 people were rendered homeless. Of the

¹⁵ The Duca d’Aosta (1869-1931) was a cousin of King Vittorio Emanuele III and one of Italy’s most distinguished military figure both before and during the First World War (Anon, 2014d).

deaths, 212 occurred in the Province of Naples and 4 in the contiguous Province of Caserta, which at the time extended to the north and north east of Vesuvius. This pattern of losses reflects the distribution of airfall ash and lapilli, with the greatest mortality and morbidity being in San Giuseppe where 125 met their deaths and 107 were injured as a result of tephra fall (mainly from roof collapses) (Fig. 8). The mortality figure comprises 116 people whose bodies were indentified plus a further 9 unidentified corpses which were recorded as missing. Avvisati and Casale (2006) note that many of the deceased were drawn from the same families, a situation repeated in Ottaviano where 78 people died and 40 were injured. At least 105 of the deaths at San Giuseppe occurred as a result of collapse of the roof of the church of the *Orotorio della Santa Spirito* (Table 1). In both villages mortality statistics were skewed towards the young and their often elderly carers. The roof collapse at Monte Oliveto market killed 11 and injured 30, and other instances of mortality and morbidity were spread across the area affected by the tephra (Fig. 3), with the effects of the ash diminishing with increasing distance¹⁶. The only deaths directly attributable to lava flows occurred at Boscotrecase. Scandone et al. (2008) refer to 7 deaths and Scarth (2009) and other sources to three elderly men who died when lava invaded the church of S. Anna in the Oratorio quarter (Table 2).

4.2 Economic losses

Losses are summarised in Table 2 and in the immediate aftermath of the eruption the region's economy was devastated (Avvisati and Casale, 2006, pp. 235).

Although as argued in section 2 the *Provincia di Napoli* in common with much of the

¹⁶ In the Province of Naples: 2 died at Resina (now Ercolano); 2 at Somma Vesuviana; 2 at Torre del Greco and 1 at Saviano. In Caserta Province: 2 died at San Gennaro di Palma; and 1 each at Saviano, Piazzolla di Nola (Avvisati and Casale, 2006, pp. 37-41). These figures, together with the 116, 78 and 11 killed respectively in San Giuseppe, Ottaviano and Naples, produces the overall death toll of 216 from ash, lapilli and asphyxiation.

south had a relatively low per-capita income, its large population meant that it was a vital element in the Italian economy, with the city of Naples being at the time Italy's most populous city.¹⁷ One estimate is that damage to productive land alone cost 60 million lire (Nazzaro, 1997, pp. 202-3; Avvisati and Casale, 2006, pp. 235)¹⁸. Actual economic costs were much higher than this because there were, not only additional direct losses (i.e. to housing and infrastructure), but also a whole raft of indirect costs which even today are rarely calculated following major disasters. These included, *inter alia*: lost production; business interruption; demand reduction; the costs of emergency responses/clean-up operations and the negative effects of deaths and injuries on the economically productive cohort of the region (Rose, 2007; Kousky, 2012). Even 60 million *lira* equates to some 2% of national government expenditure and *ca.*0.32% of Gross Domestic Product or GDP¹⁹ (see section 6. for further discussion).

Although data on the total area of land affected and the proportions that were permanently or only temporarily damaged vary (see: Delmé-Radcliffe, 1906, pp. 5; Nazzaro, 1997, pp. 205; Avvisati and Casale, 2006, pp.230, 235), sources are agreed that the greatest damage was to cropland, orchards, vineyards and chestnut forests concentrated in the local authorities area (*comuni*) of Ottaviano, Somma Vesuviana, Nola, Palma Campania, Naples and Lauro (north east of San Giuseppe), with each

¹⁷ In 1901 the population of Naples was just over 621,000, Milan 538, 470, Rome 422,441 and Turin 329,691.

¹⁸ Calculating how much 60 million lira (12 million US \$) would represent today is difficult because values may be converted into a number of measures using, for example, the consumer price index, or skilled/unskilled wages or a bundle of consumer or government purchases. A rough value of the present day buying power of 1 US \$ in 1906, is 24 US \$ in 2014 (US Inflation Calculator, 2014).

¹⁹ Italy: per-capita GDP 1905/6 was 563 *lira*; the population of Italy 1906 was 33.5 m and, therefore, GDP was 18, 861 m *lira*. Between 1870 and 1913, government expenditure as a percentage of GDP varied on a rising trend, from *ca.*14 to *ca.*17% (Tanzi and Schuknecht, 2000, pp. 6). Assuming 16%, then government expenditure represents *ca.* 3,018 million *lira*. The minimal cost of the eruption (i.e. 60 million *lira*), equates to around 2% of expenditure or 0.32% national GDP. In an earlier report and using incomplete data (Chester and Duncan, 2007), estimated a figure of 16% of GDP. This is an overestimate which is now withdrawn.

having more 2,700 ha of damaged land (Fig. 1 and Table 2). Only land covered by lava was semi-permanently sterilised, and the reclamation of ash, lapilli and lahar affected land took varying lengths of time depending on the depth of the deposits and the labour and financial resources available to farmers and the State (see section 5.).

5. Responding to the emergency

5.1 The role of the individual family and community

When studying the nineteenth century eruptions of Etna (Chester et al., 2012), we noted that panic defined as ‘irrational, groundless or hysterical flight that is carried out with complete disregard for others’ (der Heide, 2004, pp. 342), was rarely a feature of responses. The same was generally the case during the 1906 eruption of Vesuvius. Although many newspaper accounts - in particular those penned by correspondents from the United Kingdom and USA - make reference to ‘panic’ in most cases this is clearly colloquial usage of the word because reading the reports in detail shows that people, though often frightened and apprehensive, remained rational and concerned for others. For instance towards the start of the eruption the *New York Times* begins its report by claiming that people are ‘in a state of panic’, yet then goes on to give examples of rational behaviour which included: in Portici the inhabitants cleared land in a ‘effort to lessen the danger from fire’; people used umbrellas to provide albeit rudimentary self-protection and judiciously seeking ‘safety in flight’ (Anon, 1906h, pp. 1), taking care to remove possessions (Anon, 1906i) and in some cases their furniture as well (Anon, 1906d). In Ottaviano the most severely affected village, people are described as protecting themselves with mattresses, blankets and even placing iron cooking pots on their heads (Avvisati and Casale, 2006, pp. 37-41). The only exceptions seem to have been in Naples towards the start of the eruption on April 8 when people ‘rushed to the streets in terror, many persons crying: ‘the

Madonna has forsaken us! the end has come' and amongst prisoners held in local jails who rioted because they felt trapped (Anon, 1906c, pp. 1). Within two days inhabitants are described as calmly clearing ash from roofs (Anon, 1906e) and, once moved to Naples, the penal insurrections that occurred on Tuesday 10th and Wednesday 11th were both small scale and easily contained by the authorities (Anon, 1906l).

Although evacuation of affected villages was planned and executed by the authorities (section 5.2), one feature typical of *pre-industrial* responses (section 2.) is self-help and this featured prominently in 1906. Numerous people without any prompting left their homes to seek safety in other locations that they perceived to be more secure, with many seeking refuge at the coast, in Naples and even as far away as Caserta which is located *ca.*40 km north of Naples (Anon, 1906h, 1906i). Spontaneous evacuation was noted in San Giorgio, Portici, Resina²⁰, Torre del Greco and many other settlements (Anon, 1906m). Contemporary commentators note (Anon, 1906c; 1906l; 1906m, 1906n; Delmé-Radcliffe, 1906) that many of those who remained in affected settlements sought shelter in churches and this was the principal reason for the deaths in San Giuseppe which were caused by the collapse of the roof of the *Chiesa dell'Oratorio dello Spirito Santo* (section 4.1 and Tables 1 & 2).

Framing disasters in religious terms is long-standing in southern Italy, was a prominent response in 1906 and, given this worldview, fleeing to places of worship was an understandable response. It was well known at the time that conventionally constructed public buildings - in particular churches - were potentially unsafe because of their susceptibility to tectonic earthquakes, volcanic-earthquakes and tephra fall. For instance: the 1887 earthquake (maximum intensity VIII MCS) centred on the

²⁰ Since 1969 Resina has been known as Ercolano.

riviera coast of southern France and north western Italy occurred on Ash Wednesday when people were at Mass and many of the in excess of 600 victims died in churches (Kozák and Čermák, 2010, pp. 183); on Etna and following loss of life in previous eruptions, churches were closed in 1883 and 1892 (Chester et al., 2012) and as recently as 1905, the Calabrian earthquake (estimated magnitude 6.2-7.9) killed more than 550 people many of whom died in their beds because of building collapse (Tinti and Piatanesi, 2001). In 1906, some priests who were only too aware of the dangers would not open their churches to the public - this being the case in Torre dell'Annunziata (Anon, 1906k), but there were several recorded instances of people forcing their way into churches and taking possession of statues and pictures of saints (Anon, 1906m). In fact in San Giuseppe one of the priests, Don Giuseppe D' Ambrosio, knew that the roof was unsafe, tried to dissuade people from crowding into the building but in the end agreed to remain to celebrate Mass and, displaying the statue of S. Antonio, hoped for a miracle (Delmé-Radcliffe, 1906, pp. 3; Marasco, 2014d). In fact despite the deaths a miracle was claimed by some parishioners because a statue of S. Anna was still standing and undamaged after the roof collapsed (Anon, 1906m).

The religious devotion of the people, which in some cases overcame the normal human desire for self-protection, was harshly criticised by observers at the time particularly those from overseas, who neither shared nor sympathised with what has been termed southern Italy popular Catholicism (Chester et al., 2007)

'Many people were killed because they had collected in churches to pray under weak and ill-constructed roofs, instead of getting on them to clean them (since), even during the heaviest part of the fall, persons could move about if they covered their heads and shoulders with pillows, tables or other improvised shields' (Johnston-Lavis, quoted by Scarth, 2009, pp. 264).

'During the eruption, beyond running away, the utmost the people did to help themselves was to carry about images of their saints in front of the lava in

processions, which largely consisted of women and girls, with their hair loosened, wailing and singing. This strikes the feminine spectator as very “touching” and picturesque, but is a really pitiful exhibition of superstitions, a mixture of vanity and hysteria on the part of the women and indolence and ignorance in the men. It is also deplorably unpractical’ (Delmé-Radcliffe, 1906, pp. 6).

Although these comments reflect religious sectarianism and on the part of Delmé-Radcliffe the misogynistic attitudes of the early twentieth century career soldier, they do reveal one aspect of the religious response that to the authors’ knowledge is unique to this Italian eruption. In previous reports (Chester et al., 2007, 2008, 2012) we have argued that across a range of historic disasters in Italy victims displayed what we have termed ‘parallel practice’²¹ i.e. believing on the one hand that God controls human destiny and must be propitiated through the performance of elaborate religious rituals but, on the other, being prepared to adopt practical measures to protect self, family and community, and to co-operate with the authorities. As will be discussed in section 5.2, there is no evidence to suggest fatalism on the part of the inhabitants or any resistance to State and/or international help, but the fact remains that some aspects of *pre-industrial* self-help were impeded in the ways noted by Henry Johnston-Lavis, although people did help themselves to some extent and particularly at the start of the eruption and before the army arrived.

Sunday 8th April 1906 was Palm Sunday, Good Friday fell on the 13th and Easter Sunday on the 15th, and the eruption coincided with the most important week in the Christian year for which elaborate rituals had already been planned (Anon, 1906o). The principal characteristics of southern Italian popular Catholicism are summarised in Table 3 and during the eruption were expressed in several ways. There are numerous accounts of the procession of saintly relicts, statues and images and the

²¹ In hazard studies believing in two mutually incompatible explanations, or maintaining one opinion but acting contrary to it, is sometimes referred to as *cognitive dissonance*. However in religious studies and psychology *cognitive dissonance* has a more restricted definition (Carroll, 1990, pp. 123-4). For this reason *parallel practice* is used in this paper.

widespread use of intercessory prayer through the saints, not only for God's mercy, but also for miraculous interventions. Indeed these devotional expressions were common features of virtually every town and village to varying degrees, ranging from prayers to saints said in church and home to major outdoor processions (Anon, 1906a; Marasco, 2014d). Generally these religious rites were legitimised by the participation of priests and in some cases bishops, although some of the more heterodox expressions of devotion were resisted by the clergy. For instance the Cardinal Archbishop of Naples, Cardinal Giuseppe Prisco²² locally born like many of his priests, was initially reluctant to allow a clergy-led procession of the holy image of S. Gennaro through the streets of Naples, but had to relent following the occupation of his cathedral and the possibility of civil commotion (Anon, 1906l). On the night of April 7th when the town of Boscotrecase (Fig. 1) was threatened by lava, the parish priest initially resisted the parade of a sacred image of the Madonna to the flow front and there was a move to close the church, but under intense public pressure Don Carmine Russo was forced to compromise and agree to the procession of a rough wooden cross and a statue of S. Anna. The people believed that this action limited the damage to the town (Marasco, 2014d) though, as noted in section 4.1, on the next day lava entered the town and at least 3 people were killed, while in Torre Annunziata a sacred image was claimed to have miraculously halted the lava's advance (Marasco, 2014c; Anon 1906k). Following the eruption churches were crowded with worshippers giving thanks for the danger passed and praying for the repose of souls in elaborate requiem masses (Anon, 1906o).

In section 2, it was argued that crime and delinquency were and are aspects of the local cultural *milieu* of the region that have often been over-emphasised by

²² Giuseppe Antonio Ermenegildo Prisco (1833-1923) – Archbishop of Naples (1898-1923). He was born on Boscotrecase. (Anon, 2014f)

outside observers and, although there were incidents of crime, the general impression is one of social cohesion and the mutual sharing of suffering with no systematic breakdown in law and order. There were isolated incidents of looting in Boscotrecase (Anon, 1906k) and instances of misappropriating of money collected during religious processions (Anon, 1906l), but this is balanced by people working together to clear ash (Anon, 1906h). First aid was provided by villagers for the victims at Ottaviano (Avvisati and Casale, 2006), charity kitchens were established in several villages (Anon, 1906j) and contemporary photographs show communities coming together to remove ash from roofs.

5.2 The role of the State and other national and international responders

The last major eruption in Italy prior to 1906 was of Etna in 1892 and, although State-based responses were evident (Chester et al., 2012), they were far less comprehensive than those in 1906. In part this is explained by relative magnitudes of the two events and the number of people affected, the sub-plinian 1906 event dwarfing the impact of the 1892 eruption of Etna (Branca and Del Carlo, 2005), but the progressive interventionist political climate of the *Giolittian Era* (see section 2.) was also highly significant with resources, not just being deployed by the State but also by non-governmental organisations - especially the Catholic Church - in ways that had never featured to the same extent in previous responses to volcanic disasters. Although in Southern Italy and Sicily, State control over disaster management is often dated from the time of the 1908 Messina earthquake (Dickie, 1999) and, in the case of volcanic eruptions to 1928, when the Fascist government led by Benito Mussolini virtually monopolised the response to a major flank eruption of Etna which destroyed the large agricultural village of Mascali (Duncan et al., 1996; Chester et al., 1999), the events of 1906 showed a major effort on the part of central government in Rome to

respond effectively to the crisis.²³ The 1906 eruption also had an international dimension with moral and financial support and, indeed, scientific expertise coming from a wide range of countries, particularly those with large Italian diaspora populations (see section 6.).

The eruption began with an initial phase of lava emission between April 4th and 8th (Table 1), and it was only from the 8th that tephra fall and lava advance caused major problems for the people of the region. This meant that local leaders had time to prepare, and there are numerous reports of action being taken by the authorities during this early phase of eruption. These actions included: the use of artillery wagons/limbers, the railways and, in the case of coastal settlements such as Torre Annunziata, ships to evacuate people to safety (Anon, 1906b, 1906c, 1906i). The long established role in Italy of the police, *Carabinieri* (i.e. military police) and troops stationed locally to maintain order and assist the civil power in times of disaster (Chester et al., 2012), featured prominently (Anon 1906c, 1906i). From April 5th both military and *Carabinieri* units in the area were reinforced and on April 7th the Duca d'Aosta ordered military engineers to erect barriers and dig ditches in what proved to be a vain attempt to arrest the advance of lava on Boscotrecase (Anon 1906b). By April 8th an estimated 10,000 evacuees had been accommodated in Torre Annunziata (Anon, 1906i) and in Naples by late afternoon on April 8th the military had issued

²³ This was despite the fact that the government at the time was preoccupied by a number of serious domestic and international issues. These included, *inter alia*: various social conflicts; the government crisis that brought Sidney Sonnino into office for a few months; arguments over the nationalisation of railways; the Algeciras Conference; trade agreements with Ethiopia and arguments with France and the UK over spheres of influence in Ethiopia. The Algeciras Conference was potentially very serious for the maintenance of European peace and concerned a Franco/German dispute over Morocco. The Italian government did useful work in helping to craft a compromise (Bosworth, 1983, pp 64-5).

ca.10,000 rations, had ordered further supplies and placed ships on alert should further evacuation be required (Anon, 1906i).²⁴

The effects of the sub-plinian phase of the eruption which began during the night of April 8th/9th (Tables 1 and 2), could neither be managed by the provincial authorities, the *comuni*²⁵, nor by the police, local *Carabinieri* and troops they had at their disposal. Additional personnel and far greater central direction were required and the government in Rome acted quickly. By April 9th the population of Naples was swollen by many thousands of refugees, ca.15,000 had reached Castellamare di Stabia, on the coast to the south of Torre Annunziata (Fig. 1; Anon, 1906m) and great efforts were devoted to: feeding evacuees, often using field kitchens; distributing bread and sheltering people in barracks and other accommodation available to the State (Anon, 1906k). Gradually larger contingents of troops arrived, soldiers and sailors were ordered ashore from ships anchored in the Bay of Naples and fire-fighters were drafted in from as far away as Palermo in Sicily (Anon, 1906k). It soon became apparent that some local leaders and officials were insufficiently skilled and/or committed to handling an emergency of this severity and urgent action, including summary dismissal, had to be taken. For instance, the *Prefetto* (i.e. prefect)²⁶ of Naples Province had no hesitation in relieving the *Sindaco* (i.e. mayor) of San Giuseppe of his duties, because he fled the town when it was faced with danger and without informing his superiors (Anon, 1906a). The monarch also upbraided a priest for leaving his parish for which he held the cure of souls (Anon, 1906k) and there were cases where military telegraphers had to replace civilian operators who deserted their stations (Delmé-Radcliffe, 1906, pp. 7). A more common response was the

²⁴ This report from *The Times* (London) originates in Rome and is dated April 9th. It makes use of both its own reportage and extensive quotations from the April 7th edition Neapolitan paper, *Il Mattino*. It notes the positive leaderships shown by Cardinal Prisco and the Duca d' Aosta.

²⁵ *Comuni* are townships or municipalities.

²⁶ The representative of the central government in a province.

imposition of direct rule, and authority in the *comuni* of Ottaviano, San Giuseppe, Resina, Somma Vesuviana, Torre Annunciata and Torre Del Greco was temporarily vested in prefectural commissioners.

In 1906 motorised transport was limited, earth-moving equipment absent and the principal requirement at the height of the eruption was for large drafts of labour to clear roofs, roads, distribute food and restore rail and telegraphic communications. This was achieved primarily through the deployment of large bodies of troops, and this aspect of the State response was the subject of detailed independent evaluation by the British military attaché, Lt. Col. Sir Charles Delmé-Radcliffe.²⁷ Table 4 details the military response and Colonel Delmé-Radcliffe's expert evaluation is very positive, with his report drawing attention in particular to:-

- a. High quality planning at short notice on the part of the Duca d'Aosta and his staff officers.
- b. The ready supply of food. From the Naples depot alone this amounted to 32,000 people being fed with *ca.* 0.64 kg per day²⁸ between April 8th and April 14th. Similar amounts were distributed by depots in Nola and Nocera (Table 4), but Delmé-Radcliffe was not able to obtain detailed figures from these centres.
- c. The discipline and commitment shown by the troops, under very difficult conditions.

²⁷ Although Delmé-Radcliffe's report contains much valuable information on the nature of the eruption, its principal aim was to evaluate the effectiveness of the Italian military in handling a logistically complex operation. Lt. Col. (later Brigadier-General) Sir Charles Delmé-Radcliffe (1864-1937) was primarily a staff officer and an excellent linguist, who published extensively on military and scientific topics. His posting to Rome was the highlight of his career and he formed friendships, not only with the major political and military figure, but also with the monarch. Before the First World War the position of Italy within the strategic alliances of Europe was important to Britain and the role of military attaché was a posting of crucial importance. In 1906, Italy was officially allied to Germany and Austria, and the United Kingdom worked hard to achieve a re-alignment. This was ultimately successful and in 1915 Italy entered the First World War on the side of the Allies (Chester and Duncan, 2007).

²⁸ There is an arithmetical error in Delmé-Radcliffe's original report. The correction is given in Chester and Duncan (2007).

These points were also made by other outside observers (Crawford, 1906), by the Roman press (Anon, 1906p), but not apparently by the press in Naples, *Il Mattino* in particular and according to the correspondent of the London *Times*, always finding fault with the central government and its agencies including the army (Anon, 1906l, pp.4). In contrast, the government was highly satisfied with the work carried out by the army and awarded a medal to all those involved in the emergency operation (Anon, 2014h).

Delmé-Radcliffe (1906, pp. 3) reports a comment of an Italian army officer in Terzigno, that once the army arrived the local people showed a reluctance to help themselves or others without being paid and that the people generally did not display a spirit of self-reliance²⁹. This theme of alleged over-dependence on the State especially in the later stages of the eruption when the army was fully deployed is taken up by other observers included the correspondent of the London *Times* (Anon, 1906l) and Henry Johnson-Lavis (quoted by Scarth, 2009, pp. 264). In contrast to Etna where eruptions in the late nineteenth and early twentieth centuries were common occurrences so that there was a shared memory of what to do when confronted with an emergency, the last eruption of Vesuvius that had a major impact on the population occurred a generation before in 1872 and 1906 was on a far larger scale than anything faced by the people of Etna (Chester et al., 2012), but common features were the lauding of heroic acts and the supposed abilities of powerful State officials to bring about positive outcomes.

In earlier reports we argued (Chester et al., 2007, 2012) that, during emergencies southern Italian popular Catholicism focused on three elements of religious belief. Two of these - the supernatural control of eruptions and divine

²⁹ It could be that many people were suffering from a variety of disaster-related psycho-social problems that were not recognised at the time, including grief and post-traumatic stress disorder (PTSD) (Aloudat and Christiansen, 2012, pp.570-71).

appeasement of the supposed wrath of God - have been discussed in section 5.1, but the third, the role of heroic figures, is relevant to the State response. In addition a common feature of many *pre-industrial* societies is that, when faced with catastrophes, people relate to individuals rather than anonymous administrative structures (Chester et al., 2012, Table 1). Accounts of the reactions of the people to: visits by members of the royal family, particularly the King and Queen; the example of devotion to duty shown by Raffaele Matteucci, Director of the Observatory and to a lesser extent visits by government ministers, often went beyond simply applauding their actions and became hagiographic. To quote two of many reports: the *New York Times*, notes that when the King and Queen³⁰ arrived, ‘without question...their presence ... had a really tranquilizing effect upon the peasantry (*sic*) evicted by the forces of nature’ (Anon, 1906q, pp.8); while the same paper remarks later in the eruption and with reference to Raffaele Matteucci, that ‘the knowledge of this man, in the midst of peril far greater, indescribably greater than that of the inhabitants of Naples, (he) remained cool and full of faith that conditions were about to grow brighter, (and this) must surely have served to calm the fears of thousands’ (Anon, 1906r). There can be no doubt that Matteucci and his team³¹ acted in an exemplary fashion, that the presence of the monarch³², cabinet ministers³³ and other dignitaries³⁴,

³⁰ Queen Elena (1873-1952), formerly Princess of Montenegro.

³¹ The role of Raffaele Matteucci, Giuseppe Mercalli, Frank Perret and others at the observatory has been discussed by many authors (e.g. Delmé-Radcliffe, 1906; Hoffer, 1982; Scarth, 2009) and for detailed information reference should be made to these works. Briefly Matteucci, Mercalli and Perret stayed at their posts in the observatory during the worst of the eruption, sent frequent reports of activity and gave advice the authorities. For his dedication, Matteucci was decorated by the King following the eruption.

³² On April 12th at dawn King Vittorio Emanuele left the Royal Palace in Naples by car to visit the affected area, followed sometime later by Queen Elena (Anon, 1906t). When the royal party reached Somma Vesuviana the ash was so thick, that the King was forced to set out on foot. At this point his presence had an almost messianic effect and people fell at his feet, begging for help which he promised. The monarch then used a horse to reach Ottaviano, and later visited San Giuseppe and other settlements, the reactions of the people being the same (Scarth, 2009, pp. 267). Earlier on April 7th the Duca d’Aosta in his visit to Boscotrecase was accompanied by the Duchess and Princess Louise of Holstein, a relative and member of the British royal family.

not only raised the profile of the emergency at the time, but also encouraged actions to aid recovery involving both financial assistance and post-eruption reconstruction (see section 6.).

‘Dark’ (or grief) tourism are visits made to disaster locations in order to view destruction. On Etna in the late nineteenth and early twentieth centuries such visits were an unwelcome feature, and the authorities had to manage tourists in 1852, 1879, 1910 and 1923. Following the advent of the electric telegraph and the railways, what had been a trickle of tourists in the mid-nineteenth century became a flood by its close (Chester et al., 2012). During and following the 1906 eruption ‘dark’ tourism also featured³⁵ and photographs published by Marasco (2014e), show hoards of people visiting eruption sites. On April 27th King Edward of Great Britain, Queen Alexandra and a royal party interrupted their cruise to visit Naples and the clean up operation, having previously sent a message of support at the time of the eruption. They would later make a cash donation to aid recovery (see section 6.). More worrisome were two groups of passengers from the White Star liner, *Cretic*, and the North German Lloyd steamer, *Barbarossa*, who on April 16 visited the observatory against the wishes of the police and *Carabinieri*. One press report implies that they were clearly not welcomed by the authorities (Anon, 1906u).

6. Recovering from the eruption over the short and long term

³³ In addition to the Prime Minister, Sydney Sommino, visits were made by: the Naples-born Finance Minister and later (wartime) Prime Minister, Antonio Salandra (1853-1931); Giuseppe de Nava (1858-1924), Under-Secretary of State and born in Reggio Calabria; and the Minister of Public Works, Pietrino Carmine (1841-1913).

³⁴ The most important non-royal dignitaries represented the church. In addition to Cardinal Prisco (see section 5.1), the Naples born Bishop of Nola (Agnello Renzullo -1836-1925) was also heavily involved, while the Pope (Pius X) sent messages of support from Rome (Avvisati and Casale, 2006). The Pope was prevented from visiting in person. As a result of a long-standing dispute with the Italian State over the loss of papal lands at the time of unification, the Pope viewed himself as a prisoner confined to the Vatican (Anon, 1906s).

³⁵ On April 8th at the beginning of the eruption there was the mass exodus of many frightened tourists, which required a greatly augmented train service (Hobbs, 1906, pp. 640).

In common with the 1883 eruption of Krakatau, the 1906 San Francisco and later the 1908 Messina earthquake, the eruption of Vesuvius was one of the first disasters to be reported globally. The widespread use of the electric telegraph meant that the recovery was, not only supported from within Italy, but also had a strong international dimension. Moral support came from the Heads of State of France, Germany, Russia and the UK and official condolences were sent through their ambassadors by the governments of Argentina, Belgium, China, Japan and the Netherlands (Anon, 1906j). More practical measures soon followed with monetary donations being channelled through the *Comitato Centrale di Soccorso* (Central Relief Committee), which was chaired by the Duca d' Aosta (see section 4). By April 1908 total voluntary donations amounted to 3 million *lira* (ca. 577,000 US \$) and were dominated by sums raised from within Italy by individuals, businesses, the Catholic Church and through charitable events held across the country. From abroad major collections were made from expatriate communities, in Argentina, Brazil and the USA; and from governments, monarchs and individuals. A donation of 1,000 *lira* (ca. 200 US \$) was even made by Buffalo Bill Cody, who was touring Italy with his Wild West show at the time (Avvisati and Casale, 2006, pp. 55-56).

This international support for the people of the region was impressive, but recovery was planned and overwhelmingly funded by national and local government. In the short-term, policies and their funding were impressive. In rural areas of Naples and contiguous provinces affected by ash, lapilli and laharic debris (i.e. ca. 100, 000 ha and ca. 340,000 people), reclamation involved: land clearance; some temporary tax relief for farmers, the restoration of water supply and the dredging of sediment choked water-courses. Public works included the removal of ash and lapilli from roads, repairing public buildings and the assumption of State responsibility for road

maintenance for a period of two years. Special grants were awarded to the worst affected *comuni*, i.e. Ottaviano, San Gennaro, San Giuseppe and Somma Vesuviana, aid was given to Nola and the Oratorio area of Boscotrecase to offset losses in tax income. Loans to adversely affected *comuni* were made available for up to 50 years.³⁶ Finally the Ministry of Education assisted in the restoration of the damaged observatory with a grant of 50,000 *lira* (Avvisati and Casale, 2006).

The roads and areas of settlement in the Oratorio district of Boscotrecase that were inundated by lava were largely re-established following the pre-1906 pattern. The Circumvesuviana railway line was re-built across the southern lobe of the 1906 flow, but was redirected around the front of the northern lobe following a more direct route to Boscotrecase station. Prior to 1906 there was little development upslope from Boscotrecase so damage here was limited.

Impressive though this plan was at the time, both the solidarity of Italians for their benighted compatriots and financial support from government came to an end relatively quickly. In the longer term the region was forced to fend for itself (Avvisati and Casale, 2006, pp. 57-62). As Johnston-Lavis (1909, pp. 189) notes, in areas covered by predominantly fine ash agricultural recovery was rapid, and even in Ottaviano *comune* farmers were planting cabbages and lettuces by early May. Contaminants were washed out by heavy rainfall and much of the vegetation was showing signs of recovery when Johnston-Lavis again visited the affected areas in October. The same cannot be said for, either land covered by lapilli or other volcanic products or for the urban fabrics of affected towns and villages.

The timing of the disaster was unfortunate coming as it did a year after the 1905 Campanian earthquake and only just over two and a half years before the

³⁶ The value of aid is estimated at: water supply and rural water tanks, 5,800,000 *lira*; water-course improvement, 2 m *lira*; public works, 3 m *lira*; special grants to the 5 several affected *comuni*, 225,000 *lira* and aid to the observatory 50,000 *lira* (Avvisati and Casale, 2006, pp. 57-62).

devastating (magnitude 7.1) Messina earthquake of December 1908. Although estimates vary, around 80,000 people died in the Messina earthquake and costs are calculated at 600 m *lira*, or roughly ten times those of the 1906 eruption, but as argued in section 4.2, the figure for 1906 is probably a significant underestimate (Bosworth, 1981, Teramo et al., 2008; Guidoboni et al., 2014).

When expressed as a percentage of national GDP the costs of three events at first sight appear modest, *ca.*0.3% for the 1905 earthquake and 1906 eruption, and 3.1% for the Messina disaster, but are comparable to the costs of large-scale disasters which have occurred in *economically less developed countries* in recent years.³⁷ In common with the 2004 tsunami losses in Indonesia and Sri Lanka, from an Italian perspective losses from the three early twentieth century disasters were expressed regionally, affecting only the southern part of the country. Indeed when the maximum loss by province is calculated, losses rise to *ca.*7% of GDP for Cosenza Province in 1905 and *ca.*130% for Messina Province (Sicily) in 1908 (Daniell, 2012, personal communication). A maximum provincial loss figure has not been calculated for Naples Province following the 1906 eruption, but in view of the localised devastation it must have been very high. Recovery was also inhibited, because less than a decade later Italy entered the First World War which placed a brake on investment unrelated to the war effort.

The slow pace of recovery may be monitored using population figures. As Table 5 shows, the *Provincia di Napoli* as a whole and the city of Naples in particular (i.e. Naples *comune*) increased their population numbers despite the eruption, but for *comuni* lying in the northern zone and most affected by ash and lapilli, the effects

³⁷ The most costly recent disaster was the Haitian earthquake of 2010 (104-117% of GDP), a small island disaster that affected the whole country. Losses from the Indian Ocean tsunami of 2004, affected localised regions of many countries, yet still cost Sri Lanka and Indonesia 7% and 2% of GDP, respectively (Anon 2014e).

were devastating, with population numbers either growing very slowly or in some cases declining. Indeed for some *comuni*, rates of growth were still below the provincial average between the 1911 and 1921 censuses, with the small settlements of Lauro, San Gennaro and Scisciano being particularly badly affected.

An example of delayed recovery is evidenced by a detailed account of the reconstruction of San Giuseppe (Ambrosio, 2001) which shows that it took many years for the village to regain its former vigour and even then needed tranches of outside aid in this case from charities. The reconstructed primary school built by the Italian Red Cross did not, for instance, reopen until 1910, the partially destroyed town hall had to wait until 1926 and in the same year the church was fully re-opened, its restoration being supported by donations received from Italy and abroad as a result of the hard work of the parish priest, Don Giuseppe Ambrosio.

7. The lessons of the 1906 eruption for hazard responses today

From 1631 to 1944 Vesuvius was in almost continuous eruption, comprising: lava filling, and sometimes overflowed the summit crater; summit activity and from time to time effusions from parasitic vents (Kilburn and McGuire, 2001; Ricciardi, 2009; Brown 2012). The inhabitants of the region were well aware that they were living on or in the vicinity of an active volcano, the last major eruption was in 1872 and the Province of Naples was an area of high emigration and few newcomers, with the result that there were relatively few people who lacked direct disaster experience (see section 2.). When Vesuvius erupted in 1929 and 1944, the experience of 1906 was still part of both the folk memory of the region and the actual memories of many individuals who had been affected by these events (Chester et al., 2007).

As argued at the start of the paper (section 1.), disasters exemplify a balance between *vulnerability* and its *resilience* and in many respects the region of Vesuvius is more exposed to hazards than it was in the early twentieth century. The events of 1906 are beyond living memory, young adults in 1944 are now in their late 80s and the vast majority of the population has no first-hand experience of an eruption. The population has swollen putting more people at risk, with the flanks of the volcano supporting around 600,000 people (section 1.) and some of the villages - particularly those in the vicinity of Naples - growing to form a virtually continuous urban area. Of the villages listed in Table 5: Sant'Anastasia had a population of 27,296 in the 2011 census; Somma Vesuviana 34,592; Nola 33,979; Ottaviano 23,543; San Gennaro 11,073; San Giuseppe 27,467; Boscotrecase 10,416; Lauro 3,577 and Scisciano 5,775, a total of over 177,000 as opposed to only *ca.*67,000 in 1901.

An additional area of *vulnerability* concerns buildings. Although volcanic earthquakes only caused minor damage in 1906, this was more noticeable in 1944 (Chester et al., 2007) and all active southern Italian volcanoes have a high degree of exposure because of the large number of traditional buildings constructed of lava blocks and/or rubble stone (Chester et al., 2012). The 1906 eruption also highlighted the fragility of traditional roof construction when required to support the weight of ash and lapilli, and many towns and villages still have large number of older buildings with roofs similar to those that caused so many deaths and so much damage (see Spence et al., 2005). Much of the increased population is housed in buildings constructed since 1906, though until recently these did not comply with strict earthquake codes.³⁸

³⁸ The current building code dates from 2008 and was developed in response to the 2002 Molise earthquake which exposed major deficiencies in code in operation at the time. There were also issues over enforcement. Hence in the L'Aquila earthquake of 2009 some buildings which were only 10 to 20

In section 5 we argued that responses to the 1906 emergency were generally effective and that at least in its initial stages recovery was actively supported by the State. In one respect people were fortunate in 1906 as they were in 1944³⁹, because eruptions developed over a few days allowing time for both local people and the authorities to plan their responses.⁴⁰ As Delmé-Radcliffe (1906, pp. 8) notes, at the time the local civil authorities lacked the powers effectively to mastermind such a large-scale operation, although the positive role of the provincial prefect was noteworthy (see section 5.2). Into this partial power vacuum stepped the military and national government, generally, and more particularly Prime Minister Sonnino and the Duca d'Aosta. In 1944 Col. Kincaid played a similar leadership role. Mindful of the importance of effective management in securing the success of responses to civil emergencies, the Chief Civil Protection Officer can now obtain similar powers to those exercised by the key figures in 1906 and 1944.⁴¹

One legacy of 1906 and 1944 is less benevolent. This is the assumption amongst some inhabitants that twentieth century eruptions were normative and that future events will not cause greater or more widespread damage⁴², but this finding is not supported by a detailed questionnaire-based survey carried out in 2006 and

years old performed very badly (OECD, 2014, pp. 76). The 2008 code reflects the European-wide *Eurocode*, but has been modified for local conditions (Santucci de Magistris, 2011).

³⁹ The 1944 eruption occurred during the Second World War, and the emergency response was efficiently handled by the Allied Control Commission in Naples under the effective management of an American army officer, Lt. Col. (later Brig. General) James Leslie Kincaid (1884-1973) (Chester et al., 2007).

⁴⁰ As Delmé-Radcliffe (1906, pp. 8) notes, in 1906 the authorities were surprised by how quickly the eruption developed and by the fact it was much larger and lasted longer than the four day event of 1872. Their complacency may have been heightened by initially optimistic reports on April 6th from the Observatory that the ash fall would be limited in extent and duration. In the early stages of the eruption Raffaele Matteucci also forecast that the eruption would end after a few days (Perret, 1906, in Gidwitz, 2013). Nevertheless, when this report was sent, the eruption was already two days old and some plans were already in place (Table 1).

⁴¹ Following the declaration of a State of Emergency, by the *Presidente del Consiglio dei Ministri* (President of the Council of Ministers, or Prime Minister), the Chief Civil Protection Officer assumes similar powers to those exercised by the Duca d'Aosta and Colonel Kincaid in 1906 and 1944 (R. Scandone, personal communication 9/01/06).

⁴² In 2004 two of us (Chester and Duncan) were involved in interviews with local political leaders within *comuni* affected by the 1944 eruption. This opinion emerged strongly (see Chester et al., 2007).

focused on the *comuni* most at risk (Barberi et al., 2008). This survey found that people generally possessed a realistic view of volcanic risk, but often rated other socio-economic issues as being more important and had little confidence in the abilities of public officials, civil protection officers or scientists successfully to handle a future emergency. A sub-plinian eruption, such as that of 1631, is often assumed to be the most likely future scenario (Barberi et al., 1990), involving a high eruption column, its eventual collapse, large-scale tephra deposition and generation of dangerous pyroclastic density currents comprising flows and surges (Rosi et al., 1993). In order to boost *resilience* (section 1) and mindful that better pre-eruption planning is required, an emergency plan was published in 1995 (Dipartimento delle Protezione Civile, 1995). Assuming that a ‘1631 type’ eruption will be preceded by seismic and other warnings for up to 20 days, it is planned to evacuate around 700,000 people from a so called ‘red zone’ of particularly high risk to other parts of Italy over a period of 7 days. It is a matter of conjecture how many of these 20 days will pass before scientists are able to say with any certainty whether an eruption is imminent. The 20 day ‘window’ is based on the observation that earthquakes were felt for at least a fortnight before the 1631 eruption, which may not be the case with all sub-plinian events (Chester et al., 2002; Solana et al., 2008). More recent academic research suggests that the ‘1631 type’ event may be too extreme (e.g. Marzocchi et al., 2004), but the plan is unlikely to change because hazard managers are of the opinion that ‘downsizing’ the scenario causes fewer potential planning problems than ‘upsizing’ it (De Vivo and Rolandi, 2012). Such a view does not take into account, however, the loss of public trust engendered by failing accurately to forecast the magnitude of a future event (Solana et al., 2008).

Reacting to these criticisms the government has regularly revised the emergency plan since 1995. This has involved, *inter alia*: a. detailed changes in 2001; b. modifications to the constitution of the committee which advises the Chief Civil Protection Officer in 2003; c. in 2006 the plan was tested in a major emergency simulation exercise known as *Mesimex*; d. following *Mesimex* changes were made to the plan in 2007, 2008 and 2012 and all this culminated in a major up-dating in February 2014 (Dipartimento delle Protezione Civile, 2014). The plan now: defines the ‘red zone’, not only in terms of exposure to pyroclastic flows, but also with respect to risks associated with the collapse of buildings due to the accumulation of pyroclastic deposits and further refines the evacuation plan and the time-scale over which it will operate.

In 1906 the population was less well educated and demanding and, hence, more forgiving of scientific error. Indeed the fact that in the early stages of the eruption Raffaele Matteucci forecast that the eruption would end after a few days was soon forgotten in the wave of adulation he received because of his bravery and devotion to duty (see section 5.2). Whatever the future may hold in terms of future eruptions, the fact remains that pre-planning is required and, though 1906 and 1944 were examples of fairly successful *ad hoc* management, this cannot be taken as a guarantee of future success.

The questionnaire-based survey quoted above (Barberi, et al., 2008), showed that people had a widespread lack of knowledge about the emergency plan and little confidence in it, while a second study by members of the present research group (Solana et al., 2008) argued that the knowledge required by the civil authorities to deal successfully with a future emergency was incomplete. Together, these surveys point to the need for both: better communication between policy makers, scientists

and the public; and more focused education programmes. Two initiatives have attempted to mitigate these problem, EXPLORIS (i.e. Baxter et al., 2008) and *Vesuvius 2000* (Dobran, 2006), but with limited success in either improving communications or in fulfilling the goal of reducing the vulnerability of the population (Dobran, 2006).

Elements of *pre-industrial* resilience still feature in Italy's responses to disasters. On Etna the salvaging of personal effects, household goods and even agricultural produce is still an important part of present-day responses (Chester et al., 2012) and may be expected to recur following a future eruption of Vesuvius, provided local people have enough time to plan. Self-salvage reflects the low take-up of insurance against natural perils and may be expected to decline in future, especially if plans to provide compulsory hazard insurance policies underwritten by the Italian State come to fruition (Garonna, 2011).

The most prominent feature to survive from the *pre-industrial* era, are religious responses and these still accompany major disasters in southern Italy. Examples include reactions to: the Irpinian earthquake of 1980 (Alexander, 1990) and various eruptions of Etna which have occurred during the last twenty years (Chester et al., 2008), and there seems little doubt that religion would feature in any future eruption of Vesuvius. 'Parallel practice' (see section 5.1), where people believe that disasters reflect God's wrath which can only propitiated by liturgical action but at the same time accept State and community support to assist recovery, remains part of belief system of a large proportion of population who reside on or near to Vesuvius.

Acknowledgements

The authors wish to acknowledge the help of: Dr Raffaele Azzaro, Istituto Nazionale di Geofiscica e Vulcanologia (INGV), Catania, Italy and Dr James Daniell, Geophysikalisches Institut, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany, for supplying data on the costs of early twentieth century Italian disasters. Professor Roberto Scandone, Università Degli Studi Roma Tre, kindly clarified data on mortality.

References

- Acocella, V., Porreca, M., Neri, A., Mattei, M., Funicello, R., 2006. Fissure eruptions at Mount Vevusius (Italy): Insights on the shallow propagation of dikes at volcanoes. *Geology*, 34 (8), 673-676.
- Albatino, E., undated. *Vesuvius. A volcano and its history*. Carcavallo, Napoli.
- Alexander, D., 1990. Behaviour during earthquakes: a southern Italian example. *International Journal of Mass Emergencies and Disaster* 8 (1), 5-29.
- Alfano, G.B., Friedlander, I., 1929. *La storia del Vesuvio illustrata dai documenti coevi*. K. Holm, Ulm and Donau.
- Aloudat, T. Christensen, L., 2012. Psycho-social recovery. In: Wisner, B., Gaillard, J.C., Kelman, I. (Eds.), *The Routledge Handbook of Hazards and Disaster Risk Reduction*. Routledge, London, pp. 569-579.
- Ambrosio, F., 2001. *Primavera Sangiuseppese: San Giuseppe Vesuviano dal 1943 al 1973* (<http://www.francescoambrosio.it/primavera/libro.htm>).
- Anon, 1906a. Vesuvius causes terror. Loud detonations and frequent earthquakes – villages flee. *New York Times*, April 6, page 1.
- Anon, 1906b. Ashes from Vesuvius overwhelm a town. Bosco Trecase Destroyed – Ottajano being evacuated. Lava razing homesteads. Duke of Aosta and Cardinal Prisco try to comfort the peasants. Earthquakes grow stronger. *The New York Times*, April 8, page 1.
- Anon, 1906c. Ruin by Vesuvius: Terror in Naples. Two severe earthquakes – Fumes make breathing difficult. Big Towns Evacuated. *The New York Times*, April 9, page 1.
- Anon, 1906d. The eruption of Vesuvius. *The Times* (London), April 10, page 5, col. c.
- Anon, 1906e. Pompeii in Peril; Ottajano a ruin. *The New York Times*, April 11, page 1.
- Anon, 1906f. Delle conseguenze Arrecate ed alle Campagne ed Alle Colture Agrarie dalla eruzione Vesuviana dell' Aprile 1906. *Atti del Reale Istituto d'Incoraggiamento di Napoli, Serie VI Vol. LX*, 299-315.
- Anon, 1906g. The Eruption of Vesuvius. *The Times* (London), April 13, page 9 col. f.
- Anon 1906h. Vesuvius threatens destruction of towns. Bosco Trecase abandoned – panic in other places. 1,000 foot column of fire. Lava advancing at the rate of 21 feet a minute – Stones weighing a ton each ejected. *New York Times*, April 7th, page 1.
- Anon 1906i. The Eruption of Vesuvius. *The Times* (London) April 9, page 5, col. F.
- Anon 1906j. The eruption of Vesuvius: Scenes of desolation. *The Times* (London), April 12, page 5, col. a.

Anon 1906k. Ash fall in Naples greater than ever. The New York Times, April 13, page 1.

Anon, 1906l. The eruption of Vesuvius. The Times (London), April 17, page 4, columns c and d.

Anon, 1906m. Volcano victims may number 500. The New York Times, April 10, page 1.

Anon, 1906n. The eruption of Vesuvius: Distressing Vesuvius. The Times (London), April 11, page 5, col. a.

Anon, 1906o. Matteucchi tells of the eruption. New York Times, April 15, pages 1-2.

Anon, 1906p. The eruption of Vesuvius. The Times (London), April 14, page 3, col. d.

Anon, 1906q. Stays on Vesuvius. Mateucci, still at his post. Reports on eruption. New York Times April 10, page 1 and 8.

Anon, 1906r. Eyes of the world on hero of Vesuvius. New York Times, April 15, page SM4.

Anon, 1906s. Pope greatly distressed. Tells Cardinal Prisco to distribute relief to victims. New York Times April 9, page 1.

Anon, 1906t. The King and Queen at Naples. The Times (London), April 28, page 7, col. A.

Anon, 1906u. Americans at Vesuvius. The New York Times, April 17th, page 1.

Anon, 1908a. Eruzione vesuviana del 1906: relazione del comitato centrale di soccorso. E. Delle Torre, Portici.

Anon, 1908b. Delle conseguenze arrecate alle campagne ed alle colture agraria dalla eruzione vesuviana dell' aprile 1906. Reale di incoraggiamento di Napoli, Napoli.

Anon, 2014a. Censimenti popolazione prov. di Napoli 1861-2011. (<http://www.tuttitalia.it/campania/provincia-di-napoli/statistiche/censimenti-popolazione/>).

Anon, 2014b. Centenary of the death of G. Mercalli. (<http://www.earth-of-fire.com/centenary-of-the-death-of-g-mercalli.html>)

Anon, 2014c. Sidney Sonnino (1847-1922). Note biografiche. Centro Studi Sidney Sonnino (<http://sonnino.sp.unipi.it/index.php?page=biografia>).

Anon, 2014d. Who's Who: Duke of Aosta. (<http://www.firstworldwar.com/bio/aosta.htm>).

- Anon, 2014e. Haiti reconstruction cost may be near \$14 billion, IDS study shows. Inter-American Development Bank (<http://www.iadb.org/en/news/webstories/2010-02-16/haiti-earthquake-reconstruction-could-hit-14-billion-idb,6528.html>).
- Anon, 2014f. Giuseppe Antonio Ermenegildo *Cardinal* Prisco. Catholic Hierarchy (<http://www.catholic-hierarchy.org/bishop/bprisco.html>).
- Anon 2014g. Raffaele Vittorio Matteucci. Treccani L' Enciclopedia Italiana (<http://www.treccani.it/enciclopedia/raffaele-vittorio-matteucci/>).
- Anon, 2014h. 1906 Eruzione del Vesuvio. <http://cronologia.leonardo.it/storia/a1906d.htm>
- Anon, 2014i. Censimenti popolazione prov. di Napoli 1861-2011. Tuttitalia (<http://www.tuttitalia.it/campania/provincia-di-napoli/statistiche/censimenti-popolazione/>).
- Arrighi, S., Principe, C., Rosi, M., 2001. Violent strombolian and subplinian eruptions at Vesuvius during post-1631 activity. *Bulletin of Volcanology* 63, 126-150.
- Avvisati, C., Casale, A. 2006. Vesuvio 1906. Il drama di um popolo. Centro Studi Archeologici di Boscoreale, Boscoreale.
- Bankoff, G., 2012. Historical concepts of disasters and risk. In: Wisner, B., Gaillard, J.C., Kelman, I. (Eds.), *The Routledge Handbook of Hazards and Disaster Risk Reduction*. Routledge, London, pp. 37-47.
- Barberi, F., Macadonia, C., Pareschi, M.T., Santacroce, R., 1990. Mapping the tephra fallout risk: An example from Vesuvius (Italy). *Nature* 344, 142-144.
- Barberi, F., Davis, M. S., Isaia, R., Nave, R, Ricci, T, 2008. Volcanic risk perception in the Vesuvius population. *Journal of Volcanology and Geothermal Research* 172 (3/4), 244-258.
- Baxter, P.J., Aspinall, W.P, Neri, A., Zuccaro, G., Spence, R.J.S., Cioni, R., Woo, G., 2008. Emergency planning and mitigation at Vesuvius: A new evidence-based approach. *Journal of Volcanology and Geothermal Research* 178 (2), 454-473.
- Bertagnini, A., Landi, P., Santacroce, R., Sbrana, A., 1991. The 1906 eruption of Vesuvius: from magmatic to phreatomagmatic activity through the flashing of a shallow depth hydrothermal system. *Bulletin of Volcanology* 53, 517-532.
- Bosworth, R.J.B., 1981. The Messina earthquake of 28 December 1908. *European Studies Review* 11, 189-206.
- Bosworth, R, 1983. *Italy and the Approach of the First World War*. Macmillan, London.
- Branca, S., Del Carlo, P., 2005. Types of eruptions of Etna Volcano AD 1670-2003: Implications for short-term eruptive behaviour. *Bulletin of Volcanology* 67, 732-742.

- Brown, S.K., 2012. The Distribution and Development of Eruptive Centres and Lava Flow-Field Characteristics at Somma-Vesuvius, Italy. Ph.D. Thesis, University of Portsmouth, United Kingdom.
- Campbell-Smith, W., Margerie, E. de., 1952. Francois Antoine Alfred Lacroix. Obituary Notices of Fellows of the Royal Society 8 (21), 193-205.
- Carroll, R.P., 1990. Cognitive Dissonance. In: R.J. Coggins, J.L. Houlden (Eds.), A Dictionary of Biblical Interpretation. SCM, London pp. 123-4.
- Carroll, M.P., 1992. Madonnas that Maim. Popular Catholicism in Italy since the Fifteenth Century. The Johns Hopkins Press, Baltimore.
- Carroll, M.P., 1996. Veiled Threats. The Logic of Popular Catholicism in Italy since the Fifteenth Century. The Johns Hopkins Press, Baltimore.
- Carta, S., Figari, R., Sartoris, G., Sassi, E., Scandone, R., 1981. A statistical model for Vesuvius and its volcanological implications. Bulletin Volcanologique 44 (2), 129-51.
- Casale, A., 1996. La terribile eruzione Vesuviana dell' Aprile 1906. Scuolo Calcio Pellegrini de Boscoreale 2nd Torneo Internazionale, Boscoreale.
- Chester, D.K., Duncan, A.M., Guest, J.E., 2005. Responses to Eruptions of Etna from the Classical Period to 1900. In: Balmuth, M.S., Chester, D.K., Johnston, P.A. (Eds.), Cultural Responses to Volcanic Landscape: The Mediterranean and Beyond. Colloquia and Conference 8, Archaeological Institute of America, Boston, Mass., pp. 93-107.
- Chester, D.K., Duncan, A.M., 2007. Lieutenant-Colonel Delmé-Radcliffe's report on the 1906 eruption of Vesuvius, Italy. Journal of Volcanology and Geothermal Research 166, 204-216.
- Chester, D.K., Duncan, A.M., Dibben, C., Guest, J.E., Lister P.H., 1999. Mascali, Mount Etna Region, Sicily: An example of fascist planning during and after the 1928 eruption. Natural Hazards 19 (1), 29-46.
- Chester, D.K., Dibben, J.L., Duncan, A.M., 2002. Volcanic hazard assessment in western Europe. Journal of Volcanology and Geothermal Research 115, 411-435.
- Chester, D.K., Duncan, A.M., Wetton, P., Wetton, R., 2007. Responses of the Anglo/American military authorities to the March 1944 eruption of Vesuvius, Southern Italy. Journal of Historical Geography 33, 168-196.
- Chester, D.K., Duncan, A.M., Dibben, C.R.J., 2008. The importance of religion in shaping volcanic risk perceptions in Italy, with special reference to Vesuvius and Etna. Journal of Volcanology and Geothermal Research 172, 216-228.
- Chester, D.K., Duncan, A.M., Sangster, H., 2012. Human responses to eruptions of Etna (Sicily) during the late-Pre-Industrial Era and their implications for present-day

disaster planning. *Journal of Volcanology and Geothermal Research* 225, 65-80 doi: 10.1016/j.volgeores.2012.02.017.

Cioni, R., Bertagnini, A., Santacroce, R., Andronico, D., 2008. Explosive activity and eruption scenarios at Somma-Vesuvius (Italy): Towards a new classification scheme. *Journal of Volcanology and Geothermal Research* 178, 331-346.

Crawford, M. 1906. Marion Crawford on the eruption. Author cables his story of it to the Times. *The New York Times* April 11, page 1.

De Lucia, M., Ricciardi, G.P., Russo, M. 2006. *Vesuvio 1906 cronaca di un'eruzione, en racconto per immagini documenti scientifici e giornali d'epoca*. Istituto Nazionale di Geofisica e Vulcanologia, Conference 27-30 June 2006. Earthprints Repository (<http://www.earth-prints.org/handle/2122/3901?mode=full>)

Delmé-Radcliffe, C. 1906. Report by Lt. Col. Delmé-Radcliffe on conditions following the eruption of Vesuvius in 1906. British Foreign Office, H.M.S.O., London (report 14404 1).

Der Heide, E.A., 2004. Common misconceptions about disasters: Panic, the "Disaster Syndrome," and looting. In: O'Leary, M. (Ed.), *The First 72 Hours: A Community Approach to Disaster Preparedness*. Universe Publishing, Lincoln (Nebraska), pp. 340-380.

De Vivo, B., Rolandi, G., 2012. Vesuvius: volcanic hazard and civil defence. *Renciconti Lincei*, 24 (1), 39-45.

Dickie, J., 1999. *Darkest Italy: The Nation and Stereotypes of the Mezzogiorno*. Macmillan, London.

Dipartimento della Protezione Civile, 1995. *Pianificazione Nazionale d'Emergenza dell'Area Vesuviana*. Prefettura di Napoli, Napoli.

Dipartimento della Protezione Civile, 2014. *Aggiornamento del Piano nazionale di emergenza per il Vesuvio*. Dipartimento della Protezione Civile, Roma (http://www.protezionecivile.gov.it/jcms/it/view_dossier.wp?contentId=DOS37087).

Dobran, F., 2006. VESUVIUS 2000 towards security and prosperity under the shadow of Vesuvius. *Development in Volcanology* 8, 3-69.

Duncan, A.M., Dibben, C., Chester, D.K., Guest, J.E., 1996. The 1928 eruption of Mount Etna, Sicily, and the destruction of the town of Mascali. *Disasters* 20 (1), 1-20.

Eckaus, R.S., 1961. The north-south differential in Italian economic development. *Journal of Economic History* 21, 285-317.

Gaillard, J-C., 2007. Resilience of traditional societies in facing natural hazards, *Disasters Prevention and Management* 16 (4), 522-544.

- Gangiulo, G., 1906. Il Vesuvio attraverso i secoli e l'eruzione del 7-8 Aprile. Ed. Liguori, Napoli.
- Garonna, P. 2011. The importance of insurance for disaster risk reduction policies: lessons from the crisis. Associazione Nazionale fra le Imprese Assicuratrici, Roma. http://www.protezionecivile.gov.it/resources/cms/documents/Hyogo_paolo_garonna.pdf
- Gidwitz, T., 2014j. The Hero of Vesuvius. http://www.vesuvius.tomgidwitz.com/html/tom_gidwitz.html
- Guest, J., Cole, P., Duncan, A., Chester, D., 2003. Volcanoes of Southern Italy. The Geological Society, London.
- Guidoboni, E., Ferrari, G., Mariotti, D., Tarbusi, G., Valensise, G., 2014. The Catalogue of Strong Earthquakes in Italy 461 B.C- 1997. <http://storing.ingv.it/cfti4med/quakes/21318.html>
- Hobbs, W.H., 1906. The grand eruption of Vesuvius 1906. The Journal of Geology 14 (7), 636-655.
- Hoffer, W., 1982. Volcano the search for Vesuvius. Summit Books, New York.
- Johnston-Lavis, H.J., 1909. The eruption of Vesuvius in April 1906. Transactions of the Royal Dublin Society 9 (8), 139-200.
- Kilburn, C., McGuire, B., 2001. Italian Volcanoes. Terra, Harpenden.
- King, R., 1987. Italy. Harper and Row, London.
- Kirk, W.L., 2014. Lavis, Henry James Johnston (1856–1914). Online Oxford Dictionary of National Biography (<http://www.oxforddnb.com/view/article/95632>) accessed 12 Aug 2014.
- Kousky, C., 2012. Informing Climate Adaptation: A Review of the Economic Costs of Natural Disasters, Their Determinants, and Risk Reduction Options. Discussion Paper RFF DP 12-28, Resources for the Future, Washington DC.
- Kozák, J., Černák, V., 2010. The Illustrated History of Natural Disasters. Springer, Dordrecht.
- Lacroix, A., 1906. L' Eruption de Vésuve en April 1906. Armand Colin, Paris.
- Lacroix, A., 1908. La Montagne Pelée après ses éruptions, avec observations sur les éruptions du Vésuve en 79 et en 1906. Masson, Paris.
- Manyena, S.B., O'Brien, G., O'Keefe, P., Rose, J. 2011. Disaster resilience: a bounce back or bounce forward ability? Local Environment 16 (5), 417-424.

Marasco, V., 2014a. L'Eruzione Vesuviana del 4-21 Aprile 1906 Capitolo I. Edizioni vesuvioweb, Napoli (<http://www.vesuvioweb.com/it/wp-content/uploads/Vincenzo-Marasco-L%E2%80%99eruzione-del-Vesuvio-del-1906-tra-studio-e-ricerca-vesuvioweb-1.pdf>).

Marasco, V., 2014b. L'Eruzione del Vesuvio Aprile 1906 Capitolo II. Edizioni vesuvioweb, Napoli (<http://www.vesuvioweb.com/it/wp-content/uploads/Vincenzo-Marasco-L%E2%80%99eruzione-del-Vesuvio-del-1906-tra-studio-e-ricerca-vesuvioweb-2.pdf>).

Marasco, V., 2014c. L'Eruzione del Vesuvio April 1906 Capitolo III. Edizioni vesuvioweb, Napoli (<http://www.vesuvioweb.com/it/wp-content/uploads/Vincenzo-Marasco-L%E2%80%99eruzione-del-Vesuvio-del-1906-tra-studio-e-ricerca-vesuvioweb-3.pdf>).

Marasco, V., 2014d. L'Eruzione del Vesuvio April 1906 Capitolo IV. Edizioni vesuvioweb, Napoli (<http://www.vesuvioweb.com/it/wp-content/uploads/Vincenzo-Marasco-L%E2%80%99eruzione-del-Vesuvio-del-1906-tra-studio-e-ricerca-vesuvioweb-4.pdf>).

Marasco, V., 2014e. L'Eruzione del Vesuvio April 1906 Capitolo V. Edizioni vesuvioweb, Napoli ().

Marasco, V., 2014f. L'Eruzione del Vesuvio April 1906 Capitolo VI. Edizioni vesuvioweb, Napoli (<http://www.vesuvioweb.com/it/wp-content/uploads/Vincenzo-Marasco-L%E2%80%99eruzione-del-Vesuvio-del-1906-tra-studio-e-ricerca-vesuvioweb-6.pdf>).

Marasco, V., 2014g. L'Eruzione del Vesuvio April 1906 Capitolo VII. Edizioni vesuvioweb, Napoli (<http://www.vesuvioweb.com/it/wp-content/uploads/Vincenzo-Marasco-L%E2%80%99eruzione-del-Vesuvio-del-1906-tra-studio-e-ricerca-vesuvioweb-7.pdf>).

Marzocchi, R., Sandri, L., Gasparini, P., Newhall, C., Boschi, E., 2004. Quantifying probabilities of volcanic events: The example of volcanic hazard at Mount Vesuvius. *Journal of Geophysical Research* 109 (B11), B11201, doi: 10.1029/2004JB003155.

Mastrolorenzo, G., Munno, R., Rolandi, G., 1993. Vesuvius 1906: a case study of paroxysmal eruption and its relation to eruptive cycles. *Journal of Volcanology and Geothermal Research* 58, 217-237.

Mercalli, G., 1906. La grande eruzione vesuviana cominciata il 4 aprile 1906. *Memorie della Pontificia Accademia Romana dei Nuovi Lincei* XXIV, 34 pp.

Mercalli, G., 1908. Il Vesuvio dopo l'eruzione del 1906. *Natura ed Arte* 1, 11-19.

Nazzaro, A., 1997. Il Vesuvio – storia eruttiva e teorie vulcanologiche. Ed. Liguori, Napoli.

OECD, 2014. Review of Risk Management Policies Boosting Resilience Through Innovative Risk Governance. OECD, Paris

Palmieri, L., 1873. The eruption of Vesuvius in 1872. William Johnson, London.

Perret, F.A., 1924. The Vesuvius eruption of 1906. Carnegie Institution, Washington DC. Oxford Dictionary of National Biography online

Pesce, A., Rolandi, G., 2000. Vesuvio 1944. L' Ultima Eruzione. Fondazione Laboratorio Mediterraneo, Napoli.

Peterson, D.W., 1996. Mitigation measures and preparedness plans for volcanic emergencies. In: Scarpa, R., Tilling, R.I., (Eds.), Monitoring and Mitigation of Volcanic Hazards. Springer, Berlin, pp.701-718.

Principe, C., Tanguy, J-C., Arrighi, S., Paiotti, A., Le Goff, M., Zoppi, U., 2004. Chronology of Vesuvius' activity from A.D. 79 to 1631 based on archeomagnetism of lavas and historical sources. Bulletin of Volcanology 66, 703-724.

Ricciardi, G.P., 2009. Diario del monte Vesuvio. Venti secoli di immagini e cronache di un vulcano nella città. Edizioni scientifiche e artistiche, Napoli, Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Vesuviano, Napoli Vol. 3.

Ricciardi, G.P., De Lucia, M., Russo, M., 2006. Cronaca di un'eruzione. Un racconto per immagini, documenti scientifici e giornali d'epoca. INGV Osservatorio Vesuviano, Emeroteca Biblioteca Tucci.

Rinaldi, A., Giusti, G., Massaccesi, C., 2011. The evolution of social-economic Italian provinces: 1861-2011. Rivista Italiana di Economia Demografia e Statistica 65 (2), 221-248.

Rolandi, G., Petrosino, P., McGeehin, J.P., 1998. The interplinian activity at Somma-Vesuvius in the last 3500 years. Journal of Volcanology and Geothermal Research 82 (1-4), 19-52.

Rose, A., 2007. Economic Principles, Issues, and Research Priorities in Hazard Loss Estimation. In: Okuyama, Y., Chang, S. (Eds.), Economic Principles, Issues, and Research Priorities in Hazard Loss Estimation. Springer, Berlin, pp. 13-36.

Rosi, M., Principe, R., Vecchi, R., 1993. The 1631 Vesuvius eruption. A reconstruction based on historical and stratigraphical data. Journal of Volcanology and Geothermal Research 58, 151-182.

Sabatini, V., 1906. L'Eruzione Vesuviana dell' aprile 1906. Tipografia Nazionale di G. Bertero, Roma.

Santucci de Magistris, F., 2011. Beyond EC8: the new Italian seismic code. Geofizika, 28, 65-82.

Scandone, R., Giudicepietro, F., Gasparini, P., 1993. Mount Vesuvius: 2000 years of volcanological observations. *Journal of Volcanology and Geothermal Research* 58, 5-25.

Scandone, R., Giacomelli, L., 2013. Volcanic precursors in light of eruption mechanisms at Vesuvius. *Annals of Geophysics* 56 (SI4) DOI: 10.4401/ag-6461.

Scandone, R., Giacomelli, L., Speranza, F.F., 2008. Persistent activity and violent strombolian eruptions at Vesuvius between 1631 and 1944. *Journal of Volcanology and Geothermal Research* 170, 167-180.

Scarth, A., 2009. *Vesuvius: A Biography*. Princeton University Press, Princeton and Oxford.

Scarth, A., Tanguy, J-C., 2001. *Volcanoes of Europe*. Terra, Harpenden.

Smith, P., 1998. Thomas Cook and Son's Vesuvius Railway. *Japan Railway and Transport Review*, March 1998, 10-15.

Solana, M. C., Kilburn, C. R. J., Rolandi, G., 2008. Communicating eruption and hazard forecasts on Vesuvius, Southern Italy. *Journal of Volcanology and Geothermal Research* 172(3-4), 308-314.

Snowdon, F.M., 2002. *Naples in the time of cholera, 1884-1911*. Cambridge University Press, Cambridge.

Spence, R.J.S., Kelman, I., Baxter, P.J., Zuccaro, G. and Petrazzuoli, S., 2005. Residential building and occupant vulnerability to tephra fall. *Natural Hazards and Earth System Sciences* 5, 477-494.

Tanguy, J-C., Ribière, Ch., Scarth A., Tjetjep, W.S., 1998. Victims of volcanic eruptions: a revised database. *Bulletin of Volcanology* 60, 137-144

Tanzi, V., Schuknecht, L., 2000. *Public spending in the 20th Century*. Cambridge University Press, Cambridge.

Teramo, M.S., Crowley, H., Lopez, M., Pinho, R., Cultrera, A., Cirella, A., Cocco, M., Mai, M., Teramo, A., 2008. A damage scenario for the city of Messina, Italy, using displacement-based loss assessment. In: *Proceeding of the 14th World Conference on Earthquake Engineering*, October 12-17, 2008, Beijing, China (http://www.iitk.ac.in/nicee/wcee/article/14_07-0023.PDF).

Tinti, S., Piatanesi, A., 2001. Numerical simulations of the 8 September 1905 Calabrian tsunami (southern Italy) as a tool to improve the assessment of tsunami risk on the Calabrian coast. *Proceedings International Tsunami Symposium, Session 4*, (4-5), 547-556 (<http://nthmp-history.pmel.noaa.gov/its2001/>).

United Nations, 2006. *Hyogo Framework for Action 2005-2015*. United Nations, Geneva (http://www.unisdr.org/files/1037_hyogoframeworkforactionenglish.pdf).

United Nations, 2014. Hyogo Framework for Action (HFA)
(<http://www.unisdr.org/we/coordinate/hfa>).

United States Inflation Calculator, 2104. (<http://www.usinflationcalculator.com/>)

White, G.F., 1974. Natural hazards: concepts, methods and policy implications. In:
White, G.F. (Ed.), Natural Hazards: Local, National, Global. Oxford University Press,
pp. 3-16.

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Table 2. Economic losses (Based on: Albatino, undated; Anon, 1906e, 1906g, 1906h, 1906i, 1906j, 1906k; Anon, 1908b; Delmé-Radcliffe, 1906; Casale, 1996; Nazzaro, 1997; Avvisati & Casale, 2006; Ricciardi, 2009 and the references cited in the body of the table).

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Table 5. Population change in selected areas affected by the 1906 eruption. Sant'Anastasia, Somma Vesuviana, Nola, Ottaviano, San Gennaro and San Giuseppe are the *comuni* most damaged by ash and lapilli (Fig. 3). Boscotrecase was affected in part by lava and Lauro and Scisciano are two small settlements, which lie to the north east of Vesuvius (Fig.1) and were badly affected by distal ash and lapilli deposits (Data from Anon, 2014i).

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Table 1

Phases and effects of the Eruption	Details
Pre-Eruption	<p>a. Feb-March, strombolian activity gradually increased during the last ten days of March.</p> <p>b. From March 20th the discharge of thermal streams at Torre Annunziata became weaker and water levels in wells fell by 20-30 cm. Ground inflation was noted on the north coast of the Bay of Naples (i.e. 20 cm at Naples), 48 cm near the volcano at Portici and 30-40 cm at Torre Annunziata. These data imply that magma was moving into the volcano.</p> <p>c. April 3rd – an explosion occurred in the central crater</p>
Initial phase (April 4-8)	<p>a. The eruption began at 05.30 h on April 4th with a fissure opening at 1,200 m on the southern flank which produced a small lava flow. Many tremors occurred and solid fragments were ejected.</p> <p>b. During the night of April 4th and 5th, dark-grey ash was deposited as far away as Naples and around midnight a lower, larger vent opened at <i>ca.</i> 800 m. Lava was vigorously erupted and travelled 2.5 km from the vent.</p> <p>c. On the morning of April 5th the badly damaged funicular¹ made its last trip and Frank Perret used this service to return to the observatory where he joined the Director, Raffaele Matteucci. During the morning ash and gases were expelled explosively from the crater.</p> <p>d. April 6th – a third vent opened on the SW flank (height <i>ca.</i> 600 m and emitted a large volume of lava, the flow dividing into three streams: one flowed towards Torre Annunziata, destroying woodlands and crops; another travelled towards Boscotrecase and a third approached Terzigno and covered land sterilised by lavas from the 1834 and 1850 eruptions and, hence, caused far less damage.</p> <p>e. At 15.00 hr on April 7th the lava stopped at the cemetery about 500 m from the town. Assuming that they were safe, the inhabitants began to move furniture back into homes. At 16.30 h loud explosions were heard as far away as Naples and in the evening spatter, ash and lapilli were ejected to a height of 2 km and covered the upper 2-300 m of the volcano.</p>
Second phase (April 8)	<p>a. The central crater was the site of explosive activity which increased in intensity early on Palm Sunday, April 8th. At 00.30 h there were strong explosions and an earthquake, and at 02.30 h a violent earthquake and emission of ash covered the north east sector of the volcano with a considerable quantity of tephra (both ash and lapilli). The villages of</p>

Ottaviano (at the time known as Ottajano²) and S. Giuseppe were badly affected and tephra reached a thickness of 1.25 m, causing several buildings to collapse, including the roof of the Oratorio Church (*Chiesa dell'Oratorio dello Spirito Santo*) in San Giuseppe which collapsed and killed 105 people sheltering within it. After 03.30- 4.00 h, a sub-plinian ash column was generated and during the afternoon reached a height of 13 km. This sub-plinian phase lasted 18 hours and eroding the walls of the crater, which eventually led to the collapse of the summit cone³.

b. Beginning on April 8th, but continuing until the beginning of the final phase of the eruption on April 11th, rain containing ash fell on Naples and Torre del Greco, making the ash covering many buildings much heavier and contributing to further building collapses at Ottaviano and San Giuseppe. On the west flank fall deposits destroyed the funicular and threatened the observatory, but the Director Raffaele Matteucci and Frank Perret remained in post, continuing their meticulous recording of the eruption.

c. A further lava flow advanced on Boscotrecase. In a few hours it had destroyed the Oratorio quarter, invaded the church of Santa Anna, surrounded and killed 3 elderly men, cut the road to Torre Annunziata, filled a 500 m railway cutting and was threatening Torre Annunziata. At 08.00 h the lava halted only *ca.* 10 m from the cemetery on the outskirts of the town. Around 100 houses were destroyed in Oratorio (Figs. 4 and 5).

Final phase (April 9-22)

a. Sub-plinian activity continued on April 11th and 12th with the cocoa coloured ash changing to a grey hue. Large volumes of ash were erupted which fell on many settlements in the region including the city of Naples. On April 10th the roof of the Monte Oliveto market (located in today's Piazza Carita) collapsed and caused deaths and injuries. Heavy rainfall generated lahars which caused extensive damage particularly in and around Ottaviano.

b. April 13th and 14th the ash fall became white in colour, and the eruption continued with diminishing energy until Sunday 21st of April.

Post-eruption damage

Ash and lapilli had a thickness of: Ottaviano - 70-100 cm; San Giuseppe - 50- 60 cm; Osservatorio - 21 cm; Portici and Torre Annunziata -19 cm; Cercola - 12 cm) and Naples - 2 cm.

a. April 27th and 28th heavy rainfall mobilised thick debris into mudflows on the northern flank, which destroyed two railway bridges, field crops, vineyards, orchards, woodlands and pastures, causing damage in Pollena, Cercola and Terzigno. The upper 2/3 of the funicular was swept away including the restaurant, station, engine house, boiler and

stables.

b. May 18th a mudflow caused damage in Resina, and on May 20th/21st Cercola, Massa di Somma, Pollena and San Sebastiano were badly affected. Up to 1 m of material was deposited.

c. Portici and Torre del Greco were affected by the remobilisation ashes as mudflows in October 1908.

¹The *funicular* (It. *funicolare*) was a railway managed from the 1890's by the travel agents Thomas Cook and Sons. Officially *the Thomas Cook & Son's Vesuvius Railway*, it was colloquially termed the *funicular*, although it was only a cable railway for its upper section when it ascended the cone. The middle section was a 'rack' railway and the lower section was worked by normal adhesion. Although the lower and middle sections were quickly restored after 1906, the upper part had to re-built and was not re-opened until 1909 (Smith, 1998).

² The village of Ottajano was re-named Ottaviano in 1933. In this paper it will be referred to by its current name.

³ The eruption caused more damage to the cone than any since 1822. Some 115 m was removed from the summit and in May 1906 the new crater was 600 m deep and 700 m in diameter. The crater rim was 1,100 m high in the east and 1,200 in the west.

Table 2

	Damage
Buildings	<p>Major damage was concentrated in Boscotrecase (lava) and Ottaviano and San Giuseppe (ash and lapilli).</p> <p>Boscotrecase An estimated 100 homes in the suburb of Oratorio were destroyed or badly damaged and one stream of lava flowed into the church of S. Anna. The walls of many ruined buildings were precarious and had be knocked down or guarded by troops. Damage would have been worse if the lava had not flowed into and filled a depression known as the <i>Vallone Izzo</i> (depth <i>ca.</i> 30 m) and, indeed, the volume of lava held in this depression meant the lava did not reach Torre Annunziata. Some architecturally significant buildings were destroyed including the Bifulco Palace. The parish priest, Don Carmine Russo, reported the loss of baptismal records.</p> <p>Ottaviano Virtually all the buildings were damaged and some, including the municipal buildings, were destroyed by collapse (Fig. 8).</p> <p>San Giuseppe In addition to the collapse of the roof of the Oratorio Church (<i>Chiesa dell'Oratorio dello Spirito Santo</i>- see Table 1), several houses fell to the ground and most buildings were scarred by roof failure. Some buildings escaped damage because of their distinctive domes roofs.</p> <p>Naples The roof of the Monte Oliveto market, covering an area of 56 m², collapsed and caused deaths (see section 3.1). It may have been weakened by earlier earthquakes. Only poorly constructed houses suffered damage to their roofs.¹</p> <p>Other damaged settlements Boscoreale, Cercola, Poggiomarino, Pollena, Pomigliano d' Arco, Portici, Resina, San Gennaro, San Giorgio e Cremano, San Giovanni, Somma Vesuviana, Terzigno, Torre del Greco.</p>
Agricultural Land	<p>As Figure 3 shows a considerable area - especially on the north and north east flanks - was covered by ash, while lava sterilised land to the south east in the vicinity of Casa Bianca, Boscotrecase and Torre Annunziata.</p> <p>Later more land was covered by lahars and the effects of floods:-</p> <ol style="list-style-type: none"> April 27th to April 28th - Ottaviano and Cercola. May 17th and 18th - Resina. May 20th and 21st - San Sebastiano, Cercola and Pollena. October and November (various dates) autumn rains produced lahars that affected the Torre del Greco area. January 4th 1907 - torrential rain mobilised mudflows (<i>le collate di frango</i>) which covered land in the Resina area. October 9th/10th and 27th/28th damage in the Torre del Greco, Resina, San Sebastiano, Cercola and Pollena areas. April 14th 1908 further damage between Resina and Torre del

Greco.

h. October 24th 1910 further damage on the south west flank near Torre del Greco.

Of the estimate losses of 60,000 million *lira*: and estimated 20% occurred in the *comuni* of Ottaviano and Somma Vesuviana; 12% in S. Giuseppe Vesuviano; 9% in Nola; 5% in Palma Campania and 3% in Marigliano, Naples and Lauro.

Communications

a. Railways

The Thomas Cook & Son's Vesuvius Railway was badly affected and not fully restored until 1909 (see Table 1 footnote 1). Other railways were affected less severely and were soon restored. For instance, the circum-Vesuvian railway was cut in several places (Anon, 1906g) - at Boscotrecase by lava and elsewhere by air fall, as was railway along the coast (Delmé-Radcliffe, 1906, pp. 7 see Fig. 3). Following the eruption, some railway bridges were destroyed by lahars

b. Roads

Roads were covered by ash/lapilli and near Boscotrecase by lava. Several bridges failed, both during the eruption and subsequent laharic activity.

c. Telecommunications

Ottaviano, San Giuseppe, Terzigno and some other settlements lost their telegraph links for a short time, but these were soon restored. Links to the observatory were cut, but quickly restored by military engineers (Ricciardi, 2009, pp. 732-733). Most of the telegraph lines remained intact.

The authorities made a great and generally successful effort to restore communications (see section 5.2).

¹ Information based on an interview with Assessore Gennaro Ambrosio in the the comune of San Giuseppe Vesuviano on 10/9/04.

Table 3

Theodicy is defined as any attempt to reconcile the idea of a loving God with the existence of suffering in the world, and in the popular Catholicism of the Italian south this is expressed in three ways:-

- a. Disasters have to be accepted as justified expressions of divine anger with a sinful people.
- b. People can appease God's wrath by actions which involve the use of images, effigies and relics of saints and the Madonna.
- c. Intercession to saintly supernatural figures have the power to change God's mind through intercessory prayer.

Orthodox Catholic theology holds that Christ and God are co-equal, and the Virgin Mary and the saints are mortals and possess no power of their own to change the divine mind. Saints can only intercede through the agency of Jesus Christ.

Southern Italian popular Catholicism is, however, heterodox 'Christ is more powerful than God the Father, Mary is more powerful than Christ; and Saint Joseph, the universal father, is more powerful than God the Father, Christ and he Madonna together. But more powerful than God and all the saints is the one saint that – from as far back as... the Middle Ages – the inhabitants of a given place have selected as their patron' (Carroll, 1992, pp. 15-16).

Under the influence of the European Enlightenment in the 18th century, other models of theodicy became more important, in particular the view that the world is 'best of all possible worlds' that could be created by God, disasters representing the operation of extreme natural processes. Southern Italy Catholicism remained wedded to ideas of divine wrath and punishment..., although the 'greater good' may be found in Christian praxis where such qualities as self-sacrifice, cohesion of family and community are expressed in Catholic social action.

Table 4

Date	Military Action
Friday 6 th	1000 troops and 10 wagons were sent from Naples to Torre Annunziata. The General Officer commanding in Salerno (a major city to the south of the region) was ordered to transfer his headquarters to Nocera to be nearer Vesuvius. Although some initial efforts were made at Boscotrecase (Anon, 1906b), it was quickly concluded that it was futile to either divert lava or to provide protection against ash or lapilli were futile.
Saturday 7 th	A company of engineers and further 100 infantry and 10 wagons were sent to each of the villages of Torre del Greco and Portici.
Sunday 8 th	From dawn there was a rapid reaction to the explosive activity that occurred during the night of the 7 th /8 th (Table 1). The Duca d'Aosta, commanding the Xth Army Corps, fearing that activity would become even more violent, issued orders for the volcano to be surrounded by a 'cordon' of troops, better to support the civil power. The whole region was divided into 'zones' under the command of either a colonel, or in some cases a Major General, and supplies were moved to these forward bases. The 'cordon' was divided into two Divisional Commands, one at Naples and the other at Nocera, with Brigade-sized units being located at Torre Annunziata and Ottaviano.
Monday 9 th and subsequently	As it became clear that needs were greater in some areas than in others, 'sub-zones' were created at: Portici; Resina; San Giorgio a Cremona and Terzigno. San Giuseppe and San Gennaro were reinforced. To the rear of the 'cordon', a second line was established with command posts at Marigliano, Nola, Nocera, Palma and Poggiomarino. Major supply depots at Naples, Nola and Nocera supplied rations to the various 'zones' and 'sub-zones', and troops cooked food when and where it was required. The <i>Sindaco</i> or commissioner of each <i>comune</i> issued a tally to those requiring food. As well as supplying, distributing and in some cases cooking food, troops were also involved in clearing ash from roofs, transporting the injured to hospital, removing/storing furniture and other effects and restoring communications. The railway line from Naples to Ottaviano was, for instance, re-opened by April 15 th . Soldiers continued to dig through the ash to find any survivors and recover bodies, Colonel Delmé-Radcliffe noting that one 80 year old man was saved after being buried for five days. The number of troops in the inner cordon was <i>ca.</i> 7,000 with 200 wagons, with some 4,000 soldiers, 1,000 sailors and a further 60 wagons being held further back in reserve. Armed troops were also stationed in Naples in case of any breakdown in law and order. Later in the eruption troops in the 'cordon' were rotated with reinforcements brought in from Rome, who arrived with more equipment comprising 50 wagons, over 4,000 shovels, nearly 3,000 pickaxes and 660 sledge-hammers. The army also requisitioned local transport and many pack animals in order to distribute food.
The French and British sent naval personnel to the Bay of Naples, but	

in the event these forces were not required (Anon 1906n).

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Table 5

Settlement	Population 1901	Change 1901-1911 (%)	Change 1911-21 (%)
Naples Province	1.25 million	13.7	12.2
Naples <i>comune</i>	621,213	20.9	14.4
Sant' Anastasia	8,712	3.9	8.9
Somma Vesuviana	10,090	4.8	6.0
Nola	14,511	2.0	7.1
Ottaviano	8,533	2.7	20.4
San Gennaro	3,575	-2.5	6.4
San Giuseppe	10,063	8.1	21.9
Boscotrecase	6,286	8.9	18.3
Lauro	2,945	0.9	-1.7
Scisciano	2,546	-3.1	5.2

Fig 1

ACCEPTED

Fig 3

Fig 5

Fig 6

Fig 7

Fig 8

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c. Portici and Torre del Greco were affected by the remobilisation ashes as mudflows in October 1908.

¹The *funicular* (It. *funicolare*) was a railway managed from the 1890's by the travel agents Thomas Cook and Sons. Officially *the Thomas Cook & Son's Vesuvius Railway*, it was colloquially termed the *funicular*, although it was only a cable railway for its upper section when it ascended the cone. The middle section was a 'rack' railway and the lower section was worked by normal adhesion. Although the lower and middle sections were quickly restored after 1906, the upper part had to re-built and was not re-opened until 1909 (Smith, 1998).

² The village of Ottajano was re-named Ottaviano in 1933. In this paper it will be referred to by its current name.

³ The eruption caused more damage to the cone than any since 1822. Some 115 m was removed from the summit and in May 1906 the new crater was 600 m deep and 700 m in diameter. The crater rim was 1,100 m high in the east and 1,200 in the west.

Table 2

	Damage
Buildings	<p>Major damage was concentrated in Boscotrecase (lava) and Ottaviano and San Giuseppe (ash and lapilli).</p> <p>Boscotrecase An estimated 100 homes in the suburb of Oratorio were destroyed or badly damaged and one stream of lava flowed into the church of S. Anna. The walls of many ruined buildings were precarious and had be knocked down or guarded by troops. Damage would have been worse if the lava had not flowed into and filled a depression known as the <i>Vallone Izzo</i> (depth <i>ca.</i> 30 m) and, indeed, the volume of lava held in this depression meant the lava did not reach Torre Annunziata. Some architecturally significant buildings were destroyed including the Bifulco Palace. The parish priest, Don Carmine Russo, reported the loss of baptismal records.</p> <p>Ottaviano Virtually all the buildings were damaged and some, including the municipal buildings, were destroyed by collapse (Fig. 8).</p> <p>San Giuseppe In addition to the collapse of the roof of the Oratorio Church (<i>Chiesa dell'Oratorio dello Spirito Santo</i>- see Table 1), several houses fell to the ground and most buildings were scarred by roof failure. Some buildings escaped damage because of their distinctive domes roofs.</p> <p>Naples The roof of the Monte Oliveto market, covering an area of 56 m², collapsed and caused deaths (see section 3.1). It may have been weakened by earlier earthquakes. Only poorly constructed houses suffered damage to their roofs.¹</p> <p>Other damaged settlements Boscoreale, Cercola, Poggiomarino, Pollena, Pomigliano d' Arco, Portici, Resina, San Gennaro, San Giorgio e Cremano, San Giovanni, Somma Vesuviana, Terzigno, Torre del Greco.</p>
Agricultural Land	<p>As Figure 3 shows a considerable area - especially on the north and north east flanks - was covered by ash, while lava sterilised land to the south east in the vicinity of Casa Bianca, Boscotrecase and Torre Annunziata.</p> <p>Later more land was covered by lahars and the effects of floods:-</p> <ol style="list-style-type: none"> April 27th to April 28th - Ottaviano and Cercola. May 17th and 18th - Resina. May 20th and 21st - San Sebastiano, Cercola and Pollena. October and November (various dates) autumn rains produced lahars that affected the Torre del Greco area. January 4th 1907 - torrential rain mobilised mudflows (<i>le collate di frango</i>) which covered land in the Resina area. October 9th/10th and 27th/28th damage in the Torre del Greco, Resina, San Sebastiano, Cercola and Pollena areas. April 14th 1908 further damage between Resina and Torre del Greco. October 24th 1910 further damage on the south west flank near Torre del Greco.

Of the estimate losses of 60,000 million *lira*: and estimated 20% occurred in the *comuni* of Ottaviano and Somma Vesuviana; 12% in S. Giuseppe Vesuviano; 9% in Nola; 5% in Palma Campania and 3% in Marigliano, Naples and Lauro.

Communications

a. Railways

The Thomas Cook & Son's Vesuvius Railway was badly affected and not fully restored until 1909 (see Table 1 footnote 1). Other railways were affected less severely and were soon restored. For instance, the circum-Vesuvian railway was cut in several places (Anon, 1906g) - at Boscotrecase by lava and elsewhere by air fall, as was railway along the coast (Delmé-Radcliffe, 1906, pp. 7 see Fig. 3). Following the eruption, some railway bridges were destroyed by lahars

b. Roads

Roads were covered by ash/lapilli and near Boscotrecase by lava. Several bridges failed, both during the eruption and subsequent laharic activity.

c. Telecommunications

Ottaviano, San Giuseppe, Terzigno and some other settlements lost their telegraph inks for a short time, but these were soon restored. Links to the observatory were cut, but quickly restored by military engineers (Ricciardi, 2009, pp. 732-733). Most of the telegraph lines remained intact.

The authorities made a great and generally successful effort to restore communications (see section 5.2).

¹ Information based on an interview with Assessore Gennaro Ambrosio in the *comune* of San Giuseppe Vesuviano on 10/9/04.

Table 3

Theodicy is defined as any attempt to reconcile the idea of a loving God with the existence of suffering in the world, and in the popular Catholicism of the Italian south this is expressed in three ways:-

- a. Disasters have to be accepted as justified expressions of divine anger with a sinful people.
- b. People can appease God's wrath by actions which involve the use of images, effigies and relics of saints and the Madonna.
- c. Intercession to saintly supernatural figures have the power to change God's mind through intercessory prayer.

Orthodox Catholic theology holds that Christ and God are co-equal, and the Virgin Mary and the saints are mortals and possess no power of their own to change the divine mind. Saints can only intercede through the agency of Jesus Christ.

Southern Italian popular Catholicism is, however, heterodox 'Christ is more powerful than God the Father, Mary is more powerful than Christ; and Saint Joseph, the universal father, is more powerful than God the Father, Christ and he Madonna together. But more powerful than God and all the saints is the one saint that – from as far back as... the Middle Ages – the inhabitants of a given place have selected as their patron' (Carroll, 1992, pp. 15-16).

Under the influence of the European Enlightenment in the 18th century, other models of theodicy became more important, in particular the view that the world is 'best of all possible worlds' that could be created by God, disasters representing the operation of extreme natural processes. Southern Italy Catholicism remained wedded to ideas of divine wrath and punishment...., although the 'greater good' may be found in Christian praxis where such qualities as self-sacrifice, cohesion of family and community are expressed in Catholic social action.

Table 4

Date	Military Action
Friday 6 th	1000 troops and 10 wagons were sent from Naples to Torre Annunziata. The General Officer commanding in Salerno (a major city to the south of the region) was ordered to transfer his headquarters to Nocera to be nearer Vesuvius. Although some initial efforts were made at Boscotrecase (1906b), it was quickly concluded that it was futile to either divert lava or to provide protection against ash or lapilli were futile.
Saturday 7 th	A company of engineers and further 100 infantry and 10 wagons were sent to each of the villages of Torre del Greco and Portici.
Sunday 8 th	From dawn there was a rapid reaction to the explosive activity that occurred during the night of the 7 th /8 th (Table 1). The Duca d'Aosta, commanding the Xth Army Corps, fearing that activity would become even more violent, issued orders for the volcano to be surrounded by a 'cordon' of troops, better to support the civil power. The whole region was divided into 'zones' under the command of either a colonel, or in some cases a Major General, and supplies were moved to these forward bases. The 'cordon' was divided into two Divisional Commands, one at Naples and the other at Nocera, with Brigade-sized units being located at Torre Annunziata and Ottaviano.
Monday 9 th and subsequently	As it became clear that needs were greater in some areas than in others, 'sub-zones' were created at: Portici; Resina; San Giorgio a Cremona and Terzigno. San Giuseppe and San Gennaro were reinforced. To the rear of the 'cordon', a second line was established with command posts at Marigliano, Nola, Nocera, Palma and Poggiomarino. Major supply depots at Naples, Nola and Nocera supplied rations to the various 'zones' and 'sub-zones', and troops cooked food when and where it was required. The <i>Sindaco</i> or commissioner of each <i>comune</i> issued a tally to those requiring food. As well as supplying, distributing and in some cases cooking food, troops were also involved in clearing ash from roofs, transporting the injured to hospital, removing/storing furniture and other effects and restoring communications. The railway line from Naples to Ottaviano was, for instance, re-opened by April 15 th . Soldiers continued to dig through the ash to find any survivors and recover bodies, Colonel Delmé-Radcliffe noting that one 80 year old man was saved after being buried for five day. The number of troops in the inner cordon was <i>ca.</i> 7,000 with 200 wagons, with some 4,000 soldiers, 1,000 sailors and a further 60 wagons being held further back in reserve. Armed troops were also stationed in Naples in case of any breakdown in law and order. Later in the eruption troops in the 'cordon' were rotated with reinforcements brought in from Rome, who arrived with more equipment comprising 50 wagons, over 4,000 shovels, nearly 3,000 pickaxes and 660 sledge-hammers. The army also requisitioned local transport and many pack animals in order to distribute food.

The French and British send naval personnel to the Bay of Naples, but

in the event these forces were not required (Anon 1906n).

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Table 5

Settlement	Population 1901	Change 1901-1911 (%)	Change 1911-21 (%)
Naples Province	1.25 million	13.7	12.2
Naples <i>comune</i>	621,213	20.9	14.4
Sant' Anastasia	8,712	3.9	8.9
Somma Vesuviana	10,090	4.8	6.0
Nola	14,511	2.0	7.1
Ottaviano	8,533	2.7	20.4
San Gennaro	3,575	-2.5	6.4
San Giuseppe	10,063	8.1	21.9
Boscotrecase	6,286	8.9	18.3
Lauro	2,945	0.9	-1.7
Scisciano	2,546	-3.1	5.2

Highlights

Human impact of the 1906 eruption reconstructed using archival sources

Eruption successfully handled by a combination of traditional (local) and State-based responses.

Responses

Effective short-term recovery

Slow long-term recovery