Vulnerability, livelihoods and disaster knowledge in the volcanic highlands of Central Java, Indonesia:

'*Itu sudah biasa*'

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Candidate's declaration:

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or processional qualification.

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Cover image: Farmers harvest potatoes as Sileri Crater steams in the background, Kepakisan Village, the Dieng Plateau (source: author).

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For my daughter

Abstract

This thesis describes the interaction of vulnerability, livelihoods and disaster knowledge in a volcanic area of Central Java, Indonesia. The Dieng Plateau is a volcanically hazardous landscape, featuring a series of craters with a history of recurrent phreatic eruptions and emissions of poisonous gases. While the government manages this hazard through largely technocratic interventions, for local farmers the hazard is integrated with, and a normal part of, daily life (‘*itu sudah biasa’*). Farmers respond to heightened volcanic activity in an informed manner, while at times taking greater risks for the achievement of the often-lucrative livelihood goals that can help alleviate local vulnerabilities.

Despite boasting 127 active volcanoes, there is sill a scarcity of studies that focus on the construction of vulnerability in Indonesia’s volcanic areas. Furthermore, current disaster scholarship is yet to comprehensively describe crucial factors that influence this vulnerability, such as expert and political constructions of risk, and the benefits gained through partaking in livelihoods in volcanic landscapes. By drawing on a multi-methods and largely qualitative approach, combining semi-structured and unstructured interviews with farmers, observation of government-run exercises, a participatory workshop, and household survey, this thesis responds to these research needs.

Throughout the three empirical chapters of this thesis, I describe and relate the many and varied ways vulnerabilities are produced, or overcome, in this volcanic landscape. The first conceptualisation of vulnerability argues that it is a product of access to land resources, influenced by Dieng’s history of upland settlement, the unequal spatial distribution of land prices, and the impact of internal state-led territorialisation strategies. I expand on current vulnerability frameworks used within disaster scholarship; specifically the access model and concept of the ‘hazardscape’, to argue that vulnerabilities are also produced through the way governments define and territorialise hazardous land. The second conceptualisation of vulnerability relates it to

livelihood outcomes and the impact of a major potato crop boom. By integrating the disaster and agrarian literature, I question dominant views that rural livelihoods in volcanic areas are inherently 'unsustainable', and present a holistic picture of volcanic risk, considering capacity alongside vulnerability.

The third conceptualisation of vulnerability is related to disaster knowledge and the risk mitigation activities this knowledge informs. I expand on current approaches to the study of disaster knowledge to argue that both local and expert knowledge are locally contextualised and hybrid systems. While they differ in various aspects, they are not separate from, but rather actively inform, the other. The thesis concludes with a discussion of how these three conceptualisations of vulnerability, when combined, can contribute to a more holistic, practical, and contextualised approach to volcanic risk reduction in the Dieng Plateau.

This thesis argues that vulnerability to volcanic hazard in the Dieng Plateau is produced through the social, economic, political and environmental processes that govern access to land and livelihood outcomes, while also emerging through the way governments and locals alike define and respond to volcanic activity. This finding bears important lessons for the development of future policies aimed to reduce, or overcome the creation of new, risks in other agriculturally dominated volcanic landscapes throughout Indonesia.

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List of acronyms

APBD:	*Anggaran Pendapatan dan Belanja Daerah* (Regional Revenue and Expenditure Budgetary Body)
Bappeda:	*Badan Perencanaan dan Pembangunan Daerah* (Regional Body for Planning and Development)
Basarnas:	*Badan SAR Nasional* (National Search and Rescue Agency)
BPBD:	*Badan Penanggulangan Bencana Daerah* (District Disaster Management Agency)
BNI:	*Bank Nasional Indonesia* (National Bank of Indonesia)
BNPB:	*Badan Nasional Penanggulangan Bencana* (National Agency for Disaster Management)
BPN:	*Badan Pertanahan Nasional* (National Land Agency)
BPS:	*Badan Pusat Statistik* (Central Bureau of Statistics)
BRI:	*Bank Rakyat Indonesia* (People's Bank of Indonesia)
CBDRR:	Community-Based Disaster Risk Reduction
CO_2:	Carbon dioxide
DRR:	Disaster Risk Reduction
EM-DAT:	The International Emergency Disaster Management Database
IFRC:	International Federation of Red Cross/Red Crescent Societies
LEK:	Local Ecological Knowledge
MW:	Megawatts
NGO:	Non-Governmental Organisation
PKK:	*Pembinaan Kesejahteraan Keluarga* (Family Empowerment and Welfare Movement)
PVMBG:	*Pusat Vulkanologi dan Mitigasi Bencana Geologi* (Centre for Volcanology and Geological Hazard Mitigation)
RT:	*Rukun Tetangga* (Neighbourhood Association)
SAR:	Search and Rescue
Satlak:	*Satuan Pelaksana Penanggulangan Bencana dan Pengungsi* (District Disaster Implementation Unit)
TNI:	*Tentara Nasional Indonesia* (Indonesian National Armed Forces)

TNI-AL:	*Tentara Nasional Indonesia Angkatan Laut* (Indonesian National Navy)
UNDP:	United Nations Development Program
UNISDR:	United Nations International Strategy for Disaster Reduction
USGS:	United States Geological Survey
UU:	*Undang Undang* (National level law)

The land above the clouds*: 'Negeri di atas awan'*

In the 'land above the clouds' of Central Java, a potato farmer harvests her crop pulling clusters of large potatoes from the rich brown earth. The potatoes are loaded into large cane baskets and the *tukang pikul* lifts two-basket loads counter balanced from a staff resting over his shoulder. A nearby truck waits to transport the potatoes for grading and sale. In just a few days' time this land will once again be hoed, fertilised, built into furrows and ridges and finally planted with another crop of seed potatoes. Pesticides will be applied regularly as the plants grow, and water sourced from nearby crater lakes will be piped in using diesel-fuelled pumps. In the midst of this vibrant agricultural activity lies a crater, marked by a steady stream of vapour rising into the sky. Known as *Kawah Timbang,* this crater can effuse carbon dioxide gas in deadly concentrations. Most days the gas settles in the depths of the crater; occasionally such large volumes are released that it flows beyond the crater rim. The dense, colourless and odourless gas flows downhill from the crater, killing all life in its path. Yet today, like many, the crater is deemed safe and so agricultural activity continues as normal.

1. Introduction

The description of life in the Dieng Plateau provided above paints a picture of profitable agricultural activities coexisting alongside significant volcanic hazard. As articulated by the many farmers I spoke with in the field, volcanic eruptions are an 'already normal (*itu sudah biasa*)' occurrence and part of everyday life in the Dieng Plateau. With 127 active volcanoes, scenes such as this one, where people live alongside volcanic activity, are common throughout the vast archipelago of Indonesia. However, despite the inherent vulnerabilities that are associated with farming these volcanic landscapes, there is a scarcity of studies that focus on how this vulnerability is produced, particularly studies that address the impact local livelihood realities have on risk-taking behaviour, and how expert and political constructions of risk influence local vulnerability. Drawing on multiple political ecology frameworks and the results of a period of in-depth qualitative fieldwork, this thesis describes how vulnerabilities to natural hazards are produced, and overcome, in one of Indonesia's volcanic highlands. The grounded nature of this research bears direct policy implications for the more contextualised management of volcanic hazards in the Dieng Plateau and other agriculturally dominated volcanic landscapes throughout Indonesia.

In the forthcoming introductory chapter, I describe the background underpinning this study, and how current theoretical gaps in conceptualisations of vulnerability have informed my research objectives. I then outline my three main research questions, alongside an overview of the main findings, before concluding the chapter with a brief outline of the chapters that follow.

1.1. Context of this study

In the opening address to the Third World Conference on Disaster Risk Reduction (DRR) in Sendai[1], the then UN Secretary-General Ban Ki-moon stressed that DRR 'is in everybody's interest, and it is everybody's business' (UN, 2015). This reference was made in the context of the rising costs associated with disaster losses, which he argued affects everyone. The past decades have seen the implementation of many DRR initiatives worldwide, incited by extensive research efforts and a rise in the political awareness of disasters prompted by the catastrophic 2004 Indian Ocean tsunami. Yet despite these efforts, many people continue to occupy hazardous locations, disaster losses continue to rise (Jha and Stanton-Geddes, 2013; O'Keefe et al., 1976; White, et al., 2001), and DRR is not yet a priority for the governments of many of the most disaster prone countries (Gaillard and Mercer, 2012; Lavell and Maskrey, 2014). The 2015 Sendai Framework for Disaster Risk Reduction 2015 – 2030, highlights the high toll that disasters have had between the years of 2005 to 2015. In this 10-year time frame, worldwide over 700,000 lives were lost, more than 1.4 million people injured, and an estimated 23 million people lost their homes (UNISDR, 2015).

An increase in global vulnerabilities is implicated in the sustained rise of global disaster losses (Djalante et al., 2012; Gaillard and Mercer, 2012; UNISDR, 2015). Yet despite this international recognition of vulnerability, disaster scholarship still favours understanding the geophysical processes over the dynamics of vulnerability (Briceno, 2015). Furthermore, programs aimed at reducing vulnerability are yet to be systematically integrated into the development plans of many of the most hazardous countries (Gaillard and Mercer, 2012; Lavell and Maskrey, 2014). Within the hazardous archipelago of Indonesia, Djalante et al. (2012) argue that it 'must work harder to reduce the enormous social, economic and environmental

[1] The 2015 Sendai Framework for Action was endorsed following this Third UN World Conference on DRR held in Sendai, Japan. This non-binding 15-year agreement aims to reduce disaster loss through a focus on disaster risk management and superseded the 2005 Hyogo Framework for Action (see also Wahlstrom, 2015).

challenges that contribute to the country's vulnerability' (p. 792). As I demonstrate below, this statement is particularly pertinent for its many understudied, volcanically hazardous landscapes.

Humans have long been drawn to the slopes of active volcanoes (Cashman and Giordano, 2008), propelled by the fertile soils and resource rich environments they provide. Volcanic ash, ejected in plumes or through pyroclastic flows, nourishes soil and provides a fertile and nutrient rich environment in which agriculture flourishes. In Java, the continual deposition of andesitic ash (estimated at 5.07 billion m^3 over the past 100 years), combined with the warm humid climate has formed the basis for the island's soil fertility (Lavigne and Gunnell, 2006). Volcanic landscapes also provide rich, and often replenish-able, resources for mining. For example, sand and boulders deposited in lahar flows are mined for the cosmetic and construction industry on the slopes of Mount Merapi (de Bélizal et al., 2013), while the volcanic caldera *Kawah Ijen* in East Java is mined for its sulfur deposits. Volcanic activity brings thermal energy closer to the Earth's surface, and by the heating of surrounding rocks and groundwater a geothermal energy resource can be harnessed to generate electricity (Duffield, 2005). Despite being currently underutilised, Indonesia has the potential to establish significant geothermal plants in 250 locations across the archipelago (Azimudin, 2008).

This diverse array of livelihood opportunities has contributed to population growth and the development of new economic assets that are placing a greater number of people at risk in volcanic landscapes. Within the same 10-year period noted above (2005 to 2015), the International Disaster Database (EM-DAT, 2017) records that globally a total of 463 people have lost their lives and over 2.3 million people have been affected by the impact of volcanic disasters, with economic damages amounting to over one billion USD. As well as posing risk to life, volcanic eruptions can disrupt critical livelihood activities, particularly as volcanoes are also often the sites of significant agricultural development. Governments and development agencies work to reduce this risk through better warning, education and at times relocation

measures. However, the disaster literature has revealed that communities living on the flanks of volcanoes are more likely to view volcanic risk as one of the many risks that impact daily life (Bankoff, 2007; Dove, 2008; Laksono, 1988). This everyday attitude towards volcanic hazard means that official DRR programs, particularly those relying on technocratic interventions such as relocation or structural engineering efforts, can fail in their attempts to reduce vulnerability and sustainably mitigate risk.

To better understand and overcome the heavy impact caused by volcanic disasters the field of 'social volcanology' has arisen (see Donovan, 2010). Social volcanology employs a multidisciplinary research method wherein the social dimensions of volcanic risk are studied with the purpose of reducing volcanic impacts (for some examples see: Cashman and Cronin, 2008; Chester et al., 2008; Dibben, 2008; Dominey-Howes and Minos-Minopoulos, 2004; Donovan, 2010; Donovan et al., 2012a; Dove, 2008; Haynes et al., 2008a; Kelman et al., 2012; Lavigne et al. 2008; Gaillard, 2006; 2008; Paton et al., 2008). The sustained heavy socio-economic impacts caused by volcanic eruptions, combined with a lack of sustained political will to reduce their impacts, makes the study of volcanic disasters now as relevant as ever. Situated within the expanding field of social volcanology, this thesis directly responds to this research need.

Indonesia has 127 active volcanoes (PVMBG, 2017), and due in part to the abundance of resources outlined above, a total of 75 per cent of the population live within 100 km of one of these Holocene volcanoes (Smithsonian Institution, 2017). By far the most studied, and arguably the most hazardous, volcano in the Indonesian archipelago is Mount Merapi. Mount Merapi has drawn the attention of international and domestic scholars across various disciplines with some notable social volcanology works including Schlehe's (1996) study of mystical interpretations of eruptions, Donovan (2010) and Donovan et al.'s (2012a) study of social vulnerability, Mei et al.'s (2013) study of the institutional response to the 2010 eruption, and Laksono's (1988) and Dove's (2008, 2010) studies of volcanic risk perception. Many other geophysical researchers have focused

on understanding the magmatic and geological evolution of this volcano and mapping its hazardous zones (for some examples see de Belizal et al., 2013; Camus et al, 2000; Cronin et al., 2013; Hammer et al, 2000; Jenkins et al., 2013; Komorowski et al., 2013; Surono et al., 2012; Voight et al, 2000). It is therefore, one of the most well studied volcanoes in the world with respect to both its geology and social vulnerability. The extensive work informed through the study of Mount Merapi reveals the many livelihood opportunities gained through living on volcanic slopes (de Bélizal et al., 2013), and the difference in risk perception that exists between the state and 'at risk' communities (Laksono, 1988).

While the studies of Mount Merapi have significantly advanced our understanding of social volcanology, Indonesia contains 126 other active volcanoes scattered throughout the archipelago. Excluding the studies of Kelut and Bromo in East Java (de Belizal et al., 2012; Bachri et al., 2015), there is a scarcity of work on the social aspects of volcanic risk in Indonesia involving sites other than Mount Merapi. Mount Merapi is a popular choice for research as not only does it erupt frequently, but also these eruptions are interpreted locally through mystical tradition (Schlehe, 1996). Mount Merapi is spiritually and politically significant to the Sultanate of Yogyakarta and the actions of the spiritual world within the mountain are believed to mirror Central Java's political world, with eruptions signifying political unrest (Dove, 2010). Furthermore, a local mystic named Mbah Maridjan, previously known as *Si Juru Kunci Merapi* (the gatekeeper of Merapi) gained notoriety by refusing to evacuate, eventually perishing along with 34 of his followers in a pyroclastic flow during the 2010 eruption (Mei et al., 2013).

Yet, while Indonesia's many other volcanoes may not have the same level of known hazardousness or the depths of cultural interpretation found on Merapi, they are still significant sites due to the many people that inhabit them. Furthermore, as Mount Merapi's eruptive characteristics and local socio-economic processes are somewhat unique, lessons gained through studies of Merapi are not always transferrable to all of Indonesia's volcanoes. This is particularly pertinent given the relatively consistent style of Merapi's

modern eruptions that are characterised by the growth and collapse of lava domes (Camus et al., 2000; Hammer et al., 2000; Komorowski et al., 2013; Voight et al., 2000), and its local spiritual significance that has complicated evacuation procedures (Donovan, 2010; Mei et al., 2013). The recent activity at Mount Agung in Bali, alongside the eruptions of Mount Sinabung in North Sumatra after 400 years of dormancy (Iguchi et al., 2011), emphasise the unpredictability of volcanoes and the need for more vulnerability focused research to help reduce volcanic disaster losses throughout Indonesia.

The Dieng Plateau, situated 200 km to the north west of Mount Merapi, is one such example. Dieng is a volcanically active plateau consisting of a series of craters capable of small phreatic eruptions or the release of deadly concentrations of carbon dioxide (CO_2) gas, rather than a singular conical volcano. The region sustains a population of 50,000 people primarily supported by small-scale agriculture (BPS, 2010). While Dieng is not exposed to the same level of hazard as Merapi, does not have the strong cultural links with the sultanate of Yogyakarta, or boast spiritual leaders claiming to interpret and predict volcanic activity, volcanic eruptions in the area nonetheless instigate large-scale evacuations, have caused serious loss of life and regularly decimate vegetable crops. Furthermore, despite its significant eruption history, a burgeoning cool climate vegetable industry is maintained and volcanic hazards mitigated on a daily basis. As will be discussed in Chapter 3, the convergence of these factors emphasise the significance of the Dieng Plateau as a useful social volcanology research site.

Gaillard et al. (2009) argue that many everyday risk reduction strategies used by communities 'at risk' rely on ordinary measures rather than extraordinary actions. Ordinary measures to reduce risk can include building simple bamboo homes that are earthquake resistant (Bankoff, 2007), planting food crops resilient to wind hazard (Mercer et al., 2007), or creating spaces for evacuation above homes during floods (van Voorst, 2015). These risk-handling styles are 'ordinary' in nature and integrated into daily life activities. Yet they are prevalent in hazardous environments and can significantly reduce disaster losses. As local responses to volcanic eruptions

are often deeply intertwined with daily activities (Bankoff, 2007), this style of everyday risk-handling warrants a re-examination in volcanic areas. This line of research has the potential to better understand volcanic risk in environments like the Dieng Plateau and Indonesia's 126 other volcanoes. This thesis thereby seeks to understand how local vulnerabilities are both constructed, and overcome, on a daily basis in one of Indonesia's volcanic landscapes.

1.2. Current theoretical gaps and research objectives

In addition to the empirical need for more studies of vulnerability on Indonesia's volcanoes as described above, this thesis addresses specific gaps in the way studies of vulnerability are predominantly undertaken. In particular, many past studies downplay or overlook political and expert representations of risk (Donovan, 2017; Gould et al., 2016; Mustafa, 2005; Rebotier, 2012; Watts, 1997), and the local livelihood realities that influence risk-taking behaviour (Bachri et al., 2015; Kelman and Mather, 2008). While a more in-depth discussion is reserved for the following chapter, these research gaps, and how they have informed the research objectives addressed within this thesis, are outlined below.

1.2.1. Access to, and political representations of, hazardous land: Making of the Dieng 'hazardscape'

Within disaster scholarship, attempts to better understand and inform policies aimed at reducing vulnerability largely draw on Wisner et al.'s (2004) access model. According to this framework, vulnerabilities are produced through the processes that allocate assets and through this, preparation and coping mechanisms, within a society. By relating vulnerability to the economic necessity of inhabiting dangerous locations, this framework is well suited to the study of agrarian societies in volcanically active landscapes such as the Dieng Plateau. However, there are limitations to the processes this framework captures, primarily its tendency to overlook political processes (Middleton and O'Keefe, 1998; Watts, 1997), specifically

how political representations of risk and the governance of hazardous land, can influence vulnerability to natural hazards.

This tendency to overlook politics in studies of vulnerability is exemplified in the UNISDR's definition of vulnerability, which acknowledges the role of social, economic and environmental factors, yet omits any reference to political processes (UNISDR, 2015, p. 10). While the politics of vulnerability is not always captured in disaster studies, other authors have demonstrated that political representations of risk influence how the state responds to disasters and manages hazardous land (Bankoff, 2001; Collins, 2009; Gould et al., 2016; Mustafa, 2005; Rebotier, 2012). These political representations frame hazardous land as 'unpredictable' and in need of state control, often leading to the reinforcement of overly technocratic solutions (Gould et al., 2016; Rebotier, 2012). With Indonesia's history of relocating the Javanese to the outer islands following volcanic eruptions, studies of how the state governs hazardous land and the impact of this on vulnerability are therefore particularly insightful.

My first research objective thereby aims **to understand how access to, and claims made over land has influenced conditions of vulnerability to natural hazards in the Dieng Plateau**. This objective applies the 'hazardscape' framing (Mustafa, 2005), to understand how vulnerabilities are co-produced through the unequal distribution of land resources (Wisner et al., 2004), as well as through the state representations of, and intervention in, hazardous space, which can lead to technocratic and expert defined solutions to disaster management (Collins, 2009; Mustafa, 2005; Rebotier, 2012).

1.2.2. Local livelihood transformations in hazardous areas

While my first research objective aims to explain the construction of vulnerability by unravelling the processes that govern access to hazardous land in the Dieng Plateau, I have yet to acknowledge the role of local processes and capacity to bring about change and resist conditions of vulnerability. Various authors have described how farmers throughout the globe demonstrate capacity and adaptability as they innovate and survive

under challenging conditions (Davies, 1996; Ellis, 2000; Netting, 1993). Yet within disaster scholarship, these livelihoods are still frequently painted in a negative light and studies often assume that livelihoods are forced upon people rather than the result of active choices made to improve living conditions. This bias is highlighted in Wisner et al. (2004) who argue: 'People live in adverse economic situations that oblige them to inhabit regions and places that are affected by natural hazards, be they the flood plains of rivers, the slopes of volcanoes or earthquake zones' (p. 5).

There is a greater need to understand livelihoods from an integrated perspective, considering both the good and bad outcomes that accrue through partaking in livelihoods in hazardous environments. This is exemplified in the many studies that describe how communities are often drawn to hazardous locations, particularly volcanic slopes, due to the availability of profitable livelihoods in these areas (Donovan, 2010; Donovan et al., 2012a; Gaillard, 2008; Laksono, 1988; Lane et al., 2004; Mei and Lavigne, 2012; Seitz, 1998; Usamah and Haynes, 2012). Excluding the works of Kelman and Mather (2008) and Bachri et al. (2015), livelihoods studies within the disaster literature assume that livelihoods in hazardous areas are 'unsustainable' or 'risky' (see Wisner et al., 2004) and often rely on a simple set of indicators (see Ashley and Carney's 1999 discussion of the human, social, physical, financial and natural capital asset pentagon) to measure what are generally more complex livelihood processes (Scoones, 2015). The commonly applied 'stress and shock' terminology used within this work also implies that disasters are unusual exogenous occurrences rather than the manifestation of daily risks (see Bankoff, 2007; Hellman, 2015; van Voorst, 2015). Furthermore, these studies overlook the influence changing modes of agricultural production have on livelihood outcomes at the local level (for a counter example from the agrarian transformations literature see Rigg et al., 2016a).

My second research objective is thus concerned with **how the livelihood and agrarian transformations witnessed in the Dieng Plateau over the past decades have contributed to and/or alleviated conditions of**

vulnerability to natural hazards. To address this research gap, I combine a broad scale analysis of the potato crop boom (Hall, 2011a; Li, 2014; Mahanty and Milne, 2016; Vandergeest, 2008), with localised conditions of vulnerability by drawing on livelihoods approaches found within agrarian focused scholarship (Rigg, 2007; Rigg and Vandergeest, 2012). This integration of the livelihoods and agrarian change literature presents a nuanced picture of present vulnerability in volcanic landscapes, especially those that are characterised by changing modes of agricultural production. While the first two research objectives have related vulnerability to issues of land and livelihoods, my final objective focuses on how this vulnerability is defined and responded to from the perspective of local and expert actors, as discussed below.

1.2.3. The 'divide' between local and expert disaster knowledge

Following the successful self-evacuation of residents on the island of Simeulue, offshore Sumatra during the 2004 Indian Ocean Tsunami, an increased awareness of the importance of local disaster knowledge arose in academic and development contexts. A plethora of studies demonstrate the depth of disaster knowledge held by local communities that helps them to prepare for, and overcome, the impact of natural hazards (Dekens, 2007; Cronin and Cashman, 2007; Gaillard et al., 2008; King et al., 2007; McAdoo et al., 2006). The 2015 Sendai Framework for Action calls for the integration of 'traditional' and scientific knowledge, and many recent works argue for better platforms for the exchange of knowledge between different actors (Cadag and Gaillard, 2012; Gaillard and Mercer, 2012; UNISDR, 2015; Weichselgartner and Pigeon, 2015). However, while these studies have certainly taken a useful direction, they often present extreme or isolated examples (see Donovan et al., 2012a; Gaillard et al., 2008; McAdoo et al., 2006; UNISDR, 2008), overlook the contextualised and hybridised nature of knowledge in today's interconnected world (such as the works of Bird et al., 2009; Dominey-Howes and Minos-Minopoulos, 2004; White et al., 2001) and neglect to address the socio-political and disciplinary biases that influence

the construction of expert disaster knowledge (see Jasanoff 1987, 1990, 2003, 2007).

The embedded and contextualised nature of disaster knowledge is yet to receive adequate research attention, particularly in volcanic landscapes. As Dove (2008) argues 'not just the perception of risk, but the very concept of risk itself can vary' (p. 329). The meaning of risk is influenced by political, economic and cultural concerns and affects the types of interventions that are designed by state officials and the choice of action undertaken by communities in the preparedness and response phases (see also Dove, 2008; Donovan et al., 2012a; Kasperson et al., 1988; Laksono, 1988; Pannell, 1999; Slovic, 1999). By overlooking the locally contextualised nature of local disaster knowledge, disaster practitioners have in the past assumed that through better educational campaigns, 'at risk' communities will respond in a expertly pre-conceived appropriate manner (see Faupel et al., 1992; Dominey-Howes and Minos-Minopoulos, 2004; Bird et al., 2009). Case examples from Indonesia and New Zealand, however, contradict this assumption and highlight that other socio-economic processes influence participation in, and prioritisation of, DRR activities (Janssen and Holden, 2011; Paton et al., 2000; Paton et al., 2001; Paton, 2003).

Alongside the need for more contextualised studies, there is also a tendency to assume that local knowledge is separate from, or in opposition to, expert or scientific knowledge. Current disaster frameworks tend to assume that scientific knowledge is rational and objective, while local knowledge is perceived as irrational and subjective (Schwarz, 2014). This separation is demonstrated in Cronin et al.'s (2004) participatory study of volcanic hazard management who argue, 'In the case of Ambae, Vanuatu, the gulf between scientific and local perspectives is even greater, beginning with fundamentally different world-views and beliefs' (p. 666). It is further exemplified in the UNISDR's call that traditional knowledge should 'complement' scientific knowledge; a statement that assumes an underlying separation between these perspectives (UNISDR, 2015, p. 15). However, in contrast with these dominant views, Berkes et al. (2000), Nygren (1999) and

Shannon et al. (2011) all argue that local and scientific wisdom do not necessarily contradict one another. Drawing on examples from Indonesia and Thailand, various other authors have described how local disaster knowledge is a hybrid system with scientific explanations informing and coexisting alongside cultural-religious interpretations of disaster events (Rigg et al., 2005; Schlehe, 2010; Shannon et al., 2011).

Bryant (1998) argues that political ecologists have 'paid inadequate attention to the complex development traits and interests of different types of organisations' acting in their regions of study (p. 90). This research gap is particularly evident for the study of disaster management institutions operating in Indonesia (for some counter examples focusing on Montserrat see Donovan, 2017; Donovan et al., 2012b; Donovan and Oppenheimer, 2015). Jasanoff (1987, 1990, 2007) and Rowe and Wright (2001) argue that experts do not necessarily possess a more accurate representation of actual risks. While local knowledge has received renewed research attention, the same level of focus is yet to be directed towards understanding the limitations to expert disaster knowledge.

My third research objective therefore aims **to understand local and expert disaster knowledge as contextualised systems, focusing specifically on how these systems are locally produced and where they contradict, interrelate and inform one another.** This approach draws on the local ecological knowledge field of literature to recognise that disaster knowledge is locally contextualised and embedded (Agrawal, 1995; Goldman, 2007; Turnbull, 2000), while also a hybridisation between local and expert views (Shannon et al., 2011).

1.3. Research questions and principle findings

The overarching objective of this thesis is thereby to better understand, and provide new conceptual and policy insights, into the varied pathways through which vulnerability is constructed, and overcome, in one of Indonesia's many-understudied volcanic landscapes. To address this, and the

research objectives outlined above, I ask a number of sub-questions that stem from, and respond to, the current empirical and theoretical limitations. The first research question asks:

1. What socio-economic and political processes have determined access to hazardous land, and through this, influenced past and present conditions of vulnerability to natural hazards (or the making of the 'hazardscape') in Central Java's highlands?

To answer this research question I describe the historic socio-economic and political processes that have facilitated expansion into the Dieng Plateau, including the way state-led representations of 'hazardous space' have contributed to local vulnerabilities. The first component to my response describes the social, economic and political processes that have influenced the past and present development of hazardous land. I apply the access model (Wisner et al., 2004) to describe how the Javanese historically settled the Dieng highlands, including how Dutch colonial and New Order Regime policies intensified land pressures in the lowlands and encouraged the cultivation of largely export driven commodity crops in Java's highlands (Boomgaard, 1999; Li, 1999a; Hefner, 1990). I then describe how hazardous land is unequally distributed within the Dieng Plateau, with the poorest farmers often tied to farming land parcels situated in closest proximity to active craters or on the upper landslide prone slopes.

However, this research question also seeks to understand how political framings of risk influence access to hazardous land in the Dieng Plateau. To address this, I combine the access model (Wisner et al., 2004) with Mustafa's (2005) 'hazardscape', which argues that vulnerability is also produced through the power or control governments exert over social spaces. In the Dieng example, the making of the hazardscape draws on the concept of internal state territorialisation (Peluso, 2005; Peluso and Vandergeest, 2001; Vandergeest and Peluso, 1995) to describe how the Indonesian state has historically used volcanic eruptions as a catalyst to claim ownership and

governance over areas demarcated as 'hazardous' by state bureaucracies. During the 1970s the Indonesian state reinvigorated its transmigration program, with the aim of resettling people from the densely settled islands of Java, Madura and Bali to the outer, less developed archipelago (Eaton, 2005). While this state representation of risk allowed it to enforce relocation and achieve ambitious transmigration targets, the territorial zones that facilitated transmigration were locally contested, leading to the reoccupation of hazardous land with mixed outcomes for overall conditions of vulnerability.

My second research question is concerned with how local processes and capacity have acted against the historic and structural constraints to vulnerability that are addressed in my first research question. This research question asks:

2. How have the livelihood transformations witnessed in the Dieng Plateau over the past decades influenced present conditions of vulnerability and capacity to manage the impact of natural hazards?

To answer this research question I look at the processes that have led to the potato crop boom and how this boom has impacted local conditions of vulnerability and/or capacity. During the mid-1980s a major agrarian shift transformed the Dieng highlands and tobacco and subsistence crops were rapidly replaced with potatoes and other cool climate vegetables. Grown largely for domestic consumption, the potato and other secondary cool climate vegetables such as carrots, cabbages and onions, rapidly transformed living standards. In answering this second research question, I draw on the agrarian transformation literature (Hall, 2011a; Li, 2014; Mahanty and Milne, 2016; Vandergeest, 2008), to describe the conjuncture of social, environmental, economic and political processes that facilitated the potato boom.

As livelihoods and capacity research deals with the sustainability of agriculture in hazardous localities, this question is also concerned with the future sustainability of the potato industry in the Dieng Plateau. I respond to this by discussing the environmental consequences of the potato boom,

demonstrating that potato farming is not always, or only, an unsustainable livelihood activity (see Forsyth and Walker, 2008). Furthermore, I discuss the district government's response to the environmental impacts of the boom, and how by attempting to constrain livelihood outcomes, these actions can also unintentionally introduce vulnerabilities. The final component to this research question is concerned with the costs and benefits of potato farming and how these produce or counteract local vulnerabilities. I address this by drawing on livelihoods studies in the agrarian literature to describe how potato livelihoods have interacted with vulnerabilities and the many processes (such as livelihood diversification or migration) that rural potato farmers employ to overcome them (Dorward et al., 2009; Rigg and Vandergeest, 2012).

My third and final research question focuses on the construction and practice of disaster knowledge from the perspective of local farmers and the expert organisations acting in the Dieng Plateau. This coupled research question asks:

3. How is local and expert disaster knowledge constructed, interpreted and acted on in the Dieng Plateau? How do these forms of knowledge interact and contribute to volcanic risk reduction strategies that either reduce or increase conditions of vulnerability?

To answer these research questions I describe how both local and expert disaster knowledge is constructed and the actions that this knowledge informs. The first component focuses on how local disaster knowledge is produced and enacted. I respond to this by explaining how volcanic hazard is understood locally as a geophysical process that can be managed on a daily basis through local wisdom and scientific information, while also viewed as untameable phenomena. The second component asks how expert disaster knowledge is constructed, focusing on the institutional biases that shape its formation and the way this knowledge is shared. My response analyses the activities of the District Disaster Management Agency (BPBD) and the Centre for Volcanic and Geological Hazard Mitigation (PVMBG). I describe the

constraints on, and the limitations to, this expert knowledge including the way Indonesia's district disaster management agencies favour the production of technocratic knowledge and the intrinsic uncertainties associated with scientific risk assessment (Jasanoff, 1987; 1990; 2003; 2007).

These final research questions draw their theoretical underpinnings from the literature on local ecological knowledge (LEK) (Agrawal, 1995; Berkes et al., 2000; Goldman, 2007; Nygren, 1999) and descriptive studies of disaster knowledge (Bachri et al., 2015; Donovan et al., 2012a; Gaillard et al., 2008; Rigg et al., 2005; Schlehe, 2010; Shannon et al., 2011). I demonstrate that local and expert knowledge are not binary opposites that need to be integrated but rather a hybrid space that interacts, is subject to disciplinary biases, and influenced by science, worldview, and economic realities. These findings provide important advice for developing a more contextualised platform for dialogue between local and expert producers and users of disaster knowledge to take place.

As the theoretical and empirical premise underlying the field of political ecology argues that such research should actively inform the policy arena (Forsyth, 2008; Neumann, 2008; Rocheleau, 2008; Walker, 2006; Wisner et al., 2004), the research questions and findings I have outlined above are later drawn on within the conclusion chapter of this thesis to arrive at a discussion of policy implications. These focus on the need for holistic volcanic risk management that recognises how livelihoods can reduce vulnerabilities despite official representations of such livelihoods as 'unsustainable'. Furthermore, I discuss the role of the district government in community-based DRR activities and how local livelihood priorities can contradict the aims of such programs. I describe the immensity of the task handed to the BPBD and how its current institutional and operating environment make achieving ambitious DRR targets, specifically those tied to vulnerability reduction, unlikely. I then focus on issues of disaster knowledge sharing between expert and local actors, discussing the need for more perspectives that recognise the locally contextualised and hybrid nature of this disaster knowledge.

1.4. Chapter overview

While the present introductory chapter has laid the foundations for this thesis, the theoretical gaps that have informed my formulation of research questions are more comprehensively outlined in the following literature review of Chapter 2. This coming chapter discusses past and present approaches to the study of vulnerability in hazardous landscapes, and describes how frameworks from related political ecology fields of inquiry, specifically territorialisation, agrarian transformation and local ecological knowledge, can expand theoretical explanations of vulnerability within a disaster context. In Chapter 3, the largely qualitative methodologies I employed to answer my research questions are described, alongside a description of the particular field sites studied. Chapter 4 provides an overview of the history of natural hazard events in the Dieng Plateau, focusing on the human and livelihood impacts of explosive volcanic eruptions and effusions of poisonous volcanic gas.

In Chapter 5, I respond to my first research question and describe how access to land, facilitated by historic socio-economic and political processes, including political framings of risk, has influenced conditions of vulnerability to volcanic hazards. In Chapter 6, I answer my second research question applying a more localised lens to argue that overall the potato boom has reduced conditions of vulnerability for many farmers, endowing them with the capacity to better-overcome livelihood disturbances, hazard induced or otherwise. Chapter 7 addresses my final research questions and describes the construction of both local and expert disaster knowledge, describing how these systems, while unique on various fronts, are not contradictory but actively inform the other. In Chapter 8, I conclude the thesis with a discussion of the conceptual and policy implications of this study, arguing that the integrated study of vulnerability can contribute to a more holistic, practical and contextualised approach to volcanic risk reduction. By describing the historic and contemporary processes that dictate occupation of hazardous land, alongside an analysis of the local and expert understandings that influence risk mitigation activities, this thesis presents an integrated

approach to the study of vulnerability. Not only does this approach bear important insights for the contextualised management of hazards in the Dieng Plateau, but lessons can be drawn for other highland volcanic areas throughout Indonesia, particularly those associated with intensive agricultural production.

2. Theoretical foundations

Disaster scholarship has made many theoretical advances over the past decades. Where disasters were once viewed exclusively as the outcome of a geophysical event, they are now seen as the nexus of a natural hazard with conditions of vulnerability (Hewitt, 1983; O'Keefe et al., 1976; Wisner et al., 2004). Within the disaster literature, vulnerability is most commonly theorised as a lack of access to the resources needed to resist the impact of natural hazards largely driven by social, economic, environmental and political marginality (Burton et al., 1978; Cannon, 1994; Kates, 1971; Hewitt, 1983; Wisner et al., 2004). Over time, these studies of vulnerability have come to incorporate livelihoods perspectives, and the influence local capacity and resiliency have on conditions of vulnerability (Anderson and Woodrow, 1989; Chambers and Conway, 1992; Davis et al., 2004). This shift responds to an increased recognition of people's agency and the willingness of many to pursue livelihoods in hazardous locations (Cannon, 2008). However, despite these many theoretical and practical advances, global vulnerabilities and disaster losses are continuing to rise (Gaillard and Mercer, 2012; Jha and Stanton-Geddes, 2013; O'Keefe et al., 1976; White, et al., 2001).

Bearing in mind this trend of rising global vulnerabilities and disaster, the forthcoming review of literature outlines the foundations of current disaster scholarship while also identifying the theoretical gaps and areas warranting further study that have informed my research questions. I highlight three empirical and conceptual gaps within contemporary disaster scholarship namely: i) the need for more studies that address how political framings of risk can impact local vulnerabilities, ii) the shortage of research that uncovers the costs and benefits of agrarian transformations occurring in hazardous areas, and iii) the scarcity of studies that adequately address the contextualised nature of disaster knowledge, particularly those with a focus on expert knowledge systems. In this chapter, I describe how these thematic areas can build on, and contribute to, vulnerability research in disaster

scholarship, before concluding with a schematic operationalisation of how they are utilised within this thesis.

2.1. The foundations of disaster scholarship

The forthcoming section will outline the classic foundations of current disaster scholarship, focusing predominantly on frameworks of vulnerability. I provide an overview of the theory of access to resources (Wisner et al., 2004), followed by the more recent contributions of livelihoods (Chambers and Conway, 1992), capacity and resiliency (Anderson and Woodrow, 1989; Davis et al., 2004) research. I discuss how these approaches are grounded in political ecology, and trace their evolution as scholars have acknowledged the way local agency allows communities 'at risk' to resist and rework their situation.

2.1.1. Classic approaches to the study of vulnerability

Political ecology has formed a conceptual foundation for studying disasters since the 1980s (Comfort et al., 1999; Hewitt, 1983; Pelling, 1999; Wisner et al., 2004). Prior to this time disasters were understood as extremes in geophysical activity requiring what Hewitt (1983) referred to as 'technocratic interventions'. These technocratic approaches to disaster management focus on the technical tasks of monitoring, warning and detection, or engineering efforts (such as the construction of flood canals), while overlooking the social vulnerabilities that worsen disaster impact (Hewitt, 1983). While the 'paradigm shift' of disaster research began to emerge during the 1970s with the works of Kates (1971), Burton et al. (1978) and White (1974), it gained considerable momentum following the early political ecology works of the 1980-90s (Hewitt, 1983; Blaikie et al., 1994). From this time onwards, scholars have argued that disasters are the combination of a physical hazard event with the social, political and economic factors that create conditions of vulnerability (Susman et al., 1983), a definition that still broadly applies today. Disaster risk is still widely recognised as a function of a hazard with underlying societal vulnerabilities,

most commonly conceptualised by Wisner et al.'s (2004) pseudo-equation:

$$\text{Risk} = \text{Vulnerability} \times \text{Hazard}$$

Vulnerability studies occupy a prominent position in disaster scholarship and these are heavily guided by the theoretical foundations first described in Blaikie et al. (1994), later republished as Wisner et al.'s (2004), work 'At Risk'. Wisner et al. (2004) define vulnerability as 'the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard' (p. 11). This vulnerability framework considers the factors that place someone's life and livelihood at risk and is influenced by social markers such as gender, class, age and ethnicity (Cannon, 1994; Wisner et al., 2004). A more recent definition of vulnerability is provided in the UNISDR 2015 Sendai Framework for Action as: 'The conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impacts of hazards' (p. 10) (UNISDR, 2015). While both definitions link vulnerability to the wider processes that influence the degree of harm or susceptibility an individual or group experiences due to a hazard event, the UNISDR approach is constrained by its omission of the political drivers of vulnerability.

To capture the processes involved in the construction of vulnerability, Wisner et al. (2004) present the access to resources framework as: 'the way unsafe conditions arise in relation to the economic and political processes that allocate assets, income and other resources within a society' (p. 92). This framework recognises that disasters are not static over time and that impacts are typically differentially experienced between households based on underlying conditions of vulnerability. The approach presented in Wisner et al. (2004) has its theoretical foundations in the earlier political ecology works of Blaikie (1985) and Blaikie and Brookfield (1987) wherein the soil degradation problem of Nepal was explained in terms of a multi-scaled political contestation over natural resources. These works rely on 'chains of explanation' (Blaikie, 1985) or a process of 'progressive contextualisation'

(Vayda, 1983) to explain the construction of environmental risks and vulnerability. Wisner et al.'s (2004) access framework is also rooted in Sen's (1983) entitlement theory and related to Watts and Bohle (1993), Bohle et al. (1994) and Adgar and Kelly's (1999) conceptualisation of vulnerability as a multi-dimensional space wherein the poor are more likely to suffer the impacts of harmful disturbances (such as famine or natural hazards). The access theory is now widely applied within the disaster literature to describe the unequal impacts of disasters across many geographical settings and hazard types as discussed below.

Within the disaster literature, the theory of access considers the broad range of resources needed to adequately prepare for, and overcome, the impact of disasters. These may include, but are not limited to, land relations, livelihood opportunities, economic reserves, disaster knowledge and political representation. For example, studies conducted in coastal Bangladesh and the Philippines, reveal that access to land is constrained by political marginalisation and population growth, which has forced the poorest people into the most hazardous locations (Dove and Khan, 1995; Gaillard et al., 2007). This pattern was also observed during the impact of the 1976 Guatemala earthquake and 1974 Honduras hurricane Fifi, wherein marginalisation and underdevelopment forced peasants to build poorly constructed homes in vulnerable locations (such as steep slopes adjoining rivers) (Susman et al. 1983). These pre-existing inequalities leave fewer resources to adapt to hazardous events (see Winchester's 2000 study of flood impacts in India) and can hamper relief efforts (as occurred following the 1994 California earthquake described in Bolin and Standford 1999). Alongside access to land and livelihoods, vulnerability is also exacerbated by a lack of access to, and sharing of, specialist scientific knowledge (see Degg and Homan 2006 on earthquake hazard in Egypt). Furthermore, access to resources varies within a society and factors such as 'race', class, gender and ethnicity all influence vulnerability and disaster impact (Bolin, 2007; Wisner et al., 2004).

Importantly, vulnerability is also understood as the product of cumulative decisions made over an historical time frame (Comfort et al., 1999). For example, the devastation caused by Hurricane Mitch in 1998 in Nicaragua and Honduras is related to existing vulnerabilities caused by the clearance of old growth forest for coffee and banana plantations as well as the austerity measures enforced by international financial institutions that contributed to a lack of local government capacity (Comfort et al., 1999). Oliver-Smith's (1999) study of the 1970 Peru earthquake further extends this historical causal chain of analysis, arguing that the devastation was caused by Peru's severe state of underdevelopment, which began with the colonisation of Peru and its sudden insertion as a colony into the world's economic system. Traditional Peruvian adaptation measures such as the construction of earthquake resistant buildings and spreading of agricultural resources over a wide area were replaced with the construction of dense towns with narrow streets that were subsequently highly vulnerable to floods, earthquakes and volcanic activity. Likewise, Pelling (1999) relates vulnerability to flood hazard in urban Guyana to historical colonial programs that cleared and developed mangrove swamps.

The studies outlined above demonstrate how the structural factors of marginalisation, ethnicity, inequitable distribution of land, and population pressure have constrained certain groups to occupy hazardous locations while leaving them fewer resources to relocate, withstand and recover from hazardous events. While there are many more studies that describe the structural causation of vulnerability, the literature cited above suffices to demonstrate the often deeply historical relationships between access to resources, as defined by social, economic, environmental and political processes, and conditions of vulnerability.

2.1.2. Recent advances following the 'paradigm shift'

Recent disaster scholarship has built on the foundations outlined above to better understand the nuances of vulnerability through the concepts of livelihoods, capacity and resiliency. This shift is an attempt to move beyond

frameworks that focus on the structural constraints of vulnerability, towards a greater recognition of people's agency and the willingness of many to pursue livelihoods in hazardous locations (Cannon, 2008). Within disaster scholarship, this focus on localised processes opens questions about how people living in potentially hazardous locations make decisions about what constitutes acceptable risk, and in doing so contributes significant detail to the vulnerability framework.

Criticism of the access model (Wisner et al. 2004), and political ecology's attempts to describe land degradation more generally (Blaikie, 1985; Blaikie and Brookfield, 1987), argues that it treats the political economy as a set of completely 'exogenous' factors that the local community have little control or influence over (Peet and Watts, 1996). Various other authors have argued that there is a tendency within some disaster scholarship to focus on people's weaknesses, portraying them as victims who are unable to instigate change (Hellman, 2015; Torrence and Gratton 2007; Wisner et al., 2004). Even Wisner at al. (2004) acknowledge that by overlooking capacity their definition of vulnerability tends to 'emphasise people's weaknesses and limitations, and is in danger of showing people as passive and incapable of bringing about change' (p. 14). Furthermore, some have argued that studies of access detach overarching political and economic processes from local culture or livelihood realties that can encourage or support local risk-taking behaviour (Cannon, 2008; Nooteboom, 2015). Nooteboom (2015) in particular argues that poor people can have good reasons for regularly taking risks. Livelihoods perspective research is a reaction to these criticisms, providing a means to describe how people work with, struggle against, or rework their situation (Rigg, 2007).

The livelihoods frameworks of Chambers and Conway (1992) and Scoones (1998; 2015) are widely applied within the disaster and agrarian transformation literatures to understand rural vulnerabilities (for some examples see Ashley and Carney, 1999; Dorward et al., 2009; Goldman et al., 2000; IFRC, 2007; Kelman and Mather, 2008; Leach et al., 1997; Rigg, 2006, 2007; Rigg and Vandergeest, 2012; Sanderson, 2012; Twigg, 2001). A

sustainable livelihood is one that is able to cope with and recover from stresses and shocks while maintaining the resources needed by future generations to secure a livelihood (Chambers and Conway, 1992). Rather than referring specifically to a disaster, livelihood approaches refer to 'shocks' and 'stresses' that disturb the functioning of everyday life. An additional livelihoods approach that I will draw on later in this thesis is Dorward et al.'s (2009) 'stepping up', 'stepping out' and 'hanging in' classification. As I will demonstrate in Chapter 6, this schema offers a more flexible approach to capture the multiple livelihood aspirations and strategies of the poor, especially in the context of changing agrarian relations (see also Pritchard et al., 2017).

While these livelihoods approaches have provided a useful step forward, various critiques of livelihoods frameworks are still found within the literature. Wisner et al. (2004) argue that the definition of a 'sustainable livelihood' implies that disasters are caused by unsustainable livelihoods, which is not always true. Livelihoods approaches also tend to represent disasters as extreme or unusual events, rather than the manifestation of daily risks as highlighted by Bankoff (2007), Hellman (2015), and van Voorst (2015). Forsyth (2007) argues that sustainable livelihood approaches can enable 'environmental interventions around more meaningful, locally governed notions of risk' (p. 12), but only if government led narratives do not overpower them. Furthermore, Scoones (2015) argues that the asset pentagon frequently applied to livelihood studies is limiting, neither comparable nor measureable, and often time wasting particularly if applied rigidly (for some examples see Ashley and Carney, 1999).

Despite the shortcomings noted above, I forward that the livelihoods perspectives, without necessarily applying an asset pentagon, can still provide a useful framework to understand vulnerability and how risk is experienced at the local level. Past literature demonstrates that livelihoods influence risk perception and can encourage vulnerable populations to take greater risks for economic gains. For example, Hellman (2015) argues that for the urban poor living on Jakarta's flood prone riverbanks there is a

constant trade-off between safety and risk taking behaviour for the purpose of making a living. Likewise, the availability of productive livelihoods has attracted many people to the slopes of volcanoes in the countries of Ecuador (Lane et al., 2004), Indonesia (Bachri et al., 2015; Donovan, 2010; Donovan et al., 2012a; Laksono, 1988; Mei et al., 2013), the Philippines (Gaillard, 2008; Seitz, 1998; Usamah and Haynes, 2012) and the British territory of Montserrat (Haynes et al., 2008a), and encourages their re-settlement following eruptions, despite government intervention and provision of relocation sites. In the Philippines, both Pinatubo and Mayon volcanoes attract farmers due to the better economic conditions that can be achieved by farming these volcanic slopes, particularly in comparison to the lowlands (Gaillard, 2008; Seitz, 1998). These economic benefits encourage farmers to take risks near a volcano and can lead them to perceive the hazard as more tolerable, as observed in Montserrat (Haynes et al., 2008a) and Central Java (Lavigne et al., 2008). Volcanic eruptions can also support agricultural development, as evidenced in the shift from subsistence agriculture to market oriented livestock husbandry following the 1994 eruption of Mount Merapi (Dove and Hudayana, 2008), and the continued eruptions of Bromo in East Java, which build soil fertility and support agricultural yields (Bachri et al., 2015; Hefner, 1990).

While livelihoods are shown to be a key determinant encouraging the settlement and resettlement of volcanic areas, few studies have focused on the positives gained through accessing these livelihoods (for a counter example see Bachri et al., 2015). However, as Burton et al. (1978) articulated, people do not just persist in hazardous environments, 'they survive and prosper there' (p. 4). The capacities earned through participating in livelihoods in hazardous areas are particularly salient for volcanic landscapes. Volcanoes provide valuable livelihood resources including fertile soils, water supplies and mining opportunities (Bachri et al., 2015; Baxter, 2005; de Belizal et al., 2013; Kelman and Mather, 2008). Furthermore, many volcanic hazards have a long recurrent interval meaning livelihoods are only infrequently disturbed. An exception to the sustainable livelihoods literature

that tends to paint livelihoods in hazardous areas in a negative light is found in Kelman and Mather (2008) who acknowledge the livelihood opportunities provided by volcanoes and promote an approach that supports communities to better live with, and respond to, volcanic risks (Table 1). This work represents a holistic approach to volcanic risk reduction whereby local priorities are incorporated into risk analysis. Kelman and Mather (2008) advocate for living with risks through better community-based preparedness and response planning. Furthermore, they acknowledge that physical defence mechanisms do not always reduce risk and that relocation is predominantly an unfeasible task and often unviable from the perspective of smallholder farmers.

Table 1. Kelman and Mather's (2008) various options and implications for dealing with environmental hazards.

Option for dealing with environmental hazards	**Main implications**
1. Do nothing.	Disasters occur.
2. Protect society from hazards.	Not always feasible and leads to risk transference which augments vulnerability.
3. Avoid hazards.	Not always feasible and can exacerbate other problems, augmenting vulnerability.
4. Live with hazards and risks.	Livelihoods are integrated with environmental threats and opportunities.

The framework of capacity provides a means to study the benefits alongside the vulnerabilities incurred by partaking in livelihood activities in volcanic landscapes and avoids treating populations as passive victims (see Anderson and Woodrow, 1989). While use of the term capacity emerged along with vulnerability in the 1970s, its application expanded from the 1990s onwards in rejection of the negative connotations of vulnerability that assume an inability on behalf of the poor to re-work their situation (Gaillard, 2010). Capacity refers to the resources and assets people possess to resist, cope with and recover from disasters (Davis et al., 2004). Importantly, capacity is not situated at the other end of a spectrum with vulnerability (Davis et al., 2004) and communities can be subject to many attributes that increase

vulnerability whilst also possessing capacity. A recent study by Ribot (2014) argues that similar to vulnerability, capacity should be understood in the context of the broader political economy, calling for a 'causal-chain, progressive-contextualisation analysis of causes of capacity – rather than just viewing capacity as an explanation' (p. 679). Such an approach considers the source of capacity as an ongoing process, rather than reducing it to the measureable and static assets captured in some sustainable livelihoods frameworks.

Resilience research represents a related, yet epistemologically separate, concept through which to understand how people respond to, and overcome hazards (Miller et al., 2010). While the concept of resilience does not form a main theoretical framework within this thesis, I nonetheless draw on findings from other authors who have undertaken resilience-focused research. Pelling (2011) argues that resilience refers to the way social and ecological systems cope with shocks and stresses and maintain their capacity to function in a changing environment (Pelling, 2011). Distinct from vulnerability approaches, it focuses on local-level, positive transformations that can be upscaled to action change (Miller et al., 2010), with many examples now found within disaster scholarship (see Gaillard, 2007). For example, Benight (2004) and Paton et al. (2001) have described collective efficacy as a resilience mechanism used to overcome the impacts of floods in Colarado and eruptions of Ruapehu, New Zealand, respectively. Bankoff (2004) describes how cultural attributes in the Philippines, including story-telling and joke-making following a disaster, build resiliency and facilitate psychological recovery. These attributes are not homogenous within a society, demonstrated particularly by the many and varied capacities people living in flood prone areas of Jakarta draw on to prepare for, and adapt to, flood events (van Voorst, 2015). Disaster resilience is also linked to worldview and various authors have explained how religion helps to create social cohesion, overcome anxiety, promote psychological recovery and acts as a conduit for disaster education (Cashman and Cronin, 2008; Chester et al.,

2012; Gaillard and Texier, 2010; Kwilecki, 2004; Mitchell, 2003; Schmuck, 2000; Taylor, 2001; Wisner, 2010).

Benadusi (2014) cautions against the uncritical use of the term 'resilience', warning that it can place excessive onus on communities, ultimately shifting responsibility away from the state organisations that should be responsible for public safety. Likewise, Weichselgartner and Kelman (2010), posit that resilience thinking should move towards addressing questions of structural socio-political processes. Rather than a focus on resilience, this thesis employs both the concepts of vulnerability, which acknowledges the overarching structural processes that influence local livelihood and hazard outcomes, with the concept of capacity and the livelihoods approaches, which recognise that people possess the tools to fight against conditions of vulnerability. My choice of terminology is now described briefly below.

2.1.3. Choice of terminology applied within this thesis: Natural hazard, vulnerability, capacity, resiliency and risk

Various definitions and use of the terms vulnerability, capacity, natural hazard and risk are found within the disaster literature. In this thesis I rely largely on Wisner et al.'s (2004) definition of vulnerability as provided on page 21 above. This definition is widely applied within the disaster literature and, by also acknowledging the political construction of risk (in contrast to the UNISDR, 2015), is arguably the most comprehensive to date. The term 'natural hazard' is used to describe the geophysical phenomena, which in combination with conditions of vulnerability, produces disaster risk. This follows O'Keefe et al.'s (1976) seminal argument that there is nothing 'natural' about 'natural disasters' and supports the redundancy of this former term. My use of 'capacity' will follow the definition of Davis et al. (2004) provided earlier on page 27, and is viewed as a series of characteristics occurring in combination with, rather than on a spectrum against, conditions of vulnerability. This avoids oversimplification of the many and varied processes that determine how an individual or household is impacted by a disaster. While the term resiliency does not feature heavily throughout this

thesis, where it is used I refer to Pelling's (2011) definition provided on page 29 above. Following the argument of Ribot (2014), capacity is understood as a process of causation set in a historical-social context, similar to understandings of vulnerability (Wisner et al., 2004).

'Risk' is understood as the combination of a hazard with underlying conditions of vulnerability and capacity. I do not attempt to define risk as a quantifiable measure, but rather as the nexus of certain social, economic, political and environmental conditions and processes that interrelate to create disasters (Cutter et al. 2000; Wisner et al., 2004). While the focus of this thesis is to understand conditions of vulnerability/capacity, to exclude the hazard entirely and refer to vulnerability or capacity alone would contradict the theoretical groundings of political ecology (see Walker, 2005). A recent conceptualisation of the term 'risk' was presented in a 2015 special publication of Disaster and Prevention Management titled the 'Risky Everyday' (van Voorst, 2015). Phrases such as 'risk handling' and 'risk coping mechanisms' are applied extensively in this special edition as they refer to the daily mitigation and adaptation of *both* vulnerabilities and the natural hazard in question (see van Voorst, 2015; Hellman, 2015; Hilhorst et al., 2015). A similar approach will be taken in this thesis and risk will be conceptualised as a daily life event, rather than as a quantifiable and extreme occurrence.

2.2. Current debates and emerging themes for disaster scholarship

The discussion above has described the theoretical foundations that underpin current disaster scholarship. While this thesis draws heavily on these foundations, I have also expanded the disaster vulnerability framework to address current theoretical gaps and emerging schools of thought. The first responds to the call for more studies that consider how political representations of risk influence access to land, and through this, vulnerability to natural hazards (see Mustafa, 2005; Rebotier, 2012). The second responds to the shortage of studies that address local livelihood

outcomes in hazardous areas in the context of the costs and benefits accrued through rural integration with modern forms of agricultural production (for some counter examples in the field of social volcanology see Bachri et al., 2015, and for resource management more generally see Batterbury and Forsyth, 1999; Rigg et al., 2016a). The third responds to the paucity of studies that simultaneously consider the contextualised and integrated nature of both local and expert disaster knowledge (see Agrawal, 1995; Nygren, 1999; Shannon et al., 2011). I posit that these thematic areas offer the theoretical groundings to build current explanations of vulnerability in a case based setting.

2.2.1. The 'hazardscape'

The 'hazardscape' farmework has been applied in various disaster and vulnerability studies. Cutter et al. (2000) define the hazardscape as 'the interplay of social, political, and economic factors – interacting separately, in combination with one another, and with the physical environment – [that] creates a mosaic of risks and hazards that affect people and the places they inhabit' (p. 716). The hazardscape is closely aligned to the 'hazards of place' model that studies the distributive patterns of hazards and their underlying processes (Paul, 2011). The term 'hazardscape' has been applied in various studies, including a discussion of the place-based characteristics of volcanic hazards in Vanuatu and Hawaii (Cronin et al., 2004; Gregg et al., 2004), and a study of physical and perceived vulnerability to a range of hazards in Wellington, New Zealand (Khan et al., 2012). Furthermore, a modification of the term hazardscape to 'waterscape' has been used to describe the gender dynamics of flood hazard in Bangladesh (Sultana, 2010). While all of these studies acknowledge the role of place and perception in the construction of disasters, it was Mustafa (2005), and later Collins (2009), who expanded the hazardscape concept to include the contestation of power relations in hazardous geographies.

Using floodplain management in urban Pakistan as a case study, Mustafa (2005) argues that vulnerability is also a function of how 'hazardous

geographies are viewed, constructed and reproduced by the expert/technocratic discourses about them' (p. 566). Governments and donors exert power over social spaces and the contestation of this power also produces conditions of vulnerability (Mustafa, 2002, 2005). This argument is also demonstrated in Collins' (2009) study of the production of unequal flood risks at the US-Mexico border, wherein he argues that 'unequal risk is contingent upon how hazards are differentially perceived, represented, and contested in social spaces' (p. 589). Without explicit reference to the term 'hazardscape', various other authors have acknowledged that political narratives and power relations contribute to the construction of vulnerability. These include Bankoff (2001), Gould et al. (2016) and as will be discussed in the proceeding section on territorialisation, Rebotier (2012). Gould et al. (2016) studied disaster politics following the 2010 Chile earthquake, arguing that different representations of state-nature relations reinforced top-down and technocratic disaster reconstruction efforts. These representations reinforced the role of the state as a manager of an unpredictable and uncontrollable nature, and a financer of neoliberal development investments (Gould et al., 2016). Bankoff (2001) argues that vulnerability is a Western discourse used to render large areas of the world 'unsafe', justifying certain scientific and technocratic interventions into these so-called 'inferior' regions.

By acknowledging the impact political representations have on conditions of vulnerability, Mustafa (2005) and Collins' (2009) interpretation of the hazardscape provides a framework to capture the politics of vulnerability. This approach responds to both Middleton and O'Keefe (1998) and Watts' (1997) critique of political ecology and disaster studies and their tendency to omit the political causes of vulnerability. In Indonesia, a key process involved in building political framings of risk involves the state-identification of 'hazardous' land. As I will describe below, the concept of territorialisation can help explain how the state seeks to define and manage these geographic spaces, with often over-arching political purposes.

The territorialisation of natural resources and hazardous land

Sack (1986) defines territoriality as 'the attempt by an individual or group to affect, influence, or control people, phenomena, and relationships by delimiting and asserting control over a geographic area' (p. 19). The concept arose in the political ecology literature to describe the process through which the state gains 'control over natural resources and the people who use them' (Vandergeest and Peluso, 1995, p. 385). This form of territorialisation, which relies on the making of spatial boundaries, has been ongoing rapidly in Southeast Asian since the nineteenth century and in parallel with colonialism and the emergence of modern states. This process of spatial territorialisation is also driven by political framings of risk in hazardous geographies. For example, Rebotier's (2012) work in Latin America demonstrates that risk is both a material and discursive construction. The 'territorialisation of risk' framework presented in this study argues that territories are 'spaces where competing social meanings and identification are ascribed' (Rebotier, 2012, p. 391). By recognising the role of the state in making representations of, and claims to, hazardous land, I posit that the concept of internal territorialisation can also inform the hazardscape.

The geographical concept of territorialisation has been most widely described in Indonesia through the making of 'political forests' (Peluso, 2005; Peluso, 1992; Peluso and Vandergeest, 2001; Wadley, 2003). Peluso and Vandergeest (2001) define this form of territorial control as, 'the process by which governments demarcated specific territories as forest land, [and] claimed all resources in these territories as state property under the jurisdiction of a forestry department or its institutional equivalent' (p. 675). However, by overlooking local land tenure and land use conditions this form of territorialisation can increase local conditions of vulnerability (Kumar and Kerr, 2013). Various authors have demonstrated that these territories are not just imposed from governments, but can also emerge locally within resource management sites (Corson, 2011; Peluso, 2018). The local contestation of government defined territories has been described for the management of forests in the Dominican Republic (Holmes, 2014), Vietnam, (Sowerwine,

2004), and Kalimantan, Indonesia (Peluso, 2005; Wadley, 2003). The contestation of these territories is also illustrated in the disaster literature through Donovan et al. (2012c) who discuss the contested 'safe zone' on Montserrat, arguing that the making of boundaries is the result of a process of struggle and negotiation between expert and local actors.

While studies of the internal territorialisation of natural resources are widely found within the political ecology literature, excluding the work of Donovan et al. (2012c) and Rebotier (2012), the concept and analytical approach is underutilised within disaster studies. As much of disaster management relies on the spatial delineation of hazardous land, there is a need for more studies that examine how space and territory are constructed and the impact this has on recipient communities. This approach is particularly useful at the sites of volcanoes throughout Java, where in the past the state has enacted transmigration as a mechanism to shift people away from hazardous geographies (Dove, 2010; Laksono, 1988). Furthermore, this issue has contemporary relevance when considering the prolonged evacuation of communities from Mount Sinabung in North Sumatra and Mount Agung in Bali. The contribution the theory of territoriality provides to my explanation of the Dieng Plateau's hazardscape is presented in Chapter 5.

2.2.2. Agrarian transformations in hazardous areas

The second gap within disaster literature that this thesis responds to pertains to how agrarian transformations in hazardous areas impact local conditions of vulnerability. An agrarian transformation is broadly defined as the process through which small-scale agriculture shifts from diversified and subsistence production towards more specialised and intensive market oriented production (Kay, 2002; Staatz, 1998). In Chapter 6, I will demonstrate how integrating the livelihoods frameworks of Chambers and Conway (1992) and Dorward et al. (2009), with studies of agrarian transformation in Southeast Asia can provide greater context to the local realities that impact conditions of vulnerability. The forthcoming section describes the progress of the Southeast Asia agrarian transformation

literature and examines how the focus on changing modes of agricultural production and class relations bear important lessons for livelihood outcomes and vulnerability in hazardous areas. I then provide an outline of rural change in Java, and how this can lead to adverse (albeit contested) environmental consequences, which can likewise help to explain local conditions of vulnerability.

Livelihoods perspectives and agrarian transformations

As discussed above, the sustainable livelihoods approaches applied widely within disaster scholarship have been criticised for their assumptions that unsustainable livelihoods contribute to disasters (Wisner et al., 2004) and for their sometimes simplistic nature, being largely developed for use by NGO's (see Ashley and Carney, 1999; Goldman et al., 2000; IFRC, 2007). While from the perspective of NGO's, this simplicity is part of the appeal, relying on a set of assets, particularly land (see Pritchard et al., 2017), to describe the vulnerability of livelihoods can be limiting in its ability to draw out the beneficial outcomes associated with partaking in particular livelihood activities (see also Bachri et al., 2015; Batterbury and Forsyth, 1999). Furthermore, while sustainable livelihoods approaches provide insights into how people navigate their livelihoods, they can overlook the wider processes that influence or constrain these livelihoods such as modern economies, global market forces, state agricultural policies and regulations, and agrarian class relations. As these processes influence local conditions of vulnerability, they present an opportunity to draw on the agrarian transformation literature.

Past agrarian studies have focused on understanding rural change through a Marxist-derived lens, primarily concerned with how rural peasantries can continue in a capitalist economy (Akram-Lodhi and Kay, 2010a; Vandergeest, 2008). Nowadays, the scope of this research continues to focus on the formation of class relations (Akram-Lodhi and Kay 2010b; Bernstein, 2010), while also expanding to consider other agrarian processes of change, including: de-agrarianisation (Rigg, 2006; Rigg and Vandergeest, 2012; Rigg

et al., 2016b), commodity crop booms (Hall, 2011a; Li, 2014; Mahanty and Milne, 2016; Vandergeest, 2008), 'land grabs' (Hall, 2011b; Hall et al., 2011; Li, 2011a) and migration (Kelly, 2011; Rigg, 2013; Rigg and Vandergeest, 2012). These works reveal important processes that influence conditions of vulnerability at the local level. For example, Akram-Lodhi and Kay (2010b), Bernstein (2010) and Li (2014) describe how integration into a global market economy can increase inequalities and create class differentiation at the local level. In particular, Li (2014) discusses this process in the context of a commodity crop boom demonstrating how cocoa grown in the highlands of Sulawesi led to crisis land sales and local land conflict, which compounded class differentiation.

Crop booms are a major feature of current agrarian transformations throughout Asia and influence local livelihood outcomes and conditions of vulnerability. Alongside Li's (2014) study of cocoa in upland Sulawesi, Belton et al. (2017), Hall (2011a), Mahanty and Milne, 2016, Munster (2015) and Vandergeest (2008) all describe the way commodity crops have radically transformed rural production and local socio-economic relations. Hall (2011a) defines a crop boom as occurring when 'large areas of land are rapidly converted to mono-cropped (or nearly mono-cropped) production of a new crop and the land use transformations involved have time horizons of more than a year' (p. 508). While the current literature favours studies of export oriented booms, Belton et al. (2017) have highlighted that crop booms are not always geared to international markets. They describe how the domestic crop boom of *Pangasius* (a type of catfish) aquaculture in Bangladesh was propelled by rising domestic incomes and increased urbanisation, and led to an increase in capital costs and land values for farmers. Furthermore, as is the case with potato production in the Dieng Plateau, a major bust of this industry is yet to occur. Rigg et al. (2016a) define the new forms of vulnerability that have accompanied rural integration in the modern economy as 'produced precarity'. While the concept of precarity is not drawn on within this thesis, the notion that crop booms have contributed to new forms of vulnerability bears insights for my analysis of vulnerability

during the potato boom in Chapter 6.

The increasing trends of migration and the de-agrarianisation of rural livelihoods that are described in studies of agrarian transformation also bear implications for vulnerability. Rigg (2006) presents a case for the de-agrarianisation of rural livelihoods, arguing that they are increasingly becoming divorced from farm activities. To counter this, many authors have demonstrated that migration, often to urban centres, is now a central component of rural livelihoods (Elmhirst, 2002, 2012; Peluso et al., 2012; Rigg and Vandergeest, 2012; Rigg, et al., 2016b; Sumedi, 2012). Remittances earned from this type of migration are sent home to be re-invested in agricultural ventures (Elmhirst, 2002, 2012; Peluso et al., 2012; Rigg and Vandergeest, 2012 Sumedi, 2012). While these studies draw attention to the importance of 'off farm' work, Hall (2011a) describes how people also continue to migrate towards the sites of commodity crop booms such as coffee, cocoa, oil palm and shrimp cultivation throughout Asia, despite these trends of de-agrarianisation. He argues that 'powerful waves of migration in the direction of the agricultural frontier continue to take place in Southeast Asia even in the context of clear trends towards de-agrariansation' (p. 523). This theme will be drawn on in Chapter 6 where the relationship between contemporary migration to palm oil and rubber plantations and vulnerability is discussed.

Akram-Lodhi and Kay (2010b) argue that the creation of new class relations remains crucial to contemporary agrarian questions. The creation of landowning and labour classes' influences access to land and other resources (Bernstein, 2010) and directly impacts a household's level of vulnerability (see also Ribot and Peluso, 2003) and ability to mitigate natural hazards. The formation of new class structures is tightly linked to commodity crop booms, with some benefitting from these new ventures more than others. For example, Li's (2002; 2014) study of the Sulawesi highlands describes how the cocoa boom led to class differentiation, and left some farmers landless and more vulnerable than others. Munster (2015) analyses the seasonal cultivation of ginger in south India, arguing that while engaging in this crop

boom has been profitable for some, many have suffered financial ruin and substantial debt as a result. Mahanty and Milne (2016) arrive at a similar conclusion, demonstrating how the boom of cassava on the Cambodia-Vietnam border has deepened capitalist relations and led to an erosion of choice over modes of production for small landholders. However, as described in Vandergeest's (2008) study of shrimp aquaculture in Southern Thailand, crop booms can result in widespread economic benefits, while also creating less certain incomes as crops are more easily wiped out due to disease.

Another recent piece of work within the field of agrarian studies that bears insights for disaster scholarship is Rigg and Vandergeest's (2012) edited book, that follows a series of researchers as they return to their research sites situated throughout Southeast Asia 25 years after their initial investigations. What stands out amongst these articles is that in contrast to the prior gloomy predictions made by many of the authors, rural livelihoods have continued to survive and in many cases prosper. The authors in Rigg and Vandergeest (2012) acknowledge that agricultural activities continue to thrive, but that they are supplemented and supported by the diversification of livelihoods and remittances sent from migration to urban centres (Peluso et al., 2012; Sumedi, 2012). Again, this work demonstrates that understanding agrarian processes can help to explain the changing nature of local livelihood conditions and vulnerabilities.

Agrarian transformations in rural Java

Rural Java has been the site of many studies of agrarian change. These works describe the impact of agrarian transformations at the household level and provide context to better explain and understand the processes that have contributed to, or alleviated, conditions of vulnerability. Agrarian studies in rural Java span from the colonial era, post independence Indonesia, the New Order Regime to current day policies and practice. In the lowlands, Geertz's (1963) classic study *'Agricultural Involution'* incited much debate as it promoted a theory of 'shared poverty' amongst the peasantry arguing that

agricultural gains and losses were born relatively equally within Java's villages. Hart (1986) discussed power and labour relations in a village in Central Java during the New Order Regime and described the exercise of state power through a small yet influential group of large landowners. The focus on structures of power in these works explains the inequalities experienced by rural Java's peasantry that contribute to conditions of vulnerability.

The process of agrarian change in Java's highlands has followed a more unique trajectory compared to the lowlands, due to its greater geographical isolation from colonial and government control (Li, 1999a). Arguably, the most notable work on upland Java is Hefner's (1990) study of the political economy of development in the Tengger highlands of East Java. In this study Hefner traces the process of agrarian change and upland deforestation as highlanders have sought after the cultivation of high-value commodity driven crops. Li (2007) builds on this work and discusses the transformation of Java's uplands in the context of the commoditisation of crops and government concern over the welfare of the dispossessed. White (1997) describes the transformative power of contract farming in upland West Java arguing that the benefit to such arrangements falls to the small investors rather than the daily wage labourers. Boomgaard's (1999) historical reconstruction of agrarian change in the highlands describes two centuries of continual expansion of agricultural interests, demonstrating that upland migration is not just a contemporary process. Additional studies have also focused on forest management and the territorialisation of political forests (Boomgaard, 1992; Peluso, 1992; Peluso and Vandergeest, 2001). These studies outline the historical processes that drew the lowland Javanese to the highlands as they sought more rewarding agricultural activities. In Chapters 5 and 6 I will draw from, and expand on, these studies to explain how people came to occupy, and in doing so increase their exposure to volcanic hazards within, the Dieng Plateau.

The environmental impact of agrarian transformations

The transformation of agricultural production, which often occurs through commodity crop booms, can also initiate local and regional environmental impacts. The environmental consequences of crop booms influences vulnerability, primarily by undermining the future sustainability of such livelihoods and instigating what are often restrictive government policies. In Java, the expansion of commodity crops into highland areas has been blamed for a plethora of localised and lowland environmental problems including soil erosion, the siltation of lowland river systems, deforestation and contamination of water sources (Carson, 1989; Barbier, 1990; Lavigne and Gunnell, 2006; Rudiarto and Doppler, 2013). As quoted by Hall (2011a) 'Given that boom-crop expansion has played such a critical role in the conversion of forested landscapes to agriculture in Southeast Asia, it is hardly surprising that state actors concerned with conservation have tried to halt or even turn back booms' (p. 526). As will be discussed fully in Chapter 6, these state policies bear important considerations for conditions of vulnerability.

While analyses of land degradation have always been a part of agrarian transformation literature, it has been expanded on more fully through the critical political ecology work of Forsyth (2003) and Forsyth and Walker (2008). Forsyth (2003) argues that common assumptions about environmental degradation need to be reconsidered in order to acknowledge their political influences. Forsyth and Walker (2008) critically challenge assumptions of environmental degradation in upland Thailand and while not denying this process outright, they conclude that it is often over exaggerated and that indigenous communities receive excessive blame for processes beyond their control. The need to reassess environmental degradation narratives is also demonstrated in other studies conducted in Africa, Thailand, Indonesia and Bolivia where the extent of various detrimental environmental processes were found to be incorrect and grossly over-exaggerated by governments and development organisations (Fairhead and Leach, 1996; Forsyth, 1994, 1995, 1996; Leach and Mearns, 1996; Lukas, 2014; Preston et al., 1997). These studies demonstrate how state

bureaucracies can uncritically accept and deploy environmental orthodoxies, labelling upland communities as 'backwards' to transfer blame for environmental degradation away from the government towards the actions of small landholders (Batterbury et al., 1997; Forsyth and Walker, 2008).

Batterbury et al. (1997) argue that the study of environmental transformations should consider and question the environmental orthodoxies that influence the way agrarian change is socially and politically constructed. This approach is also pertinent to studies of vulnerability as the uncritical acceptance of environmental orthodoxies can lead to policies that attempt to readdress issues of environmental degradation, sometimes unfairly disadvantaging local land users in the process (Batterbury et al., 1997; Preston et al., 1997; Scoones, 1997). The studies above demonstrate that environmental degradation and sustainability can be complex and often contested phenomena; a theme that is addressed in Chapter 6. However, this tendency to label local communities as the source of their own problems is also reflected in various studies of local disaster knowledge. As I will outline below, like sustainability, disaster knowledge has many interpretations and meanings, varying from the perspective of local and expert actors. This field forms the final theoretical component to this thesis and it's foundations and limitations are discussed below.

2.2.3. Disaster knowledge

To briefly summarise, the discussion above has focused on the emergence of the 'hazardscape' and the utility found in incorporating theories of territoriality and agrarian transformation into understandings of vulnerability within disaster scholarship. The forthcoming discussion will now focus on the role disaster knowledge plays in the reduction of vulnerabilities to natural hazards. The field of risk perception argues that perceptions of risk are socially constructed, with attitudes and understanding differing between scientists, policy makers and the communities who are labelled 'at-risk' (Dake, 1991; Douglas, 1997; Kasperson et al., 1988; Slovic, 1999). As a result, various authors argue that

to reduce vulnerabilities we also need to bridge the 'divide' between expert and local knowledge systems (Gaillard and Mercer, 2012; Gall et al., 2015; Spiekerman et al. 2015; Weichselgartner and Kasperson, 2010; Weichselgartner and Obersteiner, 2002; White et al., 2001). The forthcoming section provides some background to the field of disaster knowledge, and by drawing on insights from the local ecological knowledge field, develops the framework that will be applied to understand, and provide advice for bridging the perceived gap between, local and expert knowledge, as discussed in Chapter 7.

A background to knowledge studies within the disaster literature

Various studies within the disaster literature demonstrate that local communities possess their own knowledge concerning the cause and consequence of disasters (Bankoff, 2004; Donovan et al., 2012a; Hoffman, 2002; Laksono, 1988; Paine, 2002; Shannon et al., 2011). However, many of these works present extreme or isolated examples (see Donovan et al., 2012a; Gaillard et al., 2008; McAdoo et al., 2006; UNISDR, 2008) and overlook the contextualised and hybridised nature of knowledge in today's interconnected world (for examples of such work see Bird et al., 2009; Dominey-Howes and Minos-Minopoulos, 2004; White et al., 2001). Furthermore, as will be discussed below there is a tendency to rely on the problematic terms of 'traditional' or 'indigenous' (Hilhorst et al., 2015), to frame expert or scientific knowledge at the opposite end of a spectrum to local knowledge (for some examples see Bankoff, 2004; Dake, 1991; Donovan et al., 2012a; Hoffman, 2002; Kasperson et al, 1988; Paine, 2002; Slovic, 1999; Wisner and Luce, 1995), and to neglect the socio-political and disciplinary constraints that influence the construction of expert disaster knowledge (see Jasanoff 1987, 1990, 2003; 2007).

Knowledge studies within the disaster literature focus predominantly on what is referred to as 'local', 'indigenous' or 'traditional' knowledge[2]. Becker et al. (2008) describe traditional knowledge as 'a system of experiential knowledge acquired through the continual observation of and interaction with the environment' (p. 488). A renewed interest in the field of traditional or local disaster knowledge came following the largely successful self-evacuation of communities in the offshore island of Simeulue during the 2004 Indian Ocean tsunami (Hilhorst et al., 2015). Unlike mainland Sumatra, residents of Simeulue identified the natural warning signs of the tsunami and self-evacuated to higher ground resulting in fewer casualties than mainland Aceh (Gaillard et al., 2008; McAdoo et al., 2006).

Additional examples within the disaster literature describe how local knowledge has supported communities to recognise warning signs, prepare for, and respond to a host a of disasters, including volcanic eruptions, tsunamis, floods, cyclones and landslides throughout the countries of New Zealand, Vanuatu, Australia, the USA and Nepal (Becker et al., 2008; Cashman and Cronin, 2008; Cronin et al., 2004; Dekens, 2007; Johnson et al., 1982; King et al., 2007; Skertchly and Skertchly, 1999). These examples all demonstrate how local knowledge of disasters is produced and circulated within a local context (Goldman, 2007; Turnbull, 2000). Furthermore, many of these cases have contributed to the recent policy significance of local disaster knowledge, reflected particularly in the UNISDR's (2008) report entitled '*Indigenous Knowledge for Disaster Risk Reduction*'. This report argues for sustained efforts to better recognise, mainstream, exchange and disseminate what it refers to as 'indigenous' disaster knowledge into official programs.

While the examples above demonstrate the many contexts in which disaster knowledge is held, the reliance on the terms 'traditional' or 'indigenous'

[2] Traditional, indigenous and local knowledge are all terms that are used to describe the contextually bound knowledge held by vulnerable people within the disaster knowledge literature. In Chapter 7, I explain why I settle on the term 'local' rather than 'traditional' or 'indigenous'.

within these works suggests that this knowledge is always present at a local level, is historically embedded and has developed in isolation from outside influences. Mercer et al. (2008) however argue that: 'Indigenous and Western knowledge bases are dynamic, constantly changing and adapting, and therefore need to be seen as such' (p. 181). This statement is of particular importance when studying local knowledge in modernised societies with access to scientific information, such as the Dieng Plateau. Hilhorst et al.'s (2015) study of disaster knowledge in Thailand and the Philippines concurs with this idea and 'caution[s] against a view that indigenous knowledge is grounded in a long tradition of coping with disasters' (p. 506). Her analysis of two communities in Thailand and the Philippines found that 'indigenous' disaster knowledge was inconsistently held and mixed with 'modern' knowledge sources such as ideas transmitted by radio. The UNISDR's (2008) treatment of 'indigenous' disaster knowledge as a series of 'best practices' and 'lessons learnt' (Hilhorst et al., 2015) is therefore at risk of what Briggs (2005) calls the over-romanticising of local knowledge.

Briggs (2005) warns that an over-valorisation or romanticisation of what he labels 'indigenous' knowledge is unhelpful, as it doesn't always contain the necessary answers to issues of resource management at the local level. This shortcoming is evidenced in a series of studies conducted on the slopes of volcanoes throughout Italy, Indonesia and Iceland that demonstrate how local disaster knowledge can in fact impeded preparedness, evacuation and relief efforts (Dibben, 2008; Donovan et al., 2012a; Jóhannesdóttir and Gísladóttir, 2010). Donovan et al.'s (2012a) work on the slopes of Mount Merapi is of particular importance as it describes how communities who relied on the traditional warning signs of premonitions, dreams and animal movements were less likely to evacuate during the 2006 eruption. Sadly, this local knowledge also contributed to the death of 35 residents in 2010 who refused to evacuate due to the counter-official advice provided by Mount Merapi's gatekeeper, Mbah Maridjan (Mei et al., 2013). These studies demonstrate that caution needs to be applied when seeking out and interpreting the impact local disaster knowledge has on DRR activities.

Mercer et al. (2007; 2009) and Gaillard and Mercer (2012) argue that local disaster knowledge needs to be incorporated with scientific knowledge; suggesting that either on its own is not enough to reduce vulnerability. While the main premise behind this statement – that expert and local knowledge should be integrated – is indeed important, caution is needed to ensure that such approaches do not proliferate the assumption that expert and local knowledge are separate, objective versus irrational systems. Forsyth (2003) argues that there is a need to deconstruct certain scientific laws and practices that may bear institutional or personal biases. However, within the disaster literature the processes shaping the construction of expert disaster knowledge are yet to receive the same attention as those involved in local disaster knowledge (Donovan, 2017; Donovan and Oppenheimer, 2015) and this expert knowledge is assumed to be objective and superior to local knowledge (Mercer, 2012). Despite the many attempts that have been made to incorporate local knowledge with expert knowledge (Cronin et al., 2004; Kelman et al., 2012; Peters-Guarin et al., 2012; Reichel and Fromming, 2014), limited attention has been directed towards critically evaluating the way expert DRR knowledge is constructed and unevenly circulated (however, for an example focusing on the field of volcanology see Donovan et al., 2012b). This includes the limitations to hazards related scientific enquiry and the institutional biases that may favour the transmission of some disaster knowledge types over others.

Expert disaster knowledge falls into two camps, knowledge that improves understanding and forecasting of geophysical process, and knowledge of the societal impacts of disasters and how they can be reduced. Technical or geophysical disaster knowledge largely relies on hazard mapping (probabilistic and scenario based), forecasting and monitoring. The basic premise underlying the hazard mapping approach is that a record of past occurrences (often preserved through geological deposits) can inform the likelihood and intensity of future events. Jasanoff (1990) argues that to protect against harm, government agencies are tasked to undertake ever more complex predictive analyses of risk. Despite its inherent uncertainties

this process produces stabilised facts, which are validated scientifically through frameworks of shared assumptions (Jasanoff, 1987). Jasanoff's (1987; 1990; 2003) studies of the scientific method and practice are useful in understanding some of the epistemological and practical challenges inherent to expert disaster knowledge, particularly in the case of hazard mapping.

Hazard mapping is an uncertain science, relying on imprecise and incomplete data and involving many assumptions and estimations (Donovan and Oppenheimer, 2014; Stein et al., 2011). For example, the methods used to produce hazard maps frequently present so-called 'worst-case' scenarios defined by high-magnitude events (Clarke, 2005) and follow the risk-averse preference of hazard scientists (Haynes et al., 2008b). Moreover, they can rely on incomplete or low-resolution datasets (Stein et al., 2012) with uncertainties inciting conflict between hazard scientists (Aspinall, 2010). For example, the accuracy of Indonesia's volcanic hazard maps depends on the eruptive history of the volcano in question and the more that is known, the better the resultant map (Interview 86, senior volcanologist, PVMBG, Bandung, 16/09/15). Communicating hazard maps has also proved challenging and various authors have found that local communities have difficulty interpreting both the map and its level of uncertainty (Barclay et al., 2008; Haynes et al., 2007; Nave et al., 2010). While not explicitly referring to hazard maps, the mapping process itself has also been critiqued by additional authors who argue that maps are embedded in Western scientific culture (Harley, 2001), exclude non-Western styles of cartography (Pickles, 2004) and are laden with power and value judgements (Crampton, 2001; Harley, 1989; Kitchin and Dodge, 2007).

The imitations to the hazard mapping process described above align with Jasanoff's (2003) insights on the co-production of science and society. Jasanoff (2003) argues that factors such as the personality, social position, interest and ability of a scientist, alongside the often-politically dictated funding arrangements, influence the development of science (see also Donovan et al. 2012b). This is observed in the field of volcanology wherein Donovan et al. (2012b) have argued that the discipline is constructed both

through the political and social drivers that dictate funding and a volcanologist's experience of observing the natural world. During an eruption volcanologists are placed under immense pressure to warn and protect populations, and differing expert views concerning the hazard in question can arise (Aspinall, 2010; Donovan et al. 2012d). To combat the uncertainty of this scientific information, Jasanoff (2007) argues for 'policies of humility' that recognise the limitations scientific inquiry holds. The common statistical aphorism that, 'all models are wrong, but some models are useful', generally attributed to Box (1976), further reflects this sentiment and argues for caution when interpreting hazards maps. However, expressing this uncertainty is difficult particularly during the throes of an eruption when timely decisions about evacuation need to be made. Yet, as will be described in both Chapters 5 and 7, these decisions concerning evacuation and relocation significantly influence local conditions of vulnerability.

In addition to the scientifically derived hazard information discussed above, expert disaster knowledge is also produced through governments, academia and development organisations. Much of this knowledge focuses on measuring and understanding the socio-economic impact of disasters. While governments are more likely to treat disasters as a temporary anomaly to be rectified, NGO's often interpret disasters as a product of mal-development and poor governance (Bankoff and Hilhorst, 2009). This leads to a parallel focus on technocratic solutions on the part of the state and broader development programs on behalf of NGO's (Bankoff and Hilhorst, 2009). However, international development organisations also have a tendency to package disaster knowledge in the form of 'best practice' case studies that can potentially harm local DRR programs (for an example see the UNISDR's 2008 report titled '*Indigenous Knowledge for Disaster Risk Reduction: Good Practices and Lessons Learned from Experiences in the Asia-Pacific Region'*). Hilhorst et al. (2015) argue that the 'best practice' label carries an assumption that programs can be easily replicated and up-scaled into very different contexts, forgetting the localness of local knowledge in the process.

If expert disaster knowledge is applied broadly without considering the

context in which it was created, it may lead to policies that could impose unnecessary and unfair restrictions on the livelihoods of marginalised land users (see also Forsyth 2003 for resource management policies more broadly). In hazards policy, this could potentially result in over-zealous setback limits, extended evacuations or 'permanent' relocation programs. Despite the potential negative effects such programs can have on vulnerability, Donovan et al. (2012c) has demonstrated how the process of delineating the 'safe zone' on Montserrat is contested and ultimately an outcome of negotiations between expert scientists, policy makers and local citizens. A similar process has also occurred on the slopes of Mount Merapi where relocated residents have voluntarily returned before the lifting of evacuation orders causing the state to ultimately relax their position (Laksono, 1988).

The discussion above has outlined the progress of local and expert disaster knowledge studies within the literature. Importantly, disaster knowledge is presented as a locally embedded and contextualised system (Goldman, 2007; Shannon et al., 2011; Turnbull, 2000). Issues associated with the terms 'indigenous' and 'traditional' are raised, as are tendencies to over-romanticise local knowledge (Briggs, 2005). I have demonstrated that current frameworks within disaster studies do not adequately address how expert and local disaster knowledge inform each other and are influenced by local context and outside forces. This presents an opportunity to compare disaster knowledge with the field of local ecological knowledge, focusing particularly on the argument that expert and local knowledge are hybrid systems.

A comparison with local ecological knowledge (LEK)

The local ecological knowledge (LEK) field of literature has long demonstrated that tapping in to the knowledge held by resource dependent communities is essential to the success of conservation efforts (Goldman, 2007). This field describes the breadth of ecological knowledge communities possess and the way it has allowed people to manage and maintain their

livelihood activities in often changing environments (for some examples see Ferdandez-Gimenez, 2000 on pastoral management in Mongolia; Gerdahinger et al., 2009 on the protection of marine areas in Brazil; Goldman and Riosmena, 2013 on rangeland fragmentation in drought affected Tanzania; and Silvano and Valbo-Jorgensen, 2007 on fishery resources in Brazil and Southeast Asia). Such LEK's are shown to 'guide the direction of resource management' (Berkes et al., 2000, p. 1251), in the process sustaining important livelihood resources and assets. While some of these works set out to compare local and scientific views (see Silvano and Valbo-Jorgensen, 2007), LEK is increasingly conceptualised as a hybrid and interconnected space (Agrawal, 1995; Berkes et al., 2000; Nygren, 1999); an approach that also bears significance for the conceptualisation of disaster knowledge.

While local and expert knowledge often come from different epistemological standpoints, there is an emerging school of thought within LEK studies arguing that local and expert knowledge are not dichotomies. In Agrawal's (1995) words the preconceived indigenous-scientific dichotomy seeks to 'separate and fix in time and space (separate as independent and, fix as stationary and unchanging) systems that can never be thus separated or so fixed' (p. 422). Berkes et al. (2000) states that no LEK's are purely traditional but rather all incorporate Western or scientific knowledge to varying degrees, a finding also supported by Nygren (1999) who argues that there is a greater need to recognise the ongoing hybridisation of knowledge systems in today's highly interconnected world. While the hybridisation of local knowledge is well established within the LEK field of literature, disaster studies are yet to fully appreciate the interaction between local and expert knowledge bases. For example, Schwarz (2014) argues that international frameworks of risk still assume a gulf between expert objectivity and local subjectivity. The perceived dichotomy is reflected in various studies of local response to natural hazards and issues of knowledge sharing (see Bird et al., 2009; Cronin et al. 2004; Dominey-Howes and Minos-Minopoulos, 2004; White et al. 2001). This often-presumed dichotomy between local and expert

knowledge in the field of disaster management provides an opportunity to draw on examples within the LEK, and where possible disaster studies, which demonstrate how hybrid or plural knowledge co-evolves.

Despite the scarcity of studies, pluralist interpretations of disaster events have been described in some parts of Southeast Asia. In these examples scientific explanations exist alongside rather than contradict local worldviews and beliefs. For example, Rigg et al. (2005) describe how victims of the 2004 tsunami in Thailand viewed the event both as a natural phenomenon and as a religious or supernatural occurrence. Similarly, Schlehe (2010) found that following the 2006 Yogyakarta earthquake scientific explanations of plate tectonics existed alongside beliefs that the earthquake was sent to warn the Javanese to guard their traditions. Shannon et al.'s (2011) study in Bengkulu on the southern coast of Sumatra likewise describes local understandings of earthquake and tsunami hazard that combine science with religious and mystical interpretations. Furthermore, Adeney-Risakotta (2009) argue that understanding disasters through the lens of plate tectonics supports interpretations that such events are not sent as personal punishment from God, but are rather a consequence of the geophysical processes involved in building God's creation. These plural understandings contradict the dominant held notion that local and scientific wisdom contradict one another and that local interpretations of disasters, often explained through religion or cosmologies, hinder the success of sustainable development or DRR programs (Berkes et al., 2000; Nygren, 1999; Shannon et al., 2011).

Bridging the perceived local-expert divide

As local and expert disaster knowledge are often problematically viewed as a dichotomy[3], issues of knowledge sharing are frequently raised in discussions of disaster policy. The 2015 Sendai Framework for Action aims to facilitate more ways for creating and sharing disaster knowledge (Weichselgartner

[3] This is particularly found within publications from the UNISDR, see UNISDR (2008) and UNISDR (2015).

and Pigeon, 2015); however, it still assumes a divide between expert and local views and overlooks the contextualised nature of these knowledge systems. In fact, many debates within the literature draw attention to the lack of collaborative disaster knowledge creation between scientists, practitioners and communities 'at risk', and the translation of this into tangible actions (Gall et al., 2015; Spiekerman et al. 2015; Weichselgartner and Kasperson, 2010; Weichselgartner and Obersteiner, 2002). Gaillard and Mercer (2012) state that in addition to increasing global vulnerabilities, 'the escalating occurrence of disasters also reflects an inability to bridge the gap between local and scientific knowledge, and bottom-up and top-down actions in DRR' (p. 94). While I recognise that there are problems in the sharing and production of disaster knowledge at the local-expert interface, rather than focusing on these differences, this thesis adopts a framework that aims to understand the social context and inter-relatedness of local and expert of disaster knowledge.

White et al.'s (2001) study entitled '*Knowing better and losing even more*' argues that the present rise in global disaster losses is due to a lack of knowledge sharing rather than a lack of knowledge alone. However, this argument partially reflects the behaviourist approach to the hazard paradigm, wherein if communities have more knowledge they will respond to disasters in a more informed and appropriate manner (see also Bird et al., 2009; Burton et al., 1978; Dominey-Howes and Minos-Minopoulos, 2004; Faupel et al., 1992; Kates, 1971). It also implies that knowledge is unidirectional, passing from an expert to a recipient vulnerable community. While knowledge sharing is undoubtedly a requirement for effective DRR, various other authors have demonstrated that political, bureaucratic, social and economic constraints influence the construction and practical application of disaster knowledge. The work of Paton in New Zealand argues that possession of hazard knowledge does not necessarily translate into involvement in disaster preparedness activities (Paton, et al., 2000; Paton et al., 2001; Paton, 2003). This was demonstrated clearly during the aftermath of the 2009 Padang earthquake in Indonesia where despite extensive

educational campaigns to retrofit homes and 'build back better', local building construction styles were not altered (Janssen and Holden, 2011). Haynes et al. (2008a) extends this by arguing that experts and local communities possess different perceptions of what constitutes 'acceptable risk'. These findings suggest that there is a need to move beyond attempts aimed at knowledge sharing towards approaches aimed at understanding the different priorities that influence how knowledge is created and used.

One attempt to better understand the impact local priorities have on the production of disaster knowledge involves participatory mapping (Cadag and Gaillard, 2012; Cronin et al., 2004; Gaillard et al., 2013; Gaillard and Pangilinan, 2010; Kelman et al., 2012; Mercer et al., 2009; Peters-Guarin et al., 2012; Riechel and Fromming, 2014). Participatory mapping aims to engage the community in the process of identifying the threats and resources available within their surroundings. This may include the spatial location of hazard zones, evacuation routes and safe shelters. Gaillard and Mercer (2012) argue that while participatory drawn maps offer insight into local knowledge systems experts can still discard them, as they are infrequently geo-referenced. To overcome this, participatory drawn sketch maps are now increasingly being packaged into a geographic information system (GIS) by the researcher (Cadag and Gaillard, 2012).

While participatory mapping may provide a platform for dialogue, and this mapping approach is applied in Chapter 7, there are limitations to how far this process alone can be used to understand expert and local knowledge systems. A shortcoming to these projects is that they fail to comprehensively recognise a more fundamental issue – related to the locally contextualised and embedded nature of disaster knowledge itself. This limitation is touched upon in Pelling's (2007) critique of participatory disaster risk assessment, arguing that 'Imposing analytical structures from the outside is tempting—especially when attempting to scale up data—but doing so reduces the potential for unearthing unexpected views' (p. 380). Nadasdy (1999) found that programs aimed at integrating indigenous and scientific knowledge in Canada have resulted in indigenous peoples being forced to express

themselves in frameworks that conform to state-bureaucratic institutions rather than through their cultural and belief systems. This is particularly true for spatial mapping, which relies on western ways of thinking above space and organising information (Harley, 2001; Pickles, 2004). Drawing on fieldwork conducted in Samoa, Le De et al. (2015) question whether participatory disaster research can ever be truly participatory while the current methodology that excludes input from participants during the design phase continues. Participatory approaches are therefore a useful attempt to bridge the divide between expert and local knowledge; however, the outcome of such exercises is liable to bias as the methodologies used to understand and map risk may be in opposition to local ways of knowing or describing a problem. Furthermore, they operate under the assumption that local and expert knowledge are opposites, an argument that is refuted in the LEK literature.

In conclusion, local disaster knowledge has a proven record of improving preparedness and response activities (Becker et al, 2008; Cronin et al., 2004; Dekens, 2007; Gaillard et al., 2008; Johnson et al., 1982; King et al., 2007 McAdoo et al., 2006; Skertchly and Skertchly, 1999). However, there are various factors hindering its integration with DRR programs, primarily assumptions that local and expert knowledge systems are binary opposites, a lack of studies focusing on expert disaster knowledge and a difficulty recording and translating local knowledge by expert actors. More work is needed to understand the politics and practice of constructing and representing disaster knowledge and how local and expert knowledge is embedded in social systems. This research need can be advanced through greater integration of disaster knowledge studies with the LEK (Agrawal, 1995; Berkes et al., 2000; Nygren, 1999) and science studies (Jasanoff 1987, 1990, 2003) fields. This approach will be applied in Chapter 7 and the findings discussed in the policy implications of Chapter 8, which are aimed at promoting greater interaction between these often falsely separated local-expert knowledge systems for the ultimate achievement of vulnerability reduction.

2.3. An integrated approach to the study of vulnerability

The review of literature provided above provides an overview of past and present disaster theory, practice, and areas of ambiguity. From this overview, I have identified three areas that require further research attention (summarised in Table 2). Firstly, the theory of access continues to provide a robust theoretical framing to understand conditions of vulnerability. However, this approach could be expanded to more comprehensively consider the way political representations of hazardous land impact vulnerability using theories of territoriality and the hazardscape. Secondly, there is a tendency to assume that livelihoods in hazardous locations are unsustainable and arguably a reluctance to draw on related fields of inquiry, such as the agrarian change literature, to better understand the political-economic processes that shape local livelihood outcomes. Thirdly, there is a paucity of studies that simultaneously unpack and compare the construction of local and expert disaster knowledge and the practices that this knowledge informs. In Figure 1, I provide an operationalisation of these thematic areas as they are drawn on throughout this thesis. The three thematic areas represented in this triangle all contribute to understanding how vulnerability to natural hazards is both produced, and overcome, in the Dieng Plateau. As current disaster and vulnerability theory and its limitations has now been discussed, the following chapter will describe the methodologies I have used to address my research questions, including why I chose the Dieng Plateau as a field site.

Table 2. The main research gaps and current approaches that are addressed and expanded on in the three empirical chapters of this thesis.

Research question	**Research gaps and current approaches to be expanded on**	**Approach used within this thesis to respond to research need**	**Chapter**
Questions 1, 2, and 3.	There is still a need for more studies of vulnerability, particularly in Indonesia's highland agricultural volcanic landscapes.	A grounded and contextualised study of the Dieng Plateau – chosen for the extensive agricultural activities that sit alongside significant volcanic hazard.	All three empirical Chapters 5, 6 and 7.
Question 1.	Dominant studies of access and vulnerability overlook political framings of risk.	An analysis of the Dieng 'hazardscape', which combines the access model with the concept of territorialisation to arrive at a politically informed and nuanced description of vulnerability.	Chapter 5.
Question 2.	Disaster studies presume livelihoods in hazardous areas are forced on people and are inherently 'unsustainable'. There are few attempts that recognise and address local agency and the benefits gained through livelihoods in hazardous areas.	A combined study of how the macro-scale processes that govern agrarian transformations have led to micro-scale local livelihood outcomes and how these are influenced by local agency and capacity.	Chapter 6.
Question 3.	Current disaster literature assumes expert and local knowledge are 'objective' vs. 'irrational' systems and overlooks the limitations to expert knowledge.	A contextualised study of both expert and local disaster knowledge drawing on the local ecological knowledge and science studies literature.	Chapter 7.

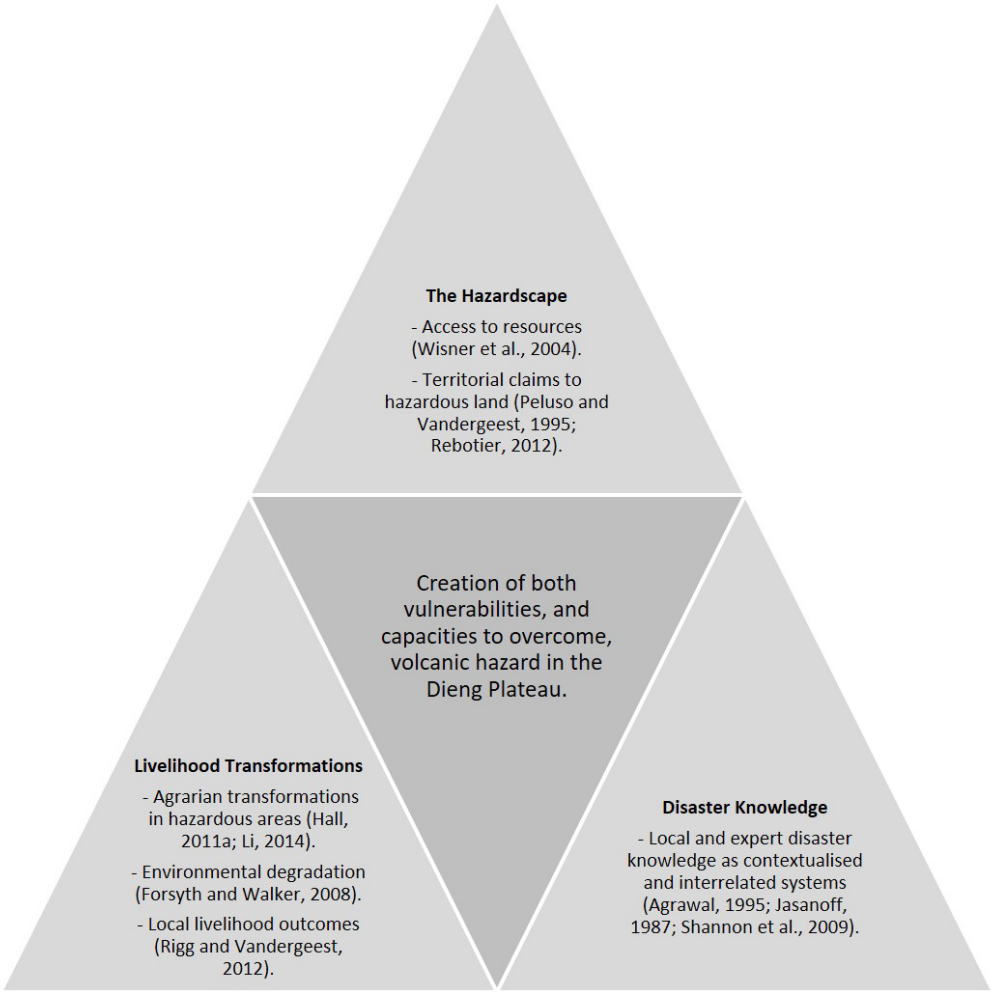

Figure 1. A schematic operationalisation of the three thematic areas that have informed this thesis' depiction of vulnerability and the interactions between them.

3. Methodology

The forthcoming chapter describes the methodologies I applied to answer my research questions, which are all primarily concerned with understanding the construction of vulnerability in the Dieng Plateau, as outlined in Chapter 1. I begin this chapter by discussing my case based approach, outlining the reasons why the Dieng Plateau forms an insightful field site. I then provide an overview of my specific sites of data collection, including the villages, hamlets and government organisations studied. The chapter proceeds to explain the multi-methods and largely qualitative approach I employed, relying on semi-structured and un-structured interviews, participant observation, household surveys and a community based workshop. The chapter concludes with a reflection on the fieldwork process, including the inductive and deductive reasoning that influenced the study's design, and a discussion of how my positionality in the field influenced relationships with informants and the type of information I collected.

3.1. A case study of vulnerability, livelihoods and disaster knowledge in the Dieng Plateau

This thesis is a case study of the interaction of vulnerability, livelihoods and disaster knowledge in a volcanically active highland area of Indonesia. The Dieng Plateau sits at 1,600 m to 2,100 m in altitude stretching across the Banjarnegara and Wonosobo districts of Central Java (Figure 2). The majority of the geographical extent of the plateau falls with the Batur subdistrict of Banjarnegara. In 2010 the population reached almost 50,000 people (BPS, 2010, Table 3), with small-scale vegetable farming, dominated by potatoes, as the main livelihood activity. While a history of development and land-use change in the plateau is reserved for Chapter 5, it is useful here to note that occupation and agricultural development has been ongoing since construction of the Arjuna Complex beginning from somewhere between 600-750 (Pudjoarinto and Cushing, 2001). The Arjuna Complex is Java's

oldest Hindu temple complex and though geographically isolated once served as the islands' centre for religious activity (Beynon and Datta, 2013).

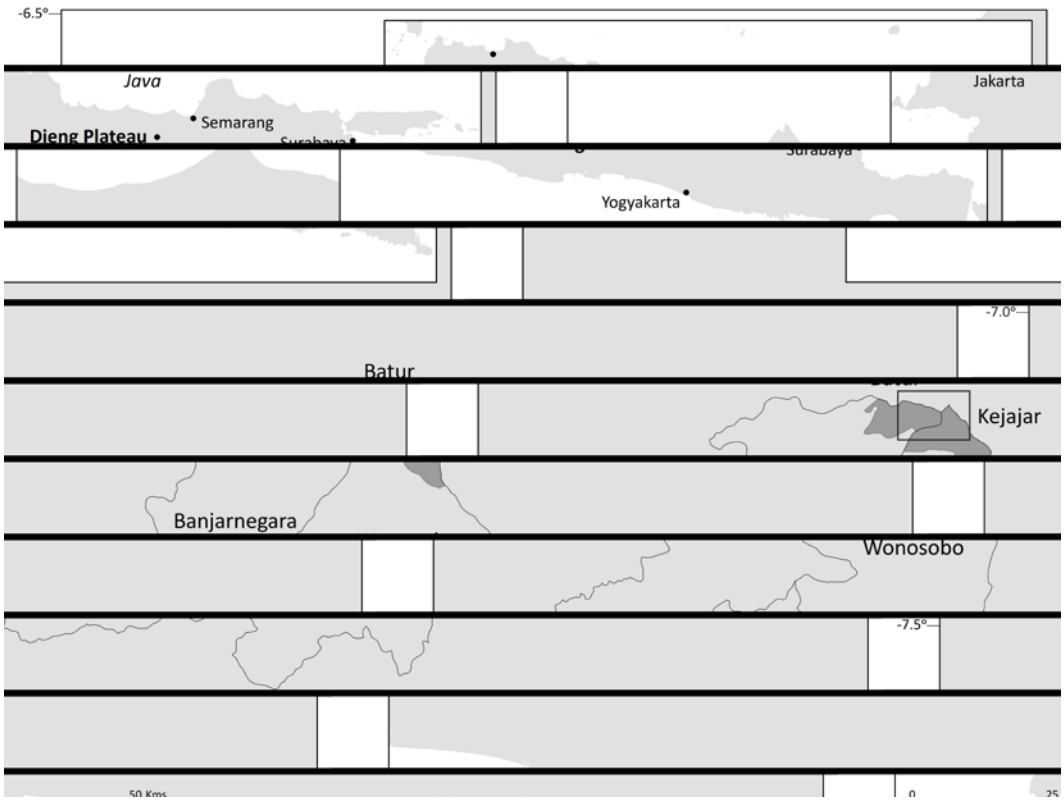

Figure 2. The location of the Dieng Plateau relative to a) Java, and b) the districts of Banjarnegara and Wonosobo and subdistricts of Batur and Kejajar, Central Java (source: author).

Table 3. Population of subdistricts and villages falling geographically within the Dieng Plateau (source: BPS, 2010).

District	Subdistrict	Village	Population
Wonosobo	Kejajar	Parikesit	1,987
		Sembungan	1,215
		Jojogan	1,342
		Patak Benteng	2,303
		Dieng	2,031
		Sikunang	2,114
		Campursari	2,250
Banjarnegara	Batur	Batur	11,431
		Sumberejo	4,648
		Pasurenan	2,330
		Bakal	3,392
		Dieng Kulon	3,248
		Karang Tengah	4,021
		Kepakisan	2,599
		Pekasiran	4,719
		Total	**49,630**

3.1.1. The usefulness of case studies in the social volcanology literature

Lund (2014) argues that a case is an intellectual construct aimed at organising field data in a manageable way. Rather than one single geographical location, the unit of analysis for my case study included the broad geographical setting of the Dieng Plateau, where I focused on understanding the interaction between the issues of vulnerability, land, livelihoods and disaster knowledge. Accordingly, my case study relied on data collected within one hamlet, two villages and two government institutions operating within the Dieng Plateau (see Table 4 located at the end of this chapter). The usefulness of case studies is widely supported in academia for their ability to create new practical knowledge that can test, falsify, expand or generate theoretical concepts and support new empirical insights (Baxter, 2010; Burawoy, 1998; Flyvbjerg, 2006). Case studies can also support policy development by providing a framework to unravel the causal relationships present in a given situation (see Small, 2009; Vayda,

1983). The case based approach of this study likewise allowed adequate time and focus to gain an in-depth understanding of the processes occurring in the Dieng Plateau (see Baxter, 2010).

Case studies are widely applied within the social volcanology literature to understand the processes influencing local-level hazard mitigation and response. Donovan (2010) describes social volcanology as the integration of social science into the physical domain of volcanology to understand the impact community level processes have on disaster impact. Some notable examples include interpretations of volcanic hazard on the slopes of Mount Merapi (Donovan, 2010; Donovan et al., 2012a; Dove 2008; Laksono, 1988; Schlehe, 1996), human vulnerability on San Miguel Volcano in Azores (Dibben and Chester, 1999), and traditional disaster knowledge on the Ambae Island Volcano of Vanuatu (Cronin et al., 2004). The dynamics of resettlement have been studied on Mayon Volcano in the Philippines (Usamah and Haynes, 2012) and Tungurahua Volcano in Ecuador (Tobin and Whiteford, 2002). Additional studies have focused on perceptions of risk, including the Santorini Volcanic Complex in Greece (Dominey-Howes and Mino-Minopoulos, 2004), Mount Pinatubo in the Philippines (Gaillard, 2008), the Soufriere Hills Volcano in Montserrat (Haynes et al. 2008a; 2008b) and Katla Volcano in southern Iceland (Bird et al., 2009). These studies rely on structured and semi-structured interviews, questionnaires, household surveys, and expert interviews to unravel the processes that shape local risk mitigation strategies in a case based setting. While the above is not an exhaustive list, these studies have helped to establish a body of case based knowledge about social volcanology, through which new research can be informed.

As many of the themes found within these social volcanology studies overlap, their findings can inform disaster policy. For example, the studies above highlight how decisions made by local residents to evacuate or resettle are heavily shaped by livelihood priorities (Dibben and Chester, 1999; Gaillard, 2008; Tobin and Whiteford, 2002). Furthermore, local risk perception is shown to vary from expert or technical definitions of risk and alongside

livelihoods, is also influenced by cultural factors and religious interpretations (Cronin et al., 2004; Dove, 2008; Haynes et al., 2008a; Schlehe, 1996; Usamah and Haynes, 2012). The selection of my case thereby aimed to test and expand on these prior studies and as I describe below, I purposefully selected a field location where important livelihood activities coexist with significant volcanic hazard.

3.1.2. Why the Dieng Plateau?

I first visited the Dieng Plateau in 2011 and while enjoying a holiday at that time, the uniqueness of the region in terms of its extensive agricultural development and volcanic hazard remained with me until I needed to choose the location for my PhD field work in 2013. With an emphasis in the disaster literature on understanding livelihoods (Chambers and Conway, 1992; Sanderson, 2012; Scoones, 2015) and everyday risk handling mechanisms (Gaillard et al. 2009; van Voorst, 2015), Dieng appeared a clear choice for a field site. In Dieng, farmers daily pass bubbling mud craters or vents that effuse deadly concentrations of CO_2 gas to reach their fields. They are constantly negotiating their interactions with volcanic risk as they make decisions about what to farm where and when. Against this volcanic backdrop, potato and other cool climate vegetables adorn every cultivatable slope. The convergence of the hazard with the intensity of potato farming suggested that Dieng would be a fruitful fieldwork location, particularly in the context of current disaster research trends.

Not only did the Dieng Plateau stand out as a unique and interesting fieldwork location, but it also addresses a gap in the social volcanology literature in Indonesia. Despite Indonesia's 127 active volcanoes (PVMBG, 2017), there is still limited research both in terms of the geophysical characteristics and social impacts associated with volcanic eruptions. As already discussed in the introductory chapter, Mount Merapi, also in Central Java, is an exception to this and forms a popular location for research. While Dieng does not boast the same cultural significance or the same high level of hazardousness associated with Mount Merapi, it does support a large

population, an important vegetable farming industry and significant geothermal energy operations. Furthermore, as will be outlined in the following chapter, past eruptions have caused significant loss of life and regularly decimate nearby vegetable crops. Dieng's agricultural assets, combined with the potential for devastation as witnessed during the 1979 gas event, highlight its research significance. In relation to Mount Merapi, Dieng forms a comparatively more 'moderately hazardous' case study, and in doing so represents many of Indonesia's 126 other volcanoes.

The final consideration explaining why the Dieng Plateau was chosen as a field site relates to the nature of the volcanic hazard itself. Dieng's most hazardous crater – the Timbang Crater Complex – periodically releases deadly concentrations of both CO_2 and sulfur gases. As volcanic gas is an understudied hazard that is inherently difficult to predict and prepare for (D'Alessandro, 2006), Dieng provided an opportunity to understand the societal impacts associated with this lesser understood volcanic hazard. The Lake Nyos, Cameroon disaster of 1986 brought the hazardousness of CO_2 to the world's attention. While this event was not related explicitly to volcanic activity, the gas was released from a volcanic crater lake during the night causing 1,700 deaths and 850 injuries (Baxter et al., 1989; Kling et al., 1987). Witham's (2005) database of volcanic disasters during the twentieth century records that 11 per cent of recorded events have been caused by gas, amounting to two per cent of total deaths during this time. D'Alessandro (2006) records that during the twentieth century 2,000 people have died, and 3,000 have been injured during volcanic gas disasters. The most dangerous and common gas is CO_2, which is responsible for more than 90 per cent of the deaths recorded. This gas is odourless and colourless making detection difficult without the use of technical instruments. Sulfur is the second most prevalent gas (as hydrogen sulfide H_2S and sulfide dioxide SO_2)

and while often accompanied by the smell of rotten eggs[4], is also deadly in high concentrations of above 30 ppm (parts per million; D'Alessandro, 2006).

The unique and understudied nature of gas eruptions in the Dieng Plateau, combined with a general lack of vulnerability research focused on Indonesia's many volcanoes, and a push to understand risks from a locally grounded livelihood perspective, all contributed to the selection of this field site. I will now provide an overview of the specific localities within the Dieng Plateau that were chosen to conduct the majority of my research activities.

3.1.3. Local fieldwork sites

Within the Dieng Plateau three sites were chosen to conduct detailed interviews, participant observation, a participatory workshop and household survey. These include Dusun Simbar (a hamlet of Sumberejo Village), Pekasiran Village and Kepakisan Village. These three villages were selected based on their proximity to areas of the highest volcanic hazard, which was ascertained by visually interpreting PVMBG's volcanic hazard map (Figure 3). Selection of the sites was then discussed with, and their significance verified by, the staff at the Dieng Volcanic Observatory.

Dusun Simbar, Sumberejo Village

Dusun Simbar forms a hamlet of 124 households within the greater Sumberejo Village. The hamlet sits at 1,700 m in altitude and is the closest locality to *Kawah Timbang* (the Timbang Crater Complex), which is situated just 1 km to the east. As with the remainder of the plateau, farming is the main livelihood activity and potatoes and cabbages are grown directly to the edge of the crater's rim. Not only is Dusun Simbar the most hazardous locality in the plateau according to the PVMBG volcanic hazard map (Figure 3), it has also witnessed the largest scale volcanic disasters in recent times,

[4] While the sulfur gases provide more clues to mark their presence than CO_2, SO_2 is still colourless and the ability to smell H_2S ceases to exist in humans when concentrations exceed 150 ppm (D'Alessandro, 2006).

including the 1979, 2011 and 2013 gas effusions from the main Timbang Crater.

As historic volcanic gas events have occurred within the period of people's memories in Dusun Simbar, this locality provided an opportunity to discuss past and present interpretations and mitigation of volcanic hazard. While the PVMBG hazard map informed the initial selection of the hamlet, Dusun Simbar also proved to be an easy place to build relationships with informants. When I first visited the hamlet with my fieldwork assistant we were warmly welcomed into people's homes and these relationships deepened further as I returned with my family. This was a stroke of good luck; not only did this hamlet possess a rich history of responding to volcanic risk but easy friendships were built with a number of the households.

Kepakisan Village

After Dusun Simbar, I conducted the second largest portion of my fieldwork interviews in Kepakisan Village. Kepakisan Village is situated at 1,890 m in altitude and boasts *Kawah Sileri* (Sileri Crater), the second most hazardous crater in the Dieng Plateau after Timbang. Sileri's largest eruption occurred in 1944, while its most recent and far less catastrophic event occurred in 2017. In 2010, BPS recorded the total population of Kepakisan Village as 2,599 people. Farming is the main livelihood activity and as the land surrounding Sileri Crater is intensively farmed it is also subjected to the deposition of mud during eruptions.

Kepakisan Village was selected as a field site due to its close proximity to Sileri Crater. The majority of the village footprint falls within the medium hazard zone (Figure 3), yet it is located just over 1 km from the crater rim. When I first began my fieldwork, we also discovered that some of Kepakisan's older residents witnessed the 1944 eruption of Sileri Crater and relocated to the village in the aftermath of this disaster. The practice of cultivating land around the crater, combined with its history of phreatic eruptions and again a warm welcome on behalf of informants, helped make Kepakisan Village an appropriate second field site.

Pekasiran Village

Pekasiran Village lies between Dusun Simbar and Kepakisan Village. It is the second largest village in the Dieng Plateau with a population of 4,719 people (BPS, 2010) and as with the other nearby villages, potato farming is the main livelihood activity. At 1,800 m in altitude, it is bound to the north by *Kawah Candradimuka* (Candradimuka Crater) and to the west by *Kawah Sinila* (Sinila Crater). Sinila Crater erupted prior to the 1979 gas disaster from Timbang Crater and ejected a large mudflow that destroyed Kepucukan Village. However, no fatal eruptions are associated with Candradimuka Crater. While Pekasiran Village also falls within the medium volcanic hazard zone (Figure 3), its residents have not directly experienced a volcanic disaster. As a result the topic of conversations held in Pekasiran shifted away from volcanic hazard to more general livelihood processes. While these were also insightful, they wavered from my main research objectives and so only a minority of my fieldwork informants came from Pekasiran Village.

Each of the three hamlets or villages described above informed my case study analysis of the relationship between vulnerability, livelihoods and disaster knowledge in the Dieng Plateau in different ways. While all three locations informed my analysis of livelihood transformations (Chapter 6), as the most hazardous locality Dusun Simbar largely informed my analysis of disaster knowledge (Chapter 7). The experience of Dusun Simbar was also drawn on in my analysis of the transmigration program and production of the Dieng hazardscape (Chapter 5). The three locations were not comparative, but rather the data collected in one locality triangulated against the data collected in another. By focusing broadly on three locations I could draw out regional trends, while also describing some of the unique processes occurring particularly in Dusun Simbar in greater detail.

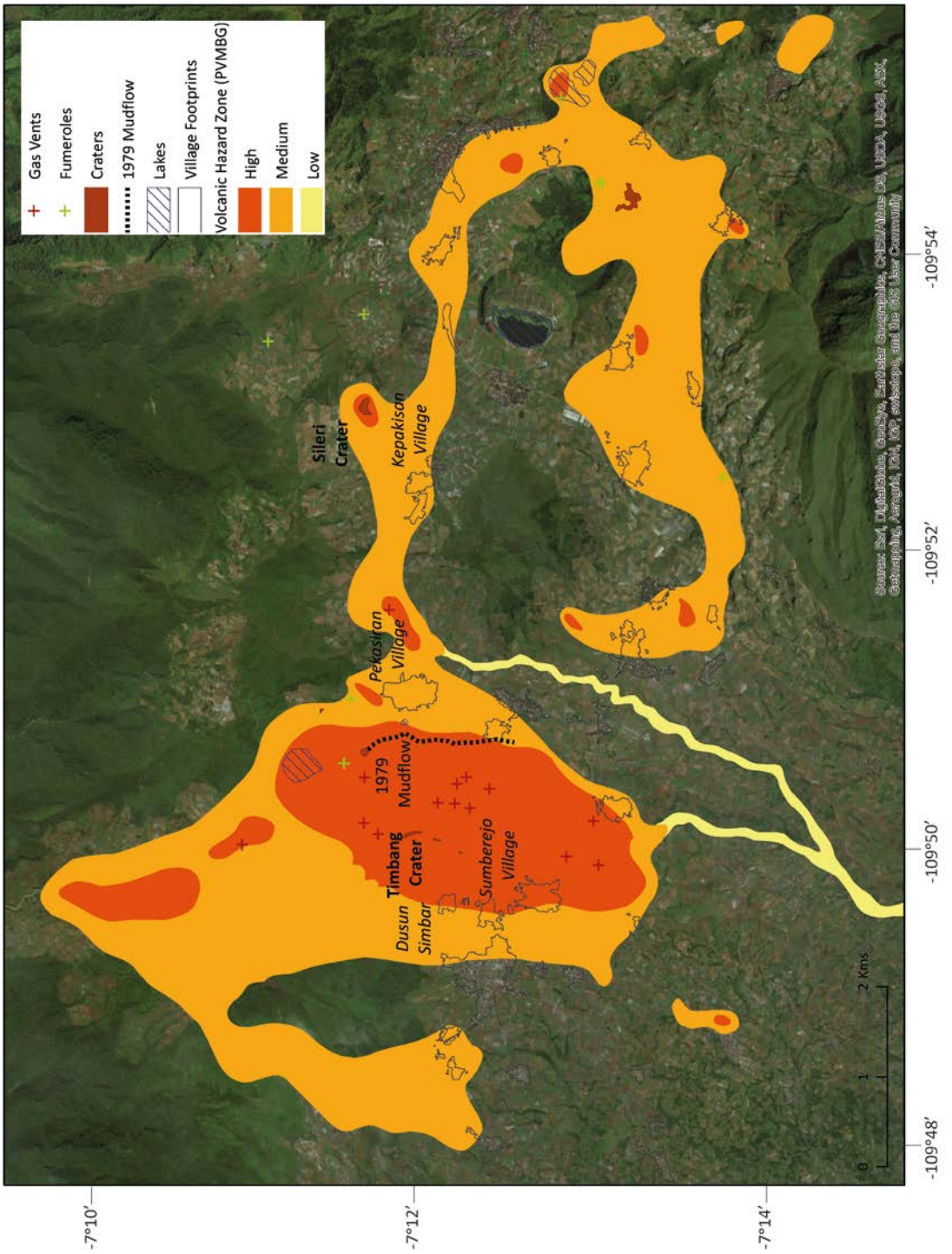

Figure 3. An aerial view of the Dieng Plateau overlain by the PVMBG volcanic hazard map, showing my fieldwork locations of Dusun Simbar, Pekasiran and Kepakisan Village (adapted from Allard et al., 1999; Le Guern et al. 1982; PVMBG, 2011).

3.1.4. Informants from the Indonesian state

In addition to the local sites described above, my fieldwork also aimed to gather information about the state agencies involved in volcanic hazard management. This aspect of my fieldwork focused predominantly on the activities of two institutions, namely the Centre for Volcanology and Geological Hazard Mitigation (*Pusat Vulkanologi dan Mitigasi Bencana Geologi, PVMBG*) within the Geology Agency (*Badan Geologi*) and the District Disaster Management Agency (*Badan Penanggulangan Bencana Daerah, BPBD*). This data was also supported by documents and legal regulations produced by the National Agency for Disaster Management (*Badan Nasional Penanggulangan Bencana, BNPB)*.

BPBD are the main organisation responsible for disaster response and preparedness activities at the district government level. While in Chapter 7 I discuss how the BPBD was formed (see section 7.2.1), in short they are a result of Indonesia's Disaster Management Law (*UU 24/2008*) and policy of decentralisation (Darwanto, 2012). They receive volcanic warnings from the PVMBG and are the first line of response during an emergency in the Banjarnegara district, overseeing the evacuation of Dusun Simbar in 2011 and 2013. Due to their involvement in community level preparedness activities and evacuation procedures, they were an ideal organisation through which to understand how 'expert' disaster knowledge is constructed and acted on.

My interest with the PVMBG focused on their twin mandates of volcanic hazard mapping and volcanic monitoring. PVMBG are actively involved in the creation of volcanic knowledge and engaging with this organisation provided an opportunity to study how this scientifically derived expert knowledge is created and shared. In addition to the BPBD and PVMBG, interviews were held with other agencies at the district government level. These included the Spatial Planning Units (*Tata Ruang*) of *Bappeda* (*Badan Perencanaan dan Pembangunan Daerah*, Regional Body for Planning and Development) in the

Wonosobo and Banjarnegara districts, the Forestry and Agricultural bodies of Banjarnegara (*Dinas Kehutanan* and *Dinas Pertanian*), and the National Land Agency (*Badan Pertanahan Nasional*). These agencies were selected because they are involved in general development or environmental programs in Dieng, the outcomes of which I will later argue also influence vulnerability to natural hazards.

3.2. Data collection

My fieldwork data was collected from September 2015 to January 2016. The majority of my time was spent with local informants in the Dieng Plateau where I conducted semi- and un-structured interviews, participant observation, a participatory workshop and household survey (Table 4). In addition to this, I interviewed and observed the main institutions involved in volcanic hazard management in Dieng namely the Dieng Volcanic Observatory of PVMBG and the Banjarnegara BPBD (Table 4). Doolittle (2008) argues that mixed methods approaches can provide important real-life solutions to natural resource management issues. This study accordingly relied on multiple methodologies to ultimately arrive at a series of policy implications for disaster management.

This research was conducted with prior approval from my university's research ethics committee. The nature of my research and involvement with local participants was largely non-sensitive and most people were willing to talk openly about the volcanic craters and their potato farming livelihoods. However, I needed to respect local bureaucratic procedures and acquire all the necessary permissions from the multiple layers of government before I commenced interviews within each village. This was not only a bureaucratic necessity but also the informants felt they were allowed to talk openly once they knew correct government approvals had been secured. I also needed to be respectful of local Islamic customs and respect prayer times and dress appropriately. We never pushed people for interviews and most interviews were conducted with people who initiated an invitation for us to enter their homes. Before commencing the fieldwork I employed a local research

assistant from the nearby regional centre of Wonsobo, which allowed me to better navigate some of the subtleties in social interactions. An overview of the activities conducted in the field is provided below.

3.2.1. Interviews

The vast majority of my fieldwork activities revolved around conducting semi- and un-structured interviews. While semi-structured interviews allow the researcher to shift the conversation back to the main research objectives when conversations stray too far off track, un-structured interviews seek personal accounts of significant events (Dunn, 2010). Combining these techniques allowed me to address my research questions whilst still leaving open the opportunity to learn about new local phenomenon.

Local informants

Interviews were held with potato farmers, who either work their own land, or labour for others, drawing predominantly from the three localities in the Dieng Plateau described above (Figure 3). A total of 75 interviews were conducted with these local informants; 68 of which were semi-structured interviews and 7 were unstructured focusing on oral life histories (Table 4). While a full breakdown of the age and occupation of informants is provided in Appendix 1, to briefly summarise 33 informants were female, 42 were male, and over 90 per cent participated in potato farming in some capacity. My research assistant or I conducted the majority of these interviews in Indonesian, though at times, especially for elderly residents, they transpired through my research assistant in the local Javanese language.

The selection of informants for the interview process occurred primarily through an informal process. Our first contact with the representative villages occurred in the respective village (*desa*) offices, with the Village Head (*Kepala Desa*), Hamlet Head (*Kepala Dusun*) or Village Council Officials (*Perangkat Desa*). During these meetings we introduced ourselves, explained our purpose and gifted a small souvenir of Australian chocolate to the office. Following initial introductions, these key informants were interviewed and

the quality and contextual appropriateness of the interview schedule was tested (see Dunn, 2010).

We then focused on building relationships with general local informants, making initial contact by walking through fields or participating in village activities (such as eating in food stalls or *warungs*). These encounters generally led to invitations to visit people's homes when their daily work was complete. This inevitably led to much 'snowball' sampling where we were invited into the homes of informant's friends and relatives. We tried to interview informants from a mix of socio-economic statuses and so continued to approach new informants ourselves whilst also taking up these new opportunities. The socio-economic markers that aided this selection included ownership of assets such as land and motor vehicles, and whether the older members of a household had completed the Hajj to Mecca[5]. As a result we met with a wide range of people including landowners, labourers, teachers, small business operators, vegetable traders and certified seedling developers (a detailed list is found in Appendix 1).

An example of the types of questions we asked during the fieldwork can be found in Appendix 2. To briefly summarise, three sets of questions were asked to address the three research objectives outlined in the introduction. The first set of questions focused on access to land surrounding craters and government relocation programs following eruptions. The second set of questions addressed more contemporary livelihood processes, and the third focused on how informants understand and respond to the volcanic hazards. In addition to the pre-defined set of questions, we found that informants readily contributed new knowledge when they believed this knowledge to be of significance. For example, informants readily contributed information concerning issues associated with seed potatoes and pesticide use. These were not included in my original list of research questions, yet as they were

[5] The Hajj is the Islamic annual pilgrimage to the holy city of Mecca that must be carried out once in a lifetime by all physically and financially able adult Muslims. In Indonesia, those who have completed the Hajj are known as Haji (or Pak Haji for males), and this achievement receives great respect at the village level.

shown to significantly impact on livelihoods, this line of questioning was pursued. The detailed nature of the information collected during these interviews provided the context that informed how participant observation, the community workshop, and household survey were also conducted.

Unstructured interviews, focusing mainly on oral life histories, were undertaken with elderly informants who were left to speak largely uninterrupted. During these discussions we let the informants explain past and present life in the Dieng Plateau in their own words. These discussions touched on past issues of poverty, the Dutch and Japanese occupations, the impact of volcanic eruptions (particularly the 1979 Timbang gas event and 1944 eruption at Sileri Crater), and the way farming and cultural activities have changed over time. These interviews provided an important historical context to my understanding of life in the Dieng Plateau; however, we were reluctant to push informants for exact details due to their age.

State institutions

Interviews with state institutions (specifically the BPBD and PVMBG) focused on how DRR programs are devised, prioritised and implemented, and how volcanic activity is monitored and responded to. I supplemented these interviews with a discussion with the Banjarnegara arm of the Indonesian Red Cross (*Palang Merah Indonesia*) on local issues of disaster management, especially the district government's capacity. The more peripheral interviews with additional district level government departments (other than the BPBD) focused on general development programs, environmental issues and spatial planning (or lack thereof) in the Dieng Plateau. While many of the responses provided during these additional interviews were normative, in that they primarily relayed official organisational mandates, they still proved useful particularly those conducted with the Banjarnegara *Bappeda*.

3.2.2. Participant observation

During my period of research I partook in participant observation, focusing on local informants in the Dieng Plateau as well as government officials from

BPBD. This data complemented and contextualised much of the information we gained during the fieldwork interviews (see Kearns, 2010), as outlined below.

Local informants

Local participant observation involved observing and interacting with both farming practices in the fields and various household activities. When in the fields, the extent to which I could genuinely become involved in farming activities was limited and most of our time was spent observing specific practices (such as harvesting, sowing seeds, building of terraces, connecting water supplies etc.). While I was distanced from the realities of daily farm work, the time spent in the field still allowed me to contextualise the information gained during interviews. For example, I was able to observe how people farm land surrounding active craters and the climatic conditions that prompt them to leave the fields.

Kearns (2010) argues that participation is most inconspicuous when the researcher is interacting most naturally with the research informants. As I have very limited experience vegetable farming, the opportunities to become naturally incorporated into local activities widened within people's homes. This was particularly true when my daughter and husband joined me on my fieldwork (see section 3.3 below). In the home I could help prepare food (or at least learn local cooking styles), clean away dishes and engage in play with my daughter and other children. This participation provided an opportunity to better understand daily household activities and everyday priorities.

BPBD workshops

Participant observation proved most insightful with my interactions with the BPBD. While interviews may have focused on their many ambitious disaster management goals and achievements, witnessing their project activities in action provided a much more nuanced and realistic picture. We participated in multiple disaster management training sessions held for community members, the village level police (*Linmas*) and other district level

government representatives. Attending these ongoing workshops allowed us to observe the efficacy of the BPBD facilitators and the level of involvement and enthusiasm shown on behalf of the participants. We were also able to quietly ask the participants questions about their workshop experience afterwards. Furthermore, we were privy to informal comments regarding the aptitude of participants made by the BPBD officials. This added a real dimension to the otherwise largely official community-based DRR narrative discussed during interviews (see Chapter 7).

3.2.3. Community based workshop

My fieldwork also involved a workshop with 10 residents of Dusun Simbar. As the active participation of participants in their own research can challenge prevailing biases and preconceptions held by the researcher (Sanderson and Kindon, 2004), such approaches are now widely applied within social volcanology research (see Cadag and Gaillard, 2012; Cronin et al., 2004; Gaillard et al., 2010; Gaillard et al., 2013; Kelman et al., 2012; Peters-Guarin et al., 2012; Riechel and Fromming, 2014). While Le De et al. (2015) argue that these approaches are restricted in their ability to genuinely reflect local issues; they still provide an opportunity to gain additional insights that may be overlooked in the interview process (Chambers, 1994). The workshop we undertook followed the techniques outlined in the IFRC's (2007) Vulnerability and Capacity Assessment Toolbox, which draws its methodology from Chambers (1994) rapid rural appraisal or participatory rural appraisal approaches (RRA/PRA). While the term 'participatory' is used within this thesis to explain how participants developed their own hazard map, this workshop was not based upon a participatory action research (PAR) approach (see Gibson-Graham, 2005), and did not lead to ongoing local-led activities.

The first half of the workshop focused on identifying and ranking the various 'threats' faced by the community. As vulnerability and risk are not easily translatable or commonly used terminology in Indonesian, we used the term *ancaman*, or 'threat', to identify potential issues. This component of the

workshop followed the IFRC's (2007) guidelines whereby participants identify and rank issues that impinge most significantly on their overall welfare and livelihood activities. This activity challenged my previously held biases that overemphasised the impact of certain natural hazards over others (the outcome of this workshop is discussed further in Chapter 7). The second half of the workshop required participants to spatially identify erosion and landslide prone regions, volcanic hazard zones and evacuation routes within their village boundary. Haynes et al.'s (2007) work in Montserrat revealed that communities are better able to spatially identify features if aided with oblique aerial photography or 3D maps and so satellite imagery was used over the sketch maps advocated by the IFRC (2007).

3.2.4. Household survey

A household survey was conducted with all of the 124 households of Dusun Simbar in Sumberejo Village. The purpose of this questionnaire was to complement the more intensive form of data collected during interviews to This survey was organised into four components of inquiry, a copy of which is found in Appendix 3, and included a mix of quantifiable, multiple choice and a few open-ended responses. The initial questions obtained general information about the participant, such as their age, level of education and occupation. The second group of questions focused on how households have responded to gas events in the past and whether their crops were affected as a result. The third group of questions addressed household financial status, including assets owned and the frequency at which money is borrowed either formally or informally. The final component to the questionnaire focused on land status such as ownership, labouring and leasing arrangements. While the village council or district government supposably hold some of this data, in my experience these records are incomplete and at times inaccurate, hence the need for the household survey.

The survey was tested on five representatives from the Sumberejo Village office, including one Pak RT (*rukun tetangga* or head of a neighbourhood association) of Dusun Simbar. After a few amendments were made and the

survey deemed appropriate for distribution, we began surveying each household in Dusun Simbar over a one-week period. The surveys were completed by either a researcher or the participant themselves, depending on each participant's preference. Only one member per household was surveyed and this generally fell to whoever was at home when we visited rather than to the official household head. As a result the survey was completed by 74 male and 50 female residents, all of whom were over the age of 18. Importantly, most of the questions contained within this survey were developed to capture the dynamics of the entire household, rather than the individual circumstances of the informant who completed the survey itself.

From a personal viewpoint the component of the survey that made me feel most uncomfortable involved asking people about their financial assets. As a result this information was asked towards the end of the survey after some rapport between researcher and informant had been established. This feeling of intruding into household financial matters was further alleviated when informants completed their own survey; however, due to differences in literacy levels this was not always possible and as such we never pushed for more information than was willingly provided. Furthermore, during interviews we found that the larger landowners were reluctant to reveal how much land they actually owned, while many small landowners couldn't provide the area of their land holdings in metric units. In an attempt to overcome this, the survey categorised land holdings into the following: 0.1 – 0.5, 0.5 – 1, 1 – 3 or > 3 hectares. This was also supplemented with information on how many land holdings each household owned.

3.3. Data analysis

As the data I collected in the field represents a 'mixed methods' approach (Doolittle, 2008), various techniques were employed to analyse and then integrate the different data sources. The discussion below outlines how this data was analysed, integrated, and the key themes extracted to present an informed picture of vulnerability to volcanic hazard in the Dieng Plateau.

3.3.1. Analysing fieldwork data

While my fieldwork involved a number of activities, semi-structured interviews formed the methodological foundation of my analyses and subsequent knowledge claims made within this thesis. Analysis of the interview data began in the field and continued after I returned to my home university. While in Central Java, interviews were audio recorded and later transcribed by my research assistant into Indonesian. I then translated these transcripts into English for the easy identification and organisation of themes. Use of the English transcriptions proved useful in the early stages of analysis; however, as I became more emerged in the data analysis process I increasingly returned to the original Indonesian transcripts as they captured greater nuance of key concepts. To ensure anonymity, all following ANU ethics protocols, all interviews were stored on my computer by number rather than name and these numbers are referred to throughout the text.

After translating the transcripts and reading over the interviews comprehensively and repeatedly, I began to identify key themes that were frequently raised. These included: the process of transmigration and resettlement of Dusun Simbar, cost of land surrounding active craters, past and present livelihood practices and agrarian change, livelihood outcomes and current livelihood pressures, local volcanic hazard mitigation practices, and knowledge of volcanic eruptions including local interpretations and response activities. I chose not to code the data and instead focused on commonalities between interviews. Word searches were conducted on each of the transcripts to highlight these commonalities, with the ultimate goal of situating key concepts within the literature on broader local and regional processes. Various quotes were extracted from the interview transcripts and have been inserted into the text as evidence of the knowledge claims I make.

I entered the data we collected during the household survey of Dusun Simbar into a comprehensive excel spread sheet, where it was checked for errors and summarised into the tables and figures that are presented throughout the coming text. This information includes data on land ownership status, the

size of landholdings, the frequency of crop failure, money lending patterns, and overall attitudes towards evacuation following eruptions. This quantitative information provided context to my analysis of vulnerability, land, livelihoods and local disaster knowledge presented in Chapters 5, 6 and 7. While the survey allowed me to corroborate some of the broad claims made by informants during interviews, the main findings of this thesis still draw predominantly from the more detailed, process-focused interviews held with local informants and observation of government officials.

Data obtained during the community workshop, primarily the ranking of local risks and the sketch map of hazardous zones, was compared to information collected during the interviews as well as PVMBG's official volcanic hazard map to provide a useful insight into the local prioritisation of risks. This process allowed me to better understand and tailor later interview questions to reflect local views of risk, as opposed to risk as understood from the perspective of the BPBD or PVMBG's hazard map. While the shortcomings of the data obtained during the workshop are discussed below, it nonetheless presented useful views on local understandings of risk that served to complement the interview process (see also Campbell, 2001).

As discussed above, participant observation proved most insightful in my dealings with the BPBD and once fieldwork was completed I relied on the notes I took after I observed their many community training workshops. These notes captured the conduct, presentation and informal comments made by the BPBD staff as well as attempting to document the level of participation and enthusiasm displayed on behalf of participants. I also collected their training materials, including presentation slides, and read relevant official documents such as *Undang Undang 24/2007* on the National Disaster Management Law and *Peraturan* 1/2012 on the regulation of disaster resilient villages/districts. My observations, alongside these documents, helped to inform the picture of the BPBD I present in Chapter 7.

Baxter and Eyles, (1997, p. 505) argue that the qualitative research methodology requires a degree of creativity 'to capture the richness of

context-dependent sites and situations', and my analysis and explanation of key themes certainly followed this approach. However, validation of the data is also required to establish research rigour (Baxter and Eyles, 1997), and to this end I relied on triangulating my mixed methodology approach and the findings of other key literatures in the field. The results I obtained using each method (interviews, participant observations, community workshops and the household survey) were triangulated against the other to ensure a general consensus of ideas was found. For example, the risks listed during the workshop were raised again during focused interviews to ascertain their level of importance. Furthermore, mitigation measures, such as avoiding the fields during overcast weather were observed in the field as well as raised by informants during interviews.

After the key concepts crossing each of my data sources were identified, I then turned back to the literature and relevant theory pertaining to livelihoods and disasters in Southeast Asia. For example, when historical events were discussed, I drew on historical literature (i.e. Boomgaard, 1999) to validate elder's knowledge. Other key literature that influenced my data analysis process included Rigg and Vandergeest's (2012) edited book '*Revisiting Rural Places: Pathways to Poverty and Prosperity in Southeast Asia'*, Li's analysis of Indonesia's development programs (Li, 2007, 2011b), and literature pertaining to the hybridisation of disaster or local ecological knowledge (see Berkes et al., 2000; Nygren, 1999; Rigg et al., 2005; Schlehe, 2010; Shannon et al., 2011). I constantly moved between this theory and my data to substantiate, contradict or correlate my claims with the literature. This approach follows Lund's (2014) assertion that researchers are constantly moving back and forth between the processes of observation, generalisation, abstraction and theorisation rather than following a linear path.

3.3.2. Data limitations

Despite my best efforts to demonstrate research integrity and thoroughness, there are still limitations to my data analysis process. While a personal

reflection on the entire research process is reserved for the section below, here I will discuss limitations associated with my site selection and the use of data obtained during the community workshop and household survey of Dusun Simbar. Firstly, I recognise that I intentionally chose villages within the Dieng Plateau that have been exposed to volcanic events in the past. The types of vulnerability I discuss throughout this thesis are therefore restricted to localities that are known to be hazardous. A different story may have emerged if I had focused on localities that are less frequently impacted by volcanic hazards.

I also recognise that my design of, and involvement during, the workshop meant that the outcomes likely reflect my research interests in natural hazards rather than an 'objective' representation of community views. By the time the workshop was held, I had built rapport with local informants and as many were willing to ensure I achieved my research outcomes they focused their discussions on local hazards, which they likely felt I would appreciate. In doing so, the opportunity to unearth new and unexpected views was minimised. Furthermore, the workshop reflected more of a rural appraisal approach (see Chambers, 1994) rather than participatory action research (see Gibson-Graham, 2005) and was therefore never likely to lead to the development of ongoing activities on behalf of the participants (see also Le De et al. 2015). This limitation was compounded by the fact that, in accordance with standard practice in Indonesia, I provided each participant of the workshop with *uang saku* (pocket money) to attend alongside a snack box. While this perhaps impinges on the 'participatory' nature of the workshop, in my circumstance, it could not be avoided or overlooked.

The final shortcoming to the data analysis process pertains to the use of the household survey data. McGruik and O'Neil (2010) posit that household surveys 'provide more in-depth perspectives on social processes and context' (p. 192); however, within this thesis the household survey was used predominantly as a means to contextualise the more detailed interview data collected in Dusun Simbar. The survey did not attempt to capture the nuance of livelihood processes, but rather provided context and background to the

socio-economic makeup of the hamlet. This data however, proved useful to triangulate certain claims, for example the relatively high levels of land ownership found in this particular hamlet.

The section above has provided an overview of the 'mixed methods' approach (see Doolittle, 2008) used to inform my case study of vulnerability, livelihoods and disaster knowledge in the Dieng Plateau. As the methodology that has produced this thesis has now been described, I will now conclude this chapter with a personal reflection on the fieldwork process.

3.4. Fieldwork reflections

My theoretical background and social standing inevitably influenced the fieldwork process and the type of knowledge I collected. Drawing on fieldwork experiences from China, Cornet (2010) and Turner (2010a) demonstrate that the process of reflecting on ones 'positionality' within the field reveals both local social structures and processes, as well as the limits of the data obtained by a researcher. I begin the discussion below by describing the theoretical base and assumptions I brought to the field, and how these changed as new data was collected. I then reflect on my own positionality, specifically how my accompanying family and research assistant influenced the ease through which we were able to access both local, and various state department, voices.

3.4.1. Inductive and deductive knowledge claims

The findings obtained from the qualitative case study presented in this thesis involved a process of both deduction and induction. As Baxter (2010) argues, qualitative research is rarely a purely inductive or purely deductive process. All researchers enter the field with some degree of theoretical knowledge and this was certainly my case. However, in the field I was also confronted with many new phenomena outside the realm of my prior theoretical understanding. From here, as Baxter (2010) articulates, I 'borrow[ed] from related fields of inquiry' (p. 89) with the intention of expanding upon current disaster theory.

I entered the field with basic hypotheses related to the structural constraints that push people into conditions of vulnerability to natural hazards (see Wisner et al., 2004). I was also armed with an understanding of livelihoods perspective research and the importance of economic needs in the prioritisation of risk (for some examples see Chambers and Conway, 1992; Chambers, 1994; Haynes et al., 2008a; Hellman, 2015). What I was less prepared to encounter in the field were issues of agrarian transformation (see Li, 2014), the rendering of 'development' as a technical problem (see Li, 1999b in Chapter 5), and territoriality (see Peluso, 2005; Peluso and Vandergeest, 2001; Vandergeest and Peluso, 1995). Furthermore, issues of disaster knowledge and the sometimes contradictory manner through which this is understood and applied in Indonesia were largely foreign ideas to me. This led me to engage with the local ecological knowledge literature, specifically frameworks that recognise the locally embedded and contextualised nature of environmental knowledge (Agrawal, 1995; Berkes et al. 2000; Goldman, 2007; Nygren, 1999; Turnbull, 2000). The inductive component of my fieldwork encouraged exploration of these new theoretical frameworks, many of which are currently underutilised within the disaster literature.

The knowledge claims I have drawn from my case study are made from both a participatory and a constructivist perspective (see Creswell, 2013). Participatory research recognises that local processes are intertwined with wider politics and aims to enact an agenda for reform that will benefit the lives of the research participants in question (Creswell, 2013). This is the legacy of Blaikie (1985), Blaikie and Brookfield (1987) and Wisner et al. (2004); works which have heavily influenced the design of this research. These participatory knowledge claims are presented in Chapters 5 and 6 where the construction of vulnerability and livelihood processes within the Dieng Plateau are related to wider processes with the aim of informing policy that can reduce overall conditions of vulnerability. Chapter 7, however, takes a more constructivist perspective wherein participants are seen to construct and interpret the meaning of volcanic hazard themselves. This recognises

that participants develop subjective meanings of their experiences (Creswell, 2013), in this case knowledge of, and response to, volcanic activity. These constructivist knowledge claims align with the broader risk literature which views risk as a social construct rather than an objective phenomenon (Dake, 1991; Douglas, 1997; Kasperson et al., 1988; Slovic, 1999).

3.4.2. My positionality and access to informants

I will now conclude this methodology chapter with a reflection on my own positionality within the field and how this influenced access to informants. Gaining the trust of both local and government informants was crucial to the success of my fieldwork and in my case this was heavily influenced by the presence of my daughter, husband, research assistant, and even at times driver, in the field. Overall, relationships were made relatively easily and I acknowledge that part of this success is owed to the contribution played by each of these people.

After the arduous process of obtaining research visas and permissions, the actual process of conducting the fieldwork proved to be relatively straightforward. I came to the Dieng Plateau with my husband and then one-year-old daughter. Including a research assistant, the four of us conducted initial meetings and interactions in Dieng as we negotiated which villages and/or hamlets to focus our efforts in. Our daughter rallied much interest in the local villagers, especially with her blue eyes and blond hair, which was not a typical sight for many Dieng residents. This helped facilitate our access to people and their lives, as many wanted the *boneka* (or 'doll') to come and play in their homes.

In Indonesia it is common for researchers or *peneliti*, to conduct their work with the help of an assistant and solo work is unusual, especially for a *bule* (Westerner). By employing a research assistant I was not only seen to be contributing to the welfare and advancement of this recently graduated

assistant[6], but I was also greatly assisted in my negotiation of important cultural practices. Local to Central Java, my assistant was able to speak Javanese and ensure we adhered to the appropriate cultural formalities, both of which greatly facilitated the building and maintaining of relationships. Turner (2010b) argues that research assistants bring their own value judgements and belief systems to the field, just as primary researchers do. This was also my experience and stemmed in part from my assistant's undergraduate studies in anthropology and education. At times she steered away from the main research objectives, for example, to discuss why children in the research villages were not attending school in their later years. While this mode of questioning opened up certain insights into the aspirations of the village youth, at times I felt it also bordered on accusatory, and I was concerned that it made some informants feel uncomfortable. Despite this however, the overall contribution made by this research assistant, in terms of cultural awareness and relationship building, proved invaluable to the success of my fieldwork.

While Turner (2010b) has drawn attention to the silent voices of research assistants, in Indonesia drivers also play a significant role in social relations. We often travelled between the villages using a rented car and driver. As an older man our driver was concerned with our welfare and safety, and having worked for many years in Dieng's now bankrupt mushroom factories, took a keen interest in the research program. He would spend his time smoking *kretek*[7] with other men along the side of the road as we interviewed. Aware that these discussions no doubt included what the *bule* was doing in Dieng, I was always conscious to maintain an amicable relationship with our driver. Inevitably, his social interactions also led to more interviews as we were invited into the homes of his newly found friends.

[6] In Indonesia, newly graduated university students are typically eager to work for Western academics as it boosts their resume and future work prospects. These jobs are also often financially rewarding in contrast with many local opportunities.

[7] Indonesia's domestically produced clove flavoured cigarettes.

Cornet (2010) reflects on the beneficial impact children can have on the fieldwork process and my experience supports this claim. As Cornet (2010) also found, my identity as a mother was a more tangible point of reference for informants to understand and relate to. There was an instant commonality between researcher and informant that provided a depth to conversations, especially those held with other women. Our children played and ate together, and this was a great equaliser. Moreover, I needed their help not only as a researcher but also more importantly as a mother trying to parent in a new and different cultural environment. While I do not suggest that all relationships were equal, this arrangement did work to break down a possible perception that I was somehow an 'international DRR expert'.

I also found that my husband contributed to the facilitation of local relationships in Dieng. Surprisingly for us, many of the men we spoke with were impressed that my husband was supporting me on this fieldwork trip and was given the opportunity to care for our daughter while I worked[8]. The acceptance we received in Dieng possibly reflects local views that both men and women should work the land and contribute to household finances. Being a part of a standard family unit also appeared to matter to informants, and in playing this role I felt less anomalous. My husband built relationships with the husbands of the women I came to know most intimately. A geophysicist by training who has worked previously with *Badan Geologi*, he also proved helpful building relationships with staff from the Dieng Volcanic Observatory.

While my family proved a great asset in gaining access to informants, as Cornet (2010) also found there are limitations to conducting fieldwork with children. Potato farmers finish work in the mid-afternoon, so the best discussions were held in the late afternoon and evening. At times these needed to be prematurely ended so that I could be involved in my daughter's bedtime routine. For practical reasons, my family did not always accompany me, leading to lots of travel and reduced spontaneous opportunities to spend

[8] These sentiments were not always reflected in the regional town of Wonosobo where my husband and daughter in particular also spent a considerable amount of time.

time in the homes of informants in the evenings as these often had to be pre-arranged.

Once trust with informants was achieved, we were readily introduced to other informants and new modes of questioning. Informants raised issues in addition to my initial research questions and provided avenues for me to pursue them. For example, some farmers accompanied me on interviews with potato traders and certified seedling developers they knew. I was also introduced to elderly members of the community who could remember historic volcanic disasters. This process of informant selection while introducing new themes, also allowed me to triangulate some of the prior information I had gained. One close informant also told me that I should conduct a household survey to collect more detailed data. While I was already planning this approach, his statement encouraged me to promptly move forward with the survey.

We gained access relatively easily with the Dieng Volcanic Observatory and the BPBD. This was in part facilitated through my husband's past collaboration with Indonesia's *Badan Geologi* in Bandung who connected me with the staff posted in Dieng. Our initial meeting with the BPBD was smoothed over by the official paperwork I obtained from *Bappeda* Banjarnegara. The second in command at BPBD proved a very helpful contact and was happy for us to accompany him on his official duties. Most of these involved the overseeing of workshops, during which our presence added to the formality of the occasion. The interest we showed validated the importance of his work and so we were treated with a welcome openness.

As my fieldwork was a collaborative process, throughout this thesis I use 'we' rather than 'I' to describe how the data was obtained. 'We' most frequently refers to my research assistant or myself, but may also include my husband, the informants, and in a few instances our driver. However, this collaboration ended after data collection and so I am responsible for the data analysis, the writing, and the foundational knowledge claims made in this thesis.

Table 4. A summary of the informants and type of activities conducted during my data collection process. A complete list of informant details is found in Appendix 1.

Location	**Fieldwork activity**	**Occupation and livelihood activities of informants**
Dusun Simbar, Sumberejo Village.	42 semi-structured and unstructured interviews, survey of all 124 households, participant observation, and a participatory workshop.	Farmers – labourers and landowners, village council officials, and small business owners.
Kepakisan Village.	20 semi-structured and unstructured interviews and participant observation.	Farmers – labourers and landowners, village council officials, and small business owners.
Pekasiran Village.	7 semi-structured interviews.	Farmers – labourers and landowners, and village council officials.
Various additional villages in the Dieng Plateau (Sumberejo, Batur, Gembol and Bakal)	6 semi-structured interviews.	Village council official, seed potato propagator and seller, land owners, a vegetable trader and the head of an Islamic emergency volunteer organisation (*Pos Bagana*).
The Dieng Volcanic Observatory (*Pos Pengamatan Dieng*), Karang Tengah.	2 semi-structured interviews.	Geologists and field officials.
The District Disaster Management Agency (BPBD), Banjarnegara.	3 semi-structured interviews and observation of official activities (primarily the running of workshops).	First and second in command of BPBD.
Various district government agencies in Banjarnegara (*Bappeda*, Environment and Forestry Body, Agricultural Body, BPN).	4 semi-structured interviews.	Spatial planning, forestry, agricultural and administrative officers.
Indonesian Red Cross, Banjarnegara.	1 semi-structured interview.	Head of the Red Cross, Banjarnegara.
Villages in the Banjarnegara district.	2 semi-structured interviews.	Members of the village level community police (*Linmas*) interviewed while attending BPBD training events.
'Dieng Go Green' NGO in Wonosobo.	1 semi-structured interview.	NGO employee.
Spatial Planning Unit of *Bappeda*, Wonosobo.	1 semi-structured interview.	Spatial planning officer.
Centre for Volcanology and Geological Hazard Mitigation (*PVMBG*), Bandung.	2 semi-structured interviews.	Landslide geologist and senior volcanologist.

4. An overview of natural hazards in the Dieng Plateau

Before vulnerability to natural hazards can be explored, a thorough analysis of the hazards in question is required (see Cardona, 2003; Walker, 2005; Wisner et al., 2004). The forthcoming chapter provides an overview of the characteristics and frequency of natural hazards that have occurred in the Dieng Plateau. Importantly, it provides the necessary background to address the three main research questions, which underpin the coming empirically-based chapters. This chapter focuses on Dieng's more catastrophic history of volcanic eruptions, but also describes other hazards including landslides, earthquakes and strong wind events (Table 5). These hazards range in magnitude and impact, and have affected both people and the livelihoods they depend on. While livelihoods are often disrupted as a result of these disasters, this chapter describes how volcanic eruptions can provide both local and nationally significant livelihood resources, such as fertile soils and geothermal energy. The field of study known as the political ecology of disasters recognises that disaster risk is the interaction of vulnerability with a hazard (Wisner et al., 2004), and this chapter aims to highlight the significance of Dieng's natural hazards. Overall, the chapter demonstrates that occupation of the Dieng Plateau is indeed a hazardous undertaking, yet significant benefits can be accrued through participating in agricultural activities in this area. In doing so, this chapter serves as a reference to understand the complex human-environment relations that are described more fully throughout the coming chapters.

4.1. Volcanic eruptions

The Dieng Plateau represents a unique volcanic landscape. Rather than a singular volcanic cone, it is a volcanic complex consisting of late Quaternary[9] to recent volcanic stratocones[10], vents and craters (Miller et al., 1983). No

[9] The late Quaternary informally refers to the past 0.5 – 1 million years ago to the present.
[10] A stratocone is a steep conical volcano built from the products of past eruptions usually constructed over a period of tens to hundreds of thousands of years (USGS, 2017).

magmatic eruptions have been recorded for the past several thousand years, and recent activity in the area has been characterised by phreatic eruptions[11] with small hot mudflows, emission of poisonous gases and hydrothermal activity (Miller et al., 1983) (Figure 4). The earliest recorded historic eruption occurred in 1786, causing the deaths of several people due to the impact of the phreatic eruption, and the loss of an additional 38 people due to a subsequent landslide (Gunawan, 1968).

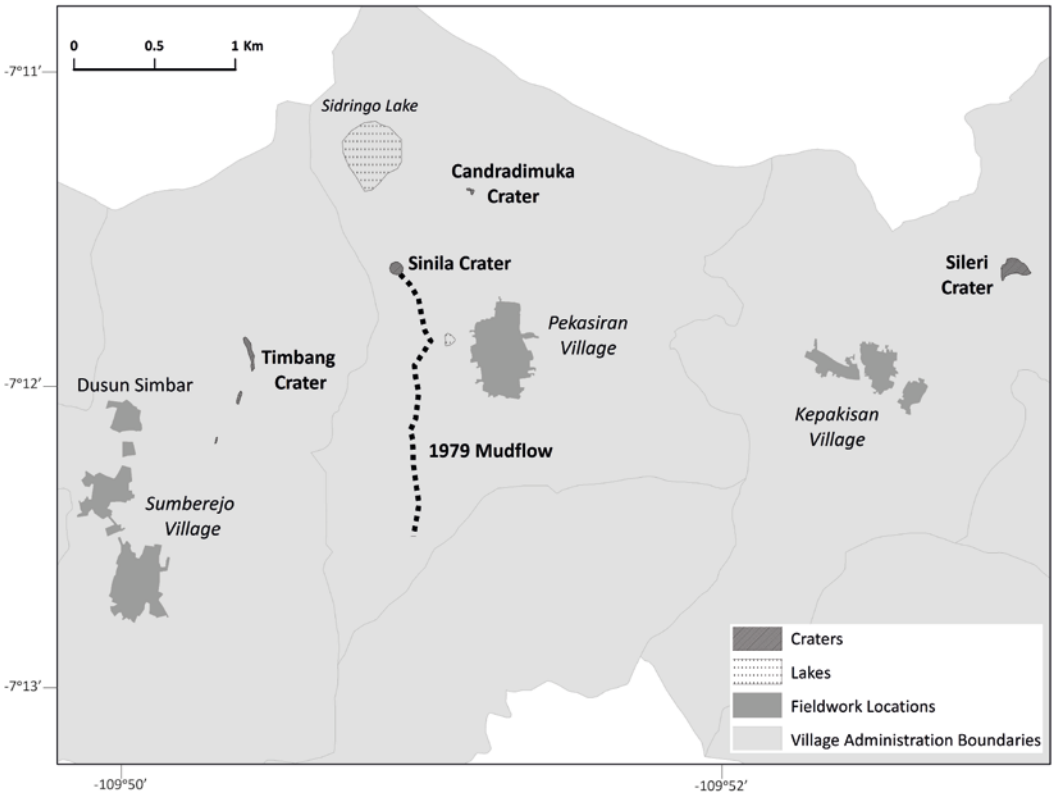

Figure 4. The location of volcanic features, including the main Timbang Crater, which was the source of the 1979 CO_2 effusion, in relation to my fieldwork locations (source: author).

The most recent volcanic hazard map of the Dieng Plateau was produced by the PVMBG in 2011 and contains three hazard zones (*kawasan rawan*

[11] A phreatic eruption is a steam driven explosion that occurs when water beneath the ground or on the surface becomes heated by magma, lava, hot rocks or new volcanic material. This causes the explosion of steam, water, ash and rocks and can be accompanied by CO_2 or hydrogen sulfide gas emissions (USGS, 2017).

bencana zona 1, 2, 3) (Kartadinata et al. 2011, Figure 5). The highest hazard zone (zone 3) includes the spatial footprint of all active craters (Timbang, Sileri and Candradimuka) as well as the majority of Sumberejo Village due to its proximity to the Timbang Crater Complex. Medium hazard (zone 2) includes the area surrounding and between the craters, and low hazard (zone 1) is delineated as the downslope valleys and streams that may become a conduit route for lahars or poisonous gas. While I later discuss some of the limitations associated with this map in Chapter 7, as already outlined in the methodology, it nonetheless informed the selection of my fieldwork sites.

Allard et al. (1989) estimate that there are approximately 100 craters distributed throughout the plateau. The most hazardous of these are located in the western, and geologically oldest, section of the plateau. This area is lined by a string of craters, namely Timbang, Sinila, Candradimuka and Sileri (Figure 4). Of these craters, Timbang and Sileri are the most active and when combined with their proximity to settlements and agricultural fields they thereby pose the greatest threat to lives and livelihoods. For this reason they were chosen as the main sites for my fieldwork interviews. An overview of their eruptive history and the societal impacts of these eruptions is provided below.

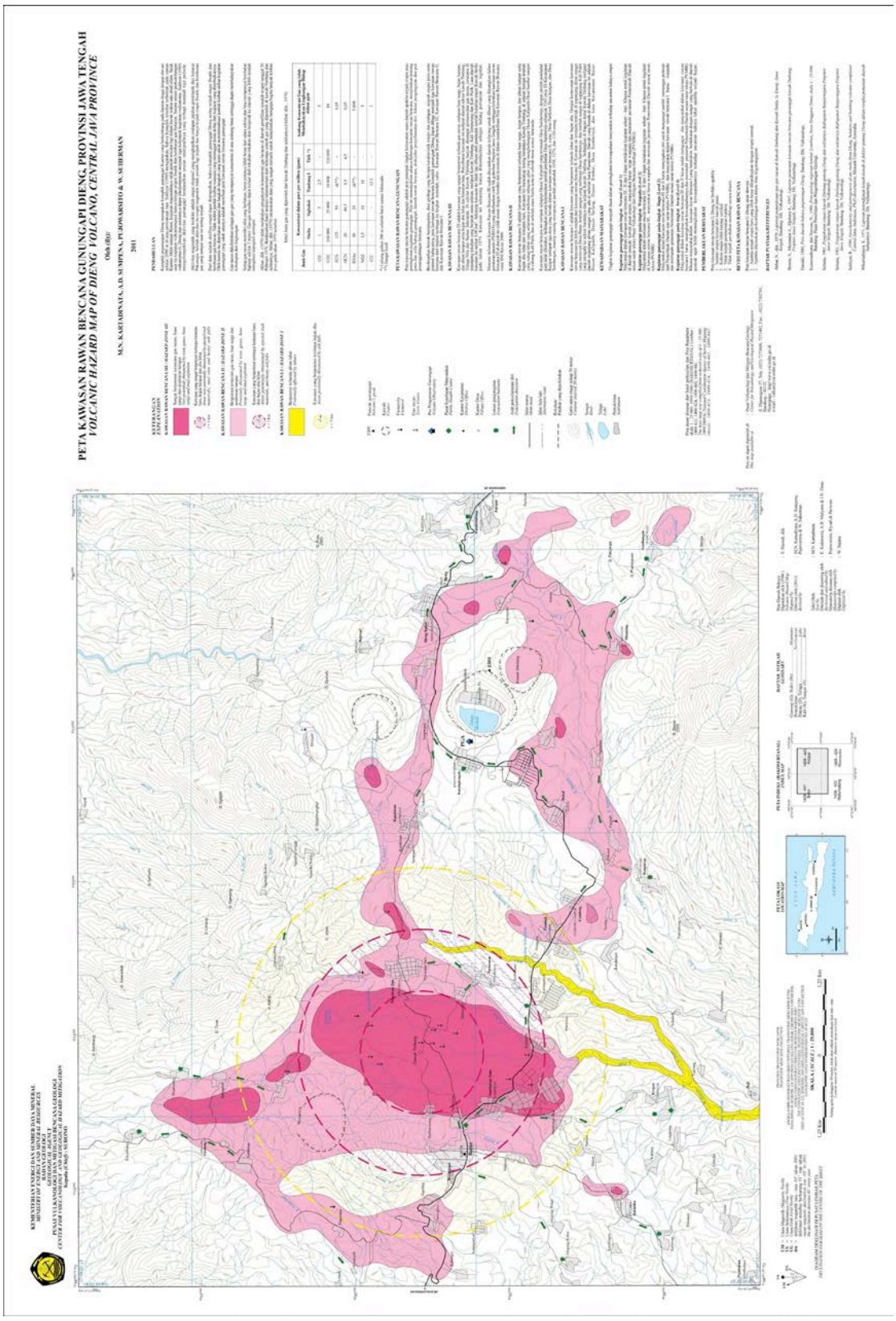

Figure 5. The 2011 Volcanic Hazard Map of the Dieng Plateau produced by PVMBG (Kartadinata et al., 2011). The dark pink represents the highest hazard zone (zone 3), the light pink depicts moderate hazard (zone 2), and the yellow is low hazard (zone 1). The concentric pink and yellow rings depict areas that could potentially be impacted by block and ash fall in the event of an eruption. For a fuller discussion of this map see section 7.2.2 of Chapter 7.

4.1.1. The Timbang Crater Complex

The Timbang Crater Complex is situated to the north east of Dusun Simbar. Three main fissures in the earth are associated with the complex, the largest that is most commonly referred to as Timbang Crater, spans 40 by 60 m in diameter (Figure 6). This main crater is characterised by phreatic eruptions and the effusion of deadly concentrations of asphyxiating gas, of which CO_2 forms the main constituent. While large effusions are often triggered by earthquakes or eruptions from nearby Sinila Crater, dangerous concentrations of CO_2 can be found within Timbang's craters and some surrounding depressions year round.

Figure 6. Farmers passing above the rim of the main Timbang Crater, Sumberejo Village (source: author).

The first recorded eruption from the Timbang Crater Complex occurred in 1928. Three craters were involved in this eruption, which threw blocks[12] a distance of 750 m to the west (Muffler, 1971). Deadly concentrations of CO_2 were present within the craters for years following the eruption (Muffler, 1971). While the Dieng Volcanic Observatory records a loss of 40 lives during this event (Interview 80, Dieng Volcanic Observatory official, Karang Tengah, 5/10/15), the extent of time since it occurred meant that I was unable to obtain eyewitness accounts of local impacts. The next eruption occurred in 1939, and this resulted in the complete destruction of what was once Timbang Village situated adjacent to the main Timbang Crater. Despite the proximity of Timbang Village the eruption only caused 10 deaths as the majority of residents were in their fields away from the crater when the eruption occurred (Muffler, 1971). State intervention following the eruption forced residents from Timbang to relocate to the nearby town of Batur. One informant who witnessed the 1939 eruption relayed the following,

> Many homes were covered in debris; when farmers here hoe their land around Timbang they find household items. However, it's amazing that while one village was lost there were no lost lives.[13] Because it happened in the middle of the day, so all the community were in the fields. Only two people were left in the village, they were disabled. What was lost were possessions not lives..…... The people who once lived around Timbang moved to Madaluhur[14]. One whole village moved there. They were given homes built by the government (Interview 9, male aged 82, Dusun Simbar, 25/11/15).

The mostly deadly eruption documented in historical records from the Timbang Crater Complex occurred in 1979. This event was characterised by

[12] A volcanic block is an angular chunk of solid rock ejected from a crater during an eruption (USGS, 2017). While no accurate record of the size of the blocks ejected from Timbang or Sileri Craters in the past is available, during fieldwork we encountered rocks with a diameter of up to 40 cm in the surrounding fields.

[13] This informant later conceded during the interview that lives were lost; however, according to his memory they consisted entirely of the elderly or disabled who couldn't work in the fields so were at home at the time of the eruption.

[14] Madaluhur is a hamlet situated to the west of Sumberejo Village and the Batur Township.

the emission of poisonous gases from existing fissures in the earth. The gas that was released contained 98-99 per cent CO_2 and effused rapidly at a rate estimated at 1.5 m^3 s^{-1} (Le Guern et al., 1982). The event was preceded by heightened seismic activity, felt by residents, which began in the early hours of the morning of 20 February. Nearby Sinila Crater also erupted at 5.15 am, creating loud noise and ejecting blocks to a distance of 150 m (Le Guern et al., 1982). Responding to the earthquakes and eruption of Sinila, the residents of Kepucukan Village, then situated to the southeast of the main Timbang Crater, began to evacuate towards the west. In doing so they passed below the main Timbang Crater and encountered the dense CO_2 gas. All 147 of Kepucukan's evacuating residents died alongside 2 people sent from Sumberejo Village to help. The evacuated Kepucukan Village was then destroyed by a subsequent mudflow originating at Sinila Crater that extended for 3.5 km (Allard et al., 1989).

While I was unable to obtain eyewitness accounts, I was able to speak with one informant who was sent to recover the victims from Kepucukan as they lay deceased along the path. He relayed the following in an interview:

> At that time someone came and asked me to help people already unconscious on the side of the road. Without much thinking I went straight away. At that time I was with my friends, there were five of us. Only two of us were hit by the gas. However, until now we still live. If you want to ask what the poisonous gas is like, I don't even know myself. Because poisonous gas doesn't smell at all. It's different to sulfur, sulfur smells if you breathe it in. Maybe if I was there for more than three minutes I would have already been dead…… I got there and lifted three corpses into the truck. After that my friend said that he wasn't strong enough and I told him to run away. When I ordered my friend to run, it was then that I fell. When the gas came all of my joints felt stiff. At that time I collapsed. I woke feeling weak three times. After that a friend helped me, I was carried in the truck to below about 50 m away and woke up (Interview 9, male aged 71, Dusun Simbar, 23/10/15).

As CO_2 gas is an odourless and colourless gas the victims walked straight into its path unaware. CO_2 is denser than air and hangs low to the ground (below 1 m in height) following topographic depressions (Allard et al. 1989; Le Guern et al., 1982). Concentrations of greater than 25 per cent CO_2 cause rapid loss of consciousness leading to death. There is no way to know the exact concentration of the gas at the height at which it killed the residents of Kepucukan. It is possible that they inhaled lower concentrations and collapsed into the denser gas cloud. The staff at the Dieng Volcanic Observatory also felt they could have died bending down to help children or those who had already fallen (Interview 80, Dieng Volcanic Observatory official, Karang Tengah, 5/10/15). The same informant above described the qualities of CO_2 gas with the following insight:

> That type of gas follows a path and doesn't reach higher than 1 m. The gas doesn't spread because the wind isn't strong enough to carry it and when the sun shines on it, it disappears[15] (Interview 9, male aged 71, Dusun Simbar, 23/10/15).

The 1979 gas eruption from the main Timbang Crater coincided with a period during which the New Order Regime's government sought to upscale the transmigration program. With the central and district government placed under political pressure to enlist participants throughout rural Java, the residents of nearby Dusun Simbar were coercively pressured into the transmigration scheme (for a more detailed discussion see Chapter 5). As a result the majority of Simbar's families left for South Sumatra, with about half returning within the following years. As I discuss in Chapter 5, the 1979 gas eruption therefore had long lasting effects on the social and economic structure of Dusun Simbar.

Timbang erupted again in 2011 and 2013, instigating large-scale evacuations. While no lives were lost, surrounding crops were destroyed and farmers displaced from the adjacent fields for a period of one and two months

[15] While attributed here to sunlight, the dispersion of gas during the day is primarily the result of the convective winds that are generated when sunlight first heats the air in the morning causing the gas to disperse.

respectively. These eruptions incited renewed efforts from the state to manage the risk of poisonous gas. As I later discuss in Chapter 7 (section 7.2.2), this prompted the PVMBG to update their volcanic hazard map to amplify the risk of gas emissions around the Timbang Crater Complex. BNPB and BPBD also constructed a large observation tower on the edge of Dusun Simbar to monitor crater activity. While these state interventions will be discussed further in Chapter 7, it suffices here to mention that the events of 2011 and 2013 have increased the resources allocated to district agencies for managing the threat of volcanic gas emissions.

4.1.2. Sileri Crater

Eruptions from Sileri Crater are characterised by hydrothermal and phreatic activity that deposits hot sulfur mud and blocks around the crater (Muffler, 1971) (Figure 7). Small earthquakes also often accompany these eruptions. The largest recorded eruption occurred in 1944 (Miller et al., 1983), causing the total destruction of the nearby villages of Njawera and Bintingan and partial destruction of Dukuh Kulon. Large blocks, capable of killing people and penetrating roofs were thrown within a distance of 1.5 km from the crater (Miller et al., 1983). Finer rock and ash debris accumulated to a depth of 1.5-2 m, also covered the aforementioned villages. During my fieldwork in Kepakisan Village I spoke with various elderly residents who could recall the events associated with the 1944 eruption. One informant recalled the following memory, paying particular attention to the way the ejected large blocks collided mid-air:

> I was standing in front of my house when Sileri erupted. At first I saw something like a red hot fire in the shape of a spear. It went up in the sky, separated into parts and came back down. So what was struck the first time was far from the crater, however everything was eventually struck because the eruption occurred three times …… For half a month rocks were ejected and collided in the air. So when a rock was ejected from below after it began to fall down again it would collide with another rock being ejected. For half a month the sound of rocks

> colliding in the air continued (Interview 63, male aged 102, Kepakisan Village, 3/11/15).

It is estimated that 117 lives were lost during the eruption; however, these estimates may be conservative due to the lack of accurate record keeping at that time. The same elderly informant quoted above told us that 270 lives were lost from his old village of Njawera (Interview 63, male aged 102, Kepakisan Village, 3/11/15). Another informant previously from Dukuh Kulon quoted the death toll at 400 people in total (Interview 65, male aged 75, Kepakisan Village, 3/11/15).

According to these informants the eruption considerably disrupted lives and livelihoods, necessitating the relocation of surviving residents from the three villages of Njawera, Bintingan and Dukuh Kulon. Many of these survivors eventually settled in nearby Kepakisan Village and established a new Bitingan Village now located 1 km to the north of Sileri Crater. The victims we spoke with now reside in Kepakisan and recalled years of moving between villages before finding a place to permanently settle again. During these years they worked as farm labourers as their own fields near Sileri were still unusable. They relayed how former residential areas were eventually transformed into agricultural fields with ownership remaining the same. However, it was a long time before these fields became productive again. The informant quoted above described the impact this eruption had on agriculture with the following:

> For 17 years the land couldn't be planted with anything. The land that was hit by the eruption reached a distance of about 1 km from the crater. The land was really hot and anything planted would dry out. If something was planted it withered within an hour (Interview 63, male aged 102, Kepakisan Village, 3/11/15).

Eruptions from Sileri Crater after the 1944 disaster have been of a less intense and destructive nature. Sileri Crater erupted in 1964, ejecting mud and debris 500 m in height for a period of two to three minutes (Muffler, 1971). The most recent eruptions occurred in 2006, 2009 and 2017 and

while no lives were lost, nearby crops suffered damaged as they were covered in hot sulfurous mud. The 2009 eruption caused the most damage to crops and mud was deposited within an area extending 1 km from the crater. Fortunately, this eruption occurred during the evening when local farmers were not working in nearby fields. During the 2017 event, several tourists were injured as hot mud exploded from the crater and crops within a 500 m radius of the crater rim destroyed (pers. comm. BPBD staff, 04/07/17) (Figure 8).

Figure 7. View of Sileri Crater, Kepakisan Village. Note the arrow marking the location of farmers harvesting potatoes in close proximity to the crater rim (source: author).

Figure 8. An aerial view of Sileri Crater following the eruption of 2 July 2017. Note the deposition of dark sulfurous mud on the adjacent crops (source: BPBD, July 2017).

Miller et al. (1983) argue that future eruptions from Sileri Crater are likely to be hydrothermal, phreatic and/or accompanied by hot mud flows. With the relocation of nearby villagers following the 1944 eruption, the risk posed by Sileri has lessened. Kepakisan Village is now the closest village to Sileri at just over 1 km distance. However, if an event the magnitude of the 1944 one occurs, it is likely that Kepakisan could suffer serious damage.

In 2015 a new thermally heated water theme park (named D'Qiano) was built less than 200 m from Sileri Crater's rim on land purchased directly from local farmers. While the park had intentions to employ local staff, during my fieldwork in 2015 it was still yet to attract the patrons required significantly boost local employment opportunities. This water park runs pipes into the crater to obtain geothermal heated water (Figure 9). Despite consultation with PVMBG who firmly advocated for the park not to be built, the developers from Semarang were granted permission by the provincial government. The opinion of a senior volcanologist at PVMBG is that this park

poses a significant risk to public safety (Interview 86, senior volcanologist, PVMBG, Bandung, 16/09/15). He informed me that the 2009 eruption of hot sulfurous mud had minimal impact on lives as it occurred during the evening; however, if such an event was to occur again during the day the outcome could be much worse especially for patrons of the nearby waterpark.

Figure 9. The location of the D'Qiano water theme park (to the left) in relation to Sileri Crater (to the right). Note that the distance from the crater rim to the park is less than 200 m. The coloured tents are as yet unoccupied stalls that line the car park and the grey plastic sheeting in the foreground mark newly planted potato crops (source: author).

4.1.3. Eruptions as resources

While the eruptive history of the Dieng Plateau has caused significant costs to lives and livelihoods, volcanoes can also produce extremely fertile, resource rich environments. In Dieng, an abundance of resources (soil, water supplies and geothermal energy) provides a diverse array of livelihood opportunities, which have encouraged the historic settlement of this volcanically active area (as described in the following chapter). Below I briefly outline the two major

industries operating in Dieng, agriculture and geothermal energy, and how they are built on the region's past and present periods of volcanism.

Agriculture

Agriculture is the primary industry operating in Dieng and is related to the region's volcanic past and present. Over the past 100 years, more than five billion m^3 of andesitic[16] volcanic ash has been deposited in Java, which combined with the warm humid climate, has significantly boosted soil fertility (Lavigne and Gunnell, 2006). Volcanic soils are often also highly fertile due to the presence of trace elements that support the growth of plants (Benson, 2005). The benefits of eruptions for agriculture are well known on the slopes of Merapi and Bromo Volcanoes in Central and East Java, respectively. Whilst still perceived as threats, in these locations villagers view eruptions as opportunities to boost agricultural productivity (Bachri et al., 2015; Dove, 2008).

Likewise, the deposition of volcanic material in Dieng has provided a nutrient rich environment for agriculture. These soils have supported the growth of cool climate vegetable crops including potatoes, cabbages, carrots, onions and celery (Figure 10). Furthermore, the landscape, dotted with crater lakes formed during historic periods of volcanic activity, provides a water source for irrigation. Diesel pumps attached to plastic (PVC) pipes line many of these crater lakes, transporting the sulfur-rich, albeit sometimes scalding hot, water to fields.

[16] Andesitic ash refers to ash derived from andesite, a grey to black coloured volcanic rock consisting largely of silica. Andesite forms the major component of volcanic rocks deposited throughout Java (USGS, 2017).

Figure 10. A typical farming landscape in the Dieng Plateau. This view faces towards the west, with Sileri Crater and Kepakisan Village located beyond the sloped hill in the middle of the image (source: author).

Geothermal energy

Alongside the fertile soils ideal for agriculture, Dieng's volcanism supports a geothermal energy industry. Volcanic activity brings thermal energy closer to the earth's surface. In doing so, it heats the surrounding rocks and groundwater, providing a geothermal energy resource that can be harnessed to generate electricity (Duffield, 2005). The Dieng Plateau has a modelled potential to produce 350 megawatts (MW) of electricity at any one time (Darma et al., 2010). Currently it is producing geothermal electricity at a rate of 60 MW for GeoDipa Energi, a subsidiary of the state owned energy firms PLN and Pertamina (Azimudin, 2008)[17]. This electricity feeds into Java, Madura and Bali's main electricity network (Darma et al. 2010).

[17] This value far exceeds the quantity of power consumed in the Dieng Plateau and is enough to power approximately 60,000 American homes. While I was unable to obtain an accurate value of the number of homes in Central Java that can be powered by this plant, it would certainly exceed the number of American homes.

GeoDipa operate 52 wells scattered across the plateau and several large geothermal power plants (Figure 11). Large pipes carry water heated to high temperatures in bores along the edge of fields and up and over roads. These pipes provide an interesting backdrop to the otherwise agriculturally dominated landscape. Large clouds of steam are released from the pipes when pressure increases. Yet, despite the visible presence of GeoDipa, the geothermal energy industry has limited interaction with local livelihoods. The vast majority of GeoDipa's employees are skilled workers transported in for shifts from nearby Wonosobo (a distance of 30 km), with minimal jobs available for local cleaners. One resident we spoke with, however, claimed that GeoDipa has sourced local knowledge on where to drill their bores in the past. He explained this with the following,

> I have seen everything around here. If there was fresh grass that suddenly dried out and then became fresh again, it meant there was steam from a crater. So that is a place they must bore. GeoDipa followed me, if I said here, they straight away checked with their instrument and sure enough it was right and there was steam. I showed them 14 points to make bores (Interview 63, male aged 102, Kepakisan village, 3/11/15).

Figure 11. One of GeoDipa's geothermal bores located in Karang Tengah Village (source: author).

While further analysis of the geothermal energy industry does not feature within this thesis, I have briefly outlined it above to provide context to the Dieng landscape and the many livelihood benefits associated with development of this volcanically active area (although to reiterate these opportunities are predominantly reserved for professional employees living in nearby Wonosobo). This overview demonstrates the national significance of the Dieng Plateau in terms of meeting Java's electricity needs, and the subsequent importance of studies of volcanic risk management in these areas.

4.2. Landslides, earthquakes and strong winds

Alongside the volcanic activity described above, the Dieng Plateau is susceptible to landslides, earthquakes and seasonal strong winds. Landslides primarily occur during the rainy season and on steep slopes; land that is often owned by the state Forestry Department. The occurrence of landslides is exacerbated by the muddy-clay soil type and deforestation of slopes for vegetable fields. While landslide risk is often linked to recent changes in land-use practices (see Chapter 6 for a full discussion), the largest recorded landslide occurred back in 1955 during the tobacco-farming era. This event buried an entire village known as Legetang (once situated between Pekasiran and Kepakisan Village) and the site has not been reoccupied. Localised landslides continue to occur frequently throughout the plateau and the impact of these is mainly restricted to crop damage. In early 2017 however, a landslide from Mount Prau blocked the Serayu River, the main watercourse draining the plateau. This landslide was accompanied by consecutive days of heavy rainfall and caused localised flooding which damaged and temporarily closed the Dieng to Wonosobo road.

Earthquakes also occur in the Dieng Plateau and while these do not always accompany volcanic activity they frequently precede it as the 1979 gas event in particular demonstrated. In 2013 a magnitude 4.6 earthquake impacted Kepaskisan Village prompting evacuation of this entire village for a period of a few days. No lives were lost, though many homes were damaged and

landslides were triggered in adjacent fields. During interviews I could still observe the impact of this event, and some informants occupied homes still in need of minor repairs. While the impact of the earthquake was not extensive, especially when compared with many of Java's more catastrophic earthquake events, local residents of Kepakisan readily recalled the fear they felt during the event. One informant recounted the following:

> When the earthquake happened, we evacuated. It was only for two days. We usually evacuate to Dieng. At that time many people continued sleeping in tents although they were already allowed back home. People were still traumatised. People were sleeping in tents for about 15 days (Interview 49, male aged 40, Kepakisan Village, 30/10/15).

During the months of January to March the plateau is also affected by seasonal strong winds that can blow down and destroy potato and other vegetable crops. In extreme cases, these winds can also tear roofs from homes. To combat this threat farmers endeavour to time harvest to occur before the winds arrive. However, the exact timing is not always predictable and the impact of winds can thereby not always be mitigated. The impact of these strong winds is mentioned in the livelihood discussion of Chapter 6 (see section 6.3) and again in Chapter 7 in relation to the local prioritisation of risk (see section 7.1).

4.3. Chapter conclusion

The discussion above has outlined the geophysical hazards that characterise the Dieng Plateau. This discussion forms the basis for the following chapters on the political ecology of vulnerability, access to land, livelihoods and disaster knowledge. Blaikie and Brookfield (1987) define political ecology as the combination of concerns of ecology with a broadly defined political economy. To overlook or exclude this 'ecology', in this case the characteristics of geophysical hazards impacting the Dieng Plateau, would contradict the aims of this field (Walker, 2005). The discussion I have

presented above highlights the hazardousness of the Dieng Plateau, the resources that these hazards provide, and provides a brief insight into local recollections of historic hazard events. These findings later inform the Dieng hazardscape presented in the following Chapter 5, which describes how vulnerability is both produced, and overcome, through the occupation of volcanically hazardous areas. My discussion above of 'eruptions as resources' also supports the livelihoods approach applied in Chapter 6, which reveals the local environmental factors that have helped to facilitate, and to some extent maintain the longevity of, the potato boom. Finally, the oral recounting of historic eruptions demonstrates the extensive level of knowledge concerning volcanic processes held by farmers in the Dieng Plateau. These largely accurate representations of volcanic hazard are used to inform my discussion of local and expert disaster knowledge provided in Chapter 7. This chapter thereby serves as a reference point for the reader as they navigate the discussion of vulnerability and volcanic hazard in the following chapters.

Table 5. A record of known natural hazard events that have occurred in the Dieng Plateau throughout the past century (source: local interview data and the PVMBG).

Year	Location	Hazard type	Characteristics	Impact
1928	Sumberejo	Phreatic eruption at Timbang Crater.	Explosion of mud and rock.	40 deaths.
1939	Sumberejo	Phreatic eruption at Timbang Crater.	Explosion of water vapour and mud.	5-10 deaths. Destruction of Timbang Village, which was r to Sumberejo Village.
1944	Kepakisan	Earthquake and phreatic eruption at Sileri Crater.	Mud flow.	117 deaths and 3 villages relocated – Njawera and Bitinga which were fully destroyed, and Dukuh Kulon, which suff considerable damage.
1955	Legetang	Landslide.	-	Legetang Village completely buried (located between Kep and Pekasiran) causing 351 deaths.
1964	Kepakisan	Phreatic eruption at Sileri Crater.	Mud flow.	Damage to crops.
1965	Pekasiran	Phreatic eruption at Candradimuka Crater and Telaga Dringo.	Eruption of water vapour and mud.	Damage to crops.
1979	Sumberejo	Eruption at fissure near Timbang Crater and phreatic eruption at Sinila Crater.	Emission of poisonous gas (CO_2). Triggered by seismic activity and phreatic eruption with mudflow at Sinila Crater.	149 deaths. Total destruction of Kepucukan Village.
2003	Kepakisan	Phreatic eruption at Sinila Crater.	Eruption of mud.	-
2006	Kepakisan	Eruption at Sileri Crater.	Material ejected to 500 m height.	Minor crop damage.
2008	Kepakisan	Landslide.	-	Crop damage.
2009	Kepakisan	Phreatic eruption at Sileri Crater.	Eruption of mud.	Crops within 1 km of the crater rim destroyed.
2009	Kepakisan	Strong winds.	-	Significant crop damage.
2011	Sumberejo	Eruption at Timbang Crater.	Emission of poisonous gas (CO_2) extending 1 km downhill of the crater.	Loss of crops surrounding crater. Residents evacuated an from fields for 4 weeks.
2013	Sumberejo	Eruption at Timbang Crater.	Emission of poisonous gas (CO_2) extending 2 km downhill of the crater.	Loss of crops surrounding crater. Residents evacuated an from fields for 2 months.
2013	Kepakisan	Magnitude 4.6 earthquake.	Epicentre located at Batang (a province to the north of the Dieng Plateau).	Destruction of homes, injuries and landslides that damag crops. Residents evacuated for 2 days.
2017	Kepakisan	Phreatic eruption at Sileri Crater.	Eruption of mud.	Crops within 500 m of the crater rim destroyed.

5. The Dieng 'hazardscape': A political ecology of vulnerability to natural hazards in Java's highlands

The forthcoming chapter describes the Dieng 'hazardscape' (Collins, 2009; Cutter et al., 2001; Mustafa, 2005), focusing on how vulnerability is produced through the processes that govern access to resources (Wisner et al., 2004), including economic opportunity and political representations of hazardous land (Rebotier, 2012). Responding to my first research question, I describe how socio-economic processes and political agendas have influenced claims to land and subsequent conditions of vulnerability to natural hazards in the Dieng Plateau. While access to resources, specifically land, has long been understood as an important determinant of vulnerability to natural hazards around the globe (Burton et al., 1978; Cannon, 2008; Gaillard et al., 2007; Oliver-Smith, 1999; Wisner et al., 2004; Wisner and Luce, 1995), few of these studies address the way political representations of risk influence how claims to land are made by the state institutions governing such areas. In the forthcoming chapter, I respond to this shortcoming by arguing that state claims to land have occurred through the production and territorialisation of hazardous spaces. Studies of the territorialisation of resources can be found within the wider political ecology literature (Peluso, 2005; Peluso and Vandergeest, 2001; Vandergeest and Peluso, 1995; Wadley, 2003); however, they are currently underutilised in disaster studies (for some counter examples see Donovan et al., 2012c; Rebotier, 2012). In this chapter, I demonstrate how they can reveal the often-historically embedded complexities of vulnerability.

The 'hazardscape' described below applies a largely historical and landscape perspective to understand the relationship between access to land and conditions of vulnerability in the Dieng Plateau. I begin by describing past and present land relations in highland Central Java focusing on the history of upland settlement and the impact of the central government's transmigration policy on land access in the hamlet of Dusun Simbar. I then discuss how these

land relations interact to create what Wisner et al. (2004) refer to as 'unsafe conditions'. I demonstrate how historic state attempts to control internal territory are linked to issues of 'development' (see Li, 1999b; Pannel, 1999) and in the context of volcanic landscapes have relied on demarcations of certain parcels of land as 'hazardous'. This territorialisation was partially enforced through the process of transmigration in the late 1970s (Hardjono, 1986). However, this process of territorialisation was locally resisted and people were ultimately allowed back into the hazardous zone, leading to both positive and negative outcomes for conditions of vulnerability.

5.1. Access to land and vulnerability

The forthcoming discussion applies the access to resources model (Wisner et al., 2004) to describe the processes that have shaped land-use and ownership in a historical context, and the influence these arrangements have over conditions of vulnerability in the Dieng Plateau. Throughout Java, upland life was historically made attractive due to the smaller populations that meant land was more equitably and often more generously distributed (Alexander and Alexander, 1992; Hefner, 1990), and the opportunity to cultivate profitable cool climate crops while escaping the oppressiveness of lowland colonial rule (Li, 1999a). However, while these economic benefits are clear, below I demonstrate that within the Dieng Plateau vulnerability is not equally distributed and those with fewer financial means also farm the most hazardous parcels of land.

5.1.1. The history of land-use change in highland Java

From colonial to present times, there have been substantial incentives associated with farming Java's highlands. As a result, migrants and locals have deforested the uplands for often commodity-driven agricultural production, in the process exposing more people and agricultural assets to volcanic hazard. The earliest recorded occupation of Dieng's highlands dates to the construction of the Arjuna complex of temples beginning around 600-750 CE (Beynon and Datta, 2013), which until around 1303 CE acted as a

large Hindu-Javanese religious centre (Pudjoarinto and Cushing, 2001). While nowadays the temples serve primarily as a domestic tourist attraction, deforestation of the upper slopes for agricultural purposes has been ongoing since the early construction date of these temples (Pudjoarinto and Cushing, 2001). To my knowledge, aside from the pollen records used by Pudjoarinto and Cushing (2001) there is a scarcity of accessible records from this time until the seventeenth century.

Boomgaard (1999) notes that tobacco was grown in Java from as early as 1644 and that maize could be found growing around Java's northern port of Semarang in the 1770s. While it is difficult to ascertain the time at which these crops entered the Dieng highlands, by the 1830s historical sources reveal they were grown in high densities in the Banjarnegara and Wonosobo districts (Boomgaard, 1999). Boomgaard (1999) argues that there was a locally cultivated complex of 'maize-pulses-tobacco-livestock' grown in highland areas in Java at this time, that he argues sustained the continual expansion into upland areas over the past two centuries. In Dieng maize was ground into a fine powder (known as *nasi jagung* or corn rice) and eaten as a staple, while tobacco was grown for commercial purposes. This agricultural complex made it both possible and rewarding for the Javanese to expand into upland areas (Boomgaard, 1999).

The Dutch colonial government's emphasis on economic development through the commoditisation of export crops significantly altered patterns of land-use and the development of highland Java from the nineteenth century. Responding to high levels of debt inherited from the former Dutch East India Company (VoC), the Dutch colonial government needed to find a way to make the colony of Java economically viable again (White, 1973). To boost government revenues the 'Cultivation System' (*Cultuurstelsel*) was thereby developed (Fasseur, 1992). This program oversaw the replacement of local subsistence crops with profitable crops including indigo, sugar, coffee, tea, tobacco, pepper, cinchona, cinnamon, cotton, silk and cochineal all geared to an export market (Geertz, 1963). During the brief British occupation of Java from 1811 to 1814 a land rent system was implemented bringing all land

under government ownership, a program that paved the way for full implementation of the cultivation system when the Dutch returned to power in 1814 (Li, 2007). Under the cultivation system farmers in Java were made exempt from land taxes if they cultivated government owned export crops on one fifth of their fields, or worked 66 days of the year on government owned estates or other projects (Geertz, 1963). The cultivation system encroached on Javanese land rights, placing harsh demands on people and the land they used to cultivate rice (Fasseur, 1992). The system relied on Javanese labour to supply export crops that could compete with those produced in other areas of the globe, particularly America where slave labour was being used (van Niel, 1964). While the cultivation system was generally constrained to lowland regions, by squeezing the land market and limiting the profits lowland farmers could make, it also encouraged upland migration.

The cultivation system was abolished in 1870 in response to the increasing public concerns about the welfare of Java's peasants that were rousing in the Netherlands (Fasseur, 1992). The Agrarian Law (1870), which followed, encouraged private enterprise but also increased colonial control by declaring forests and land not permanently cultivated as property of the state (Li, 2007). By bringing more land under colonial control and expanding commercial plantations, land pressures in lowland Java increased. Combined with the added pressure of population growth, the Javanese sought after the last remaining cultivatable lands and headed in larger numbers for Java's highland volcanoes (Hefner, 1990).

In the 1920s upland migration and intensification of agriculture in Java's volcanic environments was amplified and the period became known as the 'era of prosperity' (Li, 1999a). Combined with population pressures and declining landholdings in lowland Java, even more farmers migrated to the highlands, deforesting slopes to plant a mix of both commercial and subsistence food crops (Hefner, 1990). Upland life was made attractive due to the productivity potential of cool climate vegetables and the opportunity to escape the debts and forced labour arrangements associated with lowland colonial rule (Li, 1999a). Trade between the high and lowlands of Java

increased significantly as roads were built, Chinese traders opened dry shops, and a small transportation industry arose allowing goods to be transported to Java's urban centres and ports for export to an international market (Hefner, 1990). At this time highland areas including Dieng were dominated by tobacco grown for export, maize for consumption and livestock husbandry (Boomgaard, 1999). Photos taken of the Dieng Plateau during the 1920s and 1930s show significant deforestation of the upper slopes reflecting this period of agricultural expansion (Pudjoarinto and Cushing, 2001).

During fieldwork interviews, I found that some of Dieng's residents escaped to the highlands from colonial run tea plantations on the middle slopes. In particular, one large and prominent family in Dusun Simbar were descendants of lowland Javanese who fled from the cultivation system. These informants noted that the colonial government showed little sustained interest in the Dieng Plateau. As also noted by Li (1999a) in other highland areas of Java, interviews revealed that Dieng's highlands provided an opportunity to grow commercial crops for an export market and to own land beyond direct colonial control. While the Dutch administration managed tea plantations on the middle and lower slopes (in Batang to the north and Tambi to the south in the vicinity of Wonosobo), the difficult to traverse road linking Dieng to the closest regional centre of Wonosobo limited the potential for development. One member from another family in Dusun Simbar relayed how his grandmother moved to the area to escape Dutch rule in the mid slope tea plantations:

> My grandmother was from Pencongan area, and she moved here to escape from the Dutch. She was afraid of doing hard labour for the Dutch so she moved here. Pekalongan[18] was already controlled by the Dutch but not yet here (Interview 19, male aged 59, Dusun Simbar, 8/12/15).

[18] Pekalongan is the district to the north of Banjarnegara, and the Pencongan area is located within the district's capital city also named Pekalongan, which is situated on the north coast of Java.

The age of prosperity experienced during the 1920s ended in the 1930s to 1940s due to the reduced international demand for vegetables caused by the great depression, and the Japanese occupation of 1942-1945 that oversaw the production of subsistence or Japanese favoured crops over European oriented export crops (Hefner, 1990). During interviews Dieng's farmers reported that under Japanese occupation they were forced to build roads and to grow wheat crops alongside their commercially grown tobacco. Following the Japanese occupation and moving into the war of independence from 1945-1949, growth continued to stagnate as rural militias disrupted upland trade routes and roads fell into disrepair (Hefner, 1990). Dieng was relatively unscathed during the war of independence, likely due to its relative geographical isolation and lack of substantial economic interests in the area at the time. During discussions with informants, I learnt that this war also encouraged the upland migration of those seeking to escape the violence. One elderly woman explained how she escaped to Dieng with her family as a child from a colonially managed tea plantation on the mid slopes. As she quotes, her family fled during the war of independence because:

> We were afraid of the Dutch aeroplanes and guns. If a Dutch aeroplane went overhead then bombs would definitely fall on the houses. Many homes were burnt, and we were afraid (Interview 23, female aged 75, Dusun Simbar, 6/11/15).

Following independence upland farmers in Dieng focused again on growing and selling tobacco. At this time land reform became a focus for Indonesia's first president Sukarno. The Basic Agrarian Law (BAL), passed in 1960, sought to limit private land holdings, limit the rights of foreign ownership, abolish private absentee holdings, and redistribute land in an equitable manner (Bachriadi and Wiradi, 2013). Despite the rhetoric, problems in implementation and the government-communist struggle of 1965 meant that few gains were achieved during Sukarno's presidency (Bachriadi and Wiradi, 2013). Some authors have argued that due to lower population densities, land is distributed more equitably and generously in Java's highlands (Alexander and Alexander, 1982; Hefner, 1990). As a result Sukarno's

agrarian policies likely formed less relevance to Dieng than they did in Java's lowland and midslope regions[19].

Large areas of Central Java's rural population, including nearby Wonosobo, were then drawn into the political violence of 1965 as the president and military violently supressed the Indonesian Communist Party (*Partai Komunis Indonesia,* PKI) and the Indonesian Peasants Front (*Barisan Tani Indonesia,* BTI) (White, 2016). Dieng however, was largely excluded from this struggle possibly due to its geographically peripheral location and the absence of large land holdings and/or plantations. Following this struggle, the possibility of radical land reform ended when Suharto became president in 1967 (Bachriadi and Wiradi, 2013). Suharto's claim to the presidency relied on the necessity of instilling order and stability after this period of chaos and violence (Li, 1999b).

During Suharto's presidency from 1967 to 1998, economic growth and agricultural intensification in Java's uplands expanded once again. Suharto's presidency and New Order Regime focused on the economic development of the Indonesian archipelago by encouraging agricultural intensification and opening the country to international investment. In particular, agricultural production was enhanced through the implementation of new technologies and transmigration of rural Javanese to the outer islands (Bachriadi and Wiradi, 2013). As the Suharto presidency took advantage of the green revolution of the late 1960s, supporting the distribution of seeds, fertilisers, agrochemicals and credit in lowland Java and improving roads and distribution networks, farmers were encouraged to move from subsistence agriculture to cash crops (Hefner, 1990). While Java's uplands were largely excluded from this program, mountain farmers actively sought new seeds and agrochemicals for themselves, allowing them to produce crops with a high production value free from disease (Hefner, 1990). With the green revolution the environmental problems associated with cultivating upland

[19] However, as will be discussed in the following Chapter 6, Dieng is now facing its own land pressures relating to the declining size of land holdings, fertility of the soil, and steady increases in the price of land.

areas such as erosion, declining soil quality and disease were overcome, and crops such as maize were replaced with the more lucrative potatoes, cabbages and onion (Hefner, 1990). Furthermore, the state making and claiming of vast expanses of territory as Forestry land throughout Java under President Suharto amplified land pressures (Peluso, 1992), and also encouraged upland cultivation. The unprecedented growth of the Indonesian economy at a rate of over seven per cent gross domestic product per annum from the years 1968 to 1998 (Booth, 2002), reflects the economic success of Suharto's agrarian policies.

In the mid-1980s travelling vegetable traders and landowners from Bandung in West Java planted the first potato crops in the Dieng Plateau. These first crops were extremely successful and soon after local farmers abandoned their tobacco in preference for potatoes. Informants mentioned that potatoes shielded Dieng from the economic crisis that struck Indonesia and Southeast Asia more generally in 1997-98 (known as the *krismon* or monetary crisis). While elsewhere in Java, the *krismon* saw declining yields, in highland areas it facilitated agricultural expansion as lowland farmers cleared new land for crops (Lavigne and Gunnell, 2006).

Production of cool climate crops in Java's highlands continues to this day, resulting in the large-scale conversion of land for potatoes, cabbages and other vegetables. Participation in this livelihood activity is lucrative with the annual takings of a potato farmer in Dieng generally above the average for Java's lowland farmers (Lavigne and Gunnell, 2006), a finding also confirmed by this research. While a recent study found that agricultural incomes in lowland rural Java generally do not exceed IDR 1 million per month (AUD 94[20]) (AKATIGA and White, 2016), a reasonable earning from a potato crop in Dieng is IDR 20 million (AUD 1,880), equating to IDR 5 million per month (AUD 469). While this value needs to be spread between the family members involved in the production of each crop, in most cases it is still above lowland

[20] This value is based on an exchange rate of AUD 1 to IDR 10,675.71 (Indonesian rupiah) calculated on 19/01/18. All conversions of monetary values provided throughout this thesis are based on this exchange rate.

averages, particularly if a family owns or manages more than one parcel of farming land.

The introduction of the potato changed land-use practices and disrupted what Boomgaard (1999) argues was an ecologically sustainable 'maize-pulses-livestock-tobacco' complex. Today, while maize is still grown for personal consumption, often intercropped with or surrounding potato fields, residents are no longer reliant on this crop as a staple and have replaced it with rice purchased from market places. Furthermore, tobacco is only grown for personal consumption and generally restricted to a few plants grown around the edges of fields. The Dieng Plateau still supports large numbers of livestock[21], predominantly sheep and goats; however, many informants noted that livestock husbandry has reduced in recent times as it is seen as too labour intensive. Furthermore, for some, this source of income is no longer necessary alongside the profits that can be obtained from potatoes.

The discussion above outlines the historical and contemporary, political and financial incentives that have encouraged the upland migration and development of agricultural interests in the Dieng Plateau. These include the opportunity to pursue commodity and subsistence crops beyond colonial control, to manage larger land parcels than available in the lowlands, and to take advantage of high value vegetable crops grown in a fertile environment. I argue that this sustained development over time has increased exposure to volcanic hazards, yet as will be discussed more fully in the following Chapter 6, it has also facilitated the accumulation of financial assets that have increased local capacity to recover from disaster related losses. While the discussion above has focused on the broader scale processes that have drawn people into Dieng, I will now address how land is locally distributed and the impact this has on the uneven distribution of vulnerability to natural hazards.

[21] A total of 1,142 households in the Batur subdistrict participate in animal husbandry, with 99 households in Sumberejo Village, 60 households in Pekasiran Village and 44 households in Kepakisan Village (BPS, 2014).

5.1.2. Land distribution and vulnerability to natural hazards

The forthcoming section will discuss how local claims to land are made and the processes that determine who owns what land and the impact this has for local vulnerabilities. As I discuss above, highland Java has historically provided more equitable and generous patterns of land ownership than the lowlands (Alexander and Alexander 1982; Hefner 1990). Most land in the uplands is owner-occupied (Suryanata, 1994), and in this respect free from some of the inequalities related to absentee land holdings in the lowlands (see Lucas and Warren, 2013). As discussed in the preceding history of land-use change, the geographical isolation and smaller population of the highlands have made it an attractive option for small-scale agricultural endeavours. In 1990 Hefner argued that historically landlessness in the Tengger highlands in East Java was rare and as a result upland society had not been divided into a landless and agrarian class. Yet, while the Dieng Plateau has provided farmers with access to land, not all residents experience equal levels of vulnerability.

Despite the clear historic benefits to farming the highlands, not all farmers have benefitted equally. During my fieldwork in Dusun Simbar and Kepakisan Village we frequently visited land parcels directly surrounding both Timbang and Sileri Craters. These land parcels, especially those surrounding Sileri Crater, were difficult to access, frequently muddy and waterlogged. After scrambling through the fields and often arriving covered in mud, we would seek out landowners who told us that these land parcels, whilst being the most hazardous, were also the most affordable. The benefits to owning this land were clear; they provided an easier entry to the land market and years of profitable farming between eruptions. However, if and when an eruption occurs, these landowners suffer the greatest losses. A similar situation was found for land on the upper, most steeply inclined slopes, which is difficult to access and prone to landslides. In the past, it was these conditions that attracted buyers who would find it difficult, if not impossible, to purchase land elsewhere. This was explained by one farmer working the land next to Sileri Crater:

> I bought the land here because it was cheaper. This land was hard enough to purchase, how could I buy the land up there that's more expensive? ..... I am not worried about the crater, it's already become normal (*itu sudah biasa*). We just need to be cautious and pray that there won't be a disaster. When there is no eruption, there is no problem. If I didn't farm this land where could I find an income? (Interview 50, female aged 33, Kepakisan Village, 12/10/15).

While allowing some to enter the land market, access to this hazardous land also results in more frequent crop failures. Following an eruption from the main Timbang Crater, the released CO_2 gas immediately destroys downslope crops and this damage can extend for a distance of 2 km as it did in 2013. During the recent small-scale phreatic eruptions from Sileri Crater, surrounding crops have been destroyed by the deposition of hot sulfurous mud to a distance of 0.5 – 1 km from the crater's rim (years 2006, 2009 and 2017, see Figure 8). Likewise, steeply sloping land is more prone to erosion and landslides and requires more labour to create terraces. Furthermore, it is difficult and costly to access especially when harvests need to be transported from the fields. As well as being more frequently impacted by eruptions, land surrounding Sileri Crater and directly downslope of the main Timbang Crater is often waterlogged making it difficult for farmers to keep potato crops from rotting (Figures 12 and 13). While there are some benefits to farming land in close proximity to a crater, specifically that eruptions add needed sulfur and that CO_2 kills pests in the soil, the ongoing threat of eruptions and the poorer productivity potential, significantly reduce the value of this land.

The ecological drawbacks and hazardousness of the land is reflected in its price, with such land often valued at less than half the price of land elsewhere. In Dusun Simbar land in close proximity to the village or the main road was reported to sell for up to IDR 500,000,000 a hectare (AUD 46,865). This is compared to land situated on the upper and more inaccessible steep slopes or directly below the main Timbang Crater, which sells for closer to IDR 200,000,000 per hectare (AUD 18,746). Similar prices of land were reported to exist in Kepakisan Village, with land close to the crater and on the

upper slopes significantly lower in price than land elsewhere. This marked differentiation in price has created both local vulnerabilities and capacities. In the past this has allowed farmers to purchase land, and in the absence of hazardous events, to accrue profits. However, it has also increased vulnerability as those least able to purchase land elsewhere are left working land that is most frequently and severely impacted by volcanic eruptions or landslides.

Figure 12. Potato plants growing downslope of the main Timbang Crater, Dusun Simbar. These fields are the first to be affected by CO_2 gas emissions (source: author).

Figure 13. Farmers working fields adjacent to Sileri Crater, Kepakisan Village (source: author).

In Dusun Simbar, the village council own some of the land immediately surrounding the main Timbang Crater (*tanah bengkok*). This land, which again is more exposed to volcanic hazards and ecologically less productive than other areas, is rented out to landless farmers. However, for some, managing this land is perceived to be better than no land at all and it is preferred over sharecropping arrangements wherein earnings need to be divided with the landowner. This was explained by one informant:

> The land I rent around the crater isn't as good as other land. This land is remnant of eruptions. It's mixed with mud *(lahar*) so that in the wet season it is waterlogged and in the dry it is cracked and hard. However, if my crop is successful, I get all the profit (Interview 4, female aged 32, Dusun Simbar, 08/10/15).

As occurs in much of Java, the steepest sloping land in the Dieng Plateau forms State Forest and is managed by the Department of Forestry (*Kementrian Kehutanan*) (Peluso, 1992). Within the Batur subdistrict of

Dieng, the Department of Forestry own 1,062.30 hectares of forest (BPS, 2013), yet while this land is officially protected farmers are not always excluded from accessing it. Informants explained that some of this land is farmed under informal discretionary arrangements made between Forestry staff and local farmers. For example, individual Forestry staff may rent Forestry owned land out to local farmers at an affordable rate, sometimes under the agreement that it is also farmed with trees, however sparsely they are planted. During fieldwork I also observed a case of forestry land in an adjacent district being illegally burnt in a bid for it to be opened for fields[22]. In total we estimated that about 20 hectares of farmland (managed by 40 households situated in both Dusun Simbar and nearby Dusun Serang), is rented from Forestry. This land is often the steepest, making terracing difficult and further increasing the risk of landslide and erosion (Figure 14). It is also cheap to rent, with half a hectare rented at just IDR 2,000,000 (AUD 187) per year. Farmers least able to rent or buy land elsewhere are therefore drawn into occupying this land, that aside from being without formal property rights, is also the most vulnerable to erosion and landslides. As described by one young farmer from Dusun Simbar:

> At the moment farmers who don't own land must rent it from Forestry. If people like me couldn't rent from Forestry then we wouldn't be able to manage any land at all (Interview 31, male aged 26, Dusun Simbar, 4/12/15).

[22] This was observed 5 km north of Dusun Simbar, in the province of Batang. While I did not witness this directly occurring in the area classified as the Dieng Plateau, informants mentioned that it has happened in the past. Residents of Dusun Simbar were also very critical of the burning that occurred in Batang as they believe it has reduced the quality and quantity of their water supply.

Figure 14. An example of some of the steeply sloping fields recently leased by Forestry staff for vegetable cultivation in Dusun Simbar (source: author).

The Dieng example, through initial settlement of the plateau and the past affordability of land located in close proximity to craters and on steep slopes, supports the concept that marginal communities occupy the most hazardous pieces of land and experience increased vulnerabilities as a result (see also Bolin and Stanford 1999; Gaillard et al., 2007; Oliver-Smith, 1999; Susman et al. 1983; Winchester, 2000; Wisner et al., 2004). While the simple chain of explanation approach applied above (built from Blaikie, 1985; Blaikie and Brookfield, 1987), draws out the important socio-economic factors that have facilitated the utilisation of hazardous land, it falls short of explaining claims to land made by the Indonesian state. The process of internal territorialisation – through which state claims to land have been made – has also had marked outcomes for local vulnerabilities to natural hazards in the Dieng Plateau, as I discuss below.

5.2. The territorialisation of volcanically hazardous landscapes

The preceding section has discussed how access to land as a resource has contributed to the construction of vulnerability, drawing on examples from Dusun Simbar and Kepakisan Village. The forthcoming section will elaborate on this data and discuss the state's construction and response to the 1979, 2011 and 2013 eruptions of the Timbang Crater Complex. I argue that by rendering land in Dusun Simbar as 'hazardous' the state has used these eruptions to enact territorialisation strategies and promote transmigration. Vandergeest and Peluso (1995) argue that by delineating boundaries on maps, the state leads a process of internal territorialisation to gain 'control over natural resources and the people who use them' (p. 385). This process of internal territorialisation, while legitimising state control in Dusun Simbar, has also had unintended and often mixed outcomes for conditions of vulnerability to volcanic hazard as will be discussed below.

5.2.1. The transmigration program

The Indonesian government's transmigration program, led by Suharto's New Order Regime, has been an important force in shaping territorialisation and, through it, vulnerability in Dusun Simbar. With political pressure to relocate residents from overpopulated Java to the 'under-developed' outer islands, the state used volcanic eruptions as a mechanism to enlist participants. The relationship between transmigration and vulnerability to natural hazards demonstrates that the production of risk is in Rebotier's (2012) words, 'both material and discursive'. By making claims to land through spatially labelling areas 'unsafe', the state was able to relocate residents into transmigration sites. However, while this program aimed to move people away from hazards, it also influenced conditions of vulnerability for some in unexpected ways as will be discussed below.

The transmigration policy, which initially began in the early nineteenth century under Dutch colonial rule, aimed to relieve perceived population

pressures in Java, Madura and Bali by relocating residents to the archipelago's less developed islands, namely Sumatra, Kalimantan, Sulawesi and Papua (Eaton, 2005). While this program diminished towards the end of the colonial administration, following Indonesia's independence its aims broadened to develop and integrate the outer islands into a united Indonesia (Eaton, 2005). While the transmigration program met significant resistance and shortcomings, including conflict between local residents and migrants in the transmigration sites and broken promises made by transmigration officials (van der Wijst, 1985), a downscaled version continues today that facilitates the relocation of Javanese farmers to the sites of oil palm plantations in Kalimantan (Potter, 2012). During the New Order Regime transmigration was conducted to assert state rule and 'develop' Indonesia's more remote and 'ungovernable' areas. As Li (1999b) asserts '"Development" authorises state agencies to engage directly and openly in projects aimed at transformation and improvement' (p. 297). While transmigration certainly reduced some exposure to volcanic risk in Dusun Simbar, it was also linked to the state's plan to develop the outer islands using Javanese labour.

Following the 1979 eruption of the Timbang Crater Complex, residents of Dusun Simbar were subtly, though coercively, enlisted into Indonesia's transmigration program. With the total destruction of Kepucukan Village and the loss of all its residents, Simbar became the closest village to the main Timbang Crater. Subsequently, in the weeks following the eruption it was officially 'closed' by the state in the interest of public safety. However, to offset this loss residents were offered five hectares of land to build a home and manage a rubber plantation if they transmigrated to Palembang, South Sumatra. With few alternatives, all but seven households transmigrated. Those who remained moved around the region lodging with relatives in the Banjarnegara and Wonosobo districts. However, for many, transmigration was not permanent. The state of the rubber plantations and the homes in South Sumatra varied considerably and many informants complained of the hard labour they expended to make their new abodes and farmland both liveable and productive. Combined with the oppressive heat and the

geographical isolation, many residents chose to return to Dusun Simbar by their own means. The first families returned just three months later while other families stayed on for a period of three years and some settled there indefinitely. Estimates from village officials suggest that about half of Dusun Simbar's original population remain in Palembang.

While residents of Dusun Simbar were not technically 'forced' to join the transmigration program they found themselves temporarily excluded from their homes and fields as officials guarded the village. Many thereby had little choice other than to follow. Vandergeest et al. (2007) argue that development-induced displacement is coercive in nature and this may be expressed in violent or more subtle forms (see Barney, 2007; Jack, 2007; Szablowski, 2007). Likewise, while technically not compulsory, the majority of Simbar's residents heeded state direction and transmigrated:

> The government told us that we had to transmigrate, this village was not allowed to be lived in. So the community were forced to leave (Interview 17, male farmer aged 58, Dusun Simbar, 27/11/15).

The closure of Dusun Simbar following the eruption of the Timbang Crater Complex in 1979 was only officially enforced for a period of six months. This allowed past residents and migrants from neighbouring villages to eventually resettle homes and fields. In the years immediately following the closure, the future of Dusun Simbar was uncertain and no one knew if it would be forcibly closed again. This uncertainty resulted in a temporary drop in land prices, making Dusun Simbar an attractive location for land poor or landless farmers in neighbouring villages and those returning from the transmigration site. Furthermore, additional land became available for purchase within the village as half of the original population decided to permanently resettle in Palembang. While land prices in Dusun Simbar have since risen and are now relative to elsewhere in the Dieng Plateau, the transmigration program of the late 1970s inadvertently increased the area of land available for new migrants and returning transmigrants. One informant explained her move from Pekasiran Village to Dusun Simbar after the eruption of the main

Timbang Crater in 1979 which was prompted by the availability of affordable land at that time:

> We moved here because the land here was cheap. Land in Pekasiran was very expensive compared with the land here that became very cheap after the Sinila and Timbang eruption. We bought land for 400,000 rupiah at the size of 24 by 26 metres. That would have been several million rupiah in Pekasiran. However, nowadays the land here is also very expensive. Before if we could buy one piece of land in Pekasiran, we could buy 2 pieces of land here (Interview 2, female aged 60, Dusun Simbar, 23/10/15).

Despite initial government efforts to shift people away from the hazardous land surrounding the Timbang Crater Complex, my discussions with informants in the field revealed that such efforts were short lived. While residents were officially told their homes and fields couldn't be accessed, the district government eventually conceded and issued land certificates for land parcels located in the potentially hazardous zone. This process was articulated by one informant:

> After the eruption of Sinila, Kepucakan village and Dusun Simbar all became part of the dangerous red zone. We weren't allowed to cultivate this land. However, the community requested that the Government issue us with land titles anyway, so a program where bulk certificates were issued was initiated (Interview 19, male aged 50, Dusun Simbar, 26/10/15).

The lack of local or district government interest in land zoning following the initial relocation suggests that while transmigration occurred under the pretext of village safety, it was also tied to achieving ambitious transmigration targets. At this time Indonesia's President Suharto, with financial backing from The World Bank, strongly promoted the transmigration program, setting large (if not unrealistic) five yearly targets to be met (Fearnside, 1997; Hardjono, 1986; Leinbach, 1989). The eruption

of the Timbang Crater Complex and heavy loss of life suffered by Kupucukan Village were thereby used as a catalyst to recruit more transmigrants and support the New Order 'development' focused regime.

Indeed, there is a long record of the Indonesian state creating territorial zones in volcanically hazardous areas to enlist rural communities into the transmigration program. One of the most notable examples is Mount Merapi. Following the 1961 eruption, Laksono (1988) describes how all of the residents of Gimbal Village were forcibly relocated to Sumatra despite the village itself being unaffected by the preceding 1961, 1954 and 1930 eruptions. A similar situation occurred following the 1963 eruption of Mt Agung in Bali where 85,000 Balinese were displaced and encouraged to relocate to the outer islands (Hugo, 2006). Further afield in the Banda Islands, Pannell (1999) describes how the isolated ethnic Wortay people were forcibly relocated following the 1968 volcanic eruption into a state administered transmigration area. As argued by Dove and Hudayana (2008) and Dove (2010) in the case of Merapi, the state's focus has been on 'developing' a few thousand people living in hazardous locations rather than on the threats posed in transmigration sites including malnutrition, infant mortality and other hazards such as floods and landslides. In fact, Schlehe (1996) argues that people living on the flanks of Mount Merapi have been more fearful of forced transmigration than eruptions themselves.

The transmigration program in the Dusun Simbar example, however, failed in its goal of entirely relocating residents away from a hazardous area and actually facilitated its reoccupation. Following the initial relocation, neither the provincial nor district government ensured that land surrounding the main Timbang Crater remained off limits to farming activities. While some critics may argue this reflects a failing of the state to enforce its regulations, Li (1999b) takes a contrary position suggesting such governance reflects the necessity of 'compromised rule'. Analysing Indonesia's program of relocating isolated people to more accessible regions from the 1950s onwards, Li (1999b) argues that such 'compromises are integral to rule' (p. 296). As relocation programs are inherently prone to failure the state reinterprets

these failures as a compromised success (Li, 1999b). In the Dusun Simbar example, the fact that half of the population remained on in Palembang can likewise be interpreted as a program success.

The reoccupation of land thus reflects a subtle form of state resistance on behalf of Dusun Simbar's returning residents and new migrants. Vandergeest and Peluso (1995) argue that this 'open resistance has helped render territorial control, which is simple and efficient on paper, complex and inefficient in practice' (p. 416). The return of half of Dusun Simbar's population supports the argument that state claims to land throughout Southeast Asia are countered by local property rights (Peluso, 2005; Vandergeest and Peluso, 1995; Wadley, 2003). Just as Wadley (2003) found in West Kalimantan, district officials are hesitant to enforce official counter claims to land. After official relocation programs are completed, residents have some autonomy over decisions to return and reoccupy hazardous land. Laksono's (1988) study of relocation following the 1961 eruption of Mount Merapi likewise found that villagers resisted resettlement efforts, a situation that while persisting to this day also contributed to the heavy loss of life caused by the 2010 pyroclastic flows (see Mei et al., 2013).

Li (1999b) argues that the Indonesian state cannot, or chooses not to, implement its own laws. In the Dusun Simbar example, this is seen in the re-establishment of homes and fields following the 1979 eruption, a situation that continues today. When we discussed land use planning with village or district level officials from *Bappeda* Banjarnegara, we were told that the government couldn't forcibly move people away from the crater. Even when the state had the opportunity to re-establish land use zones following the 1979 eruption due to the absent population, none were developed nor enforced. Li (1999b) argues that the state balances their claims to land with local claims of ownership. Their generosity in allowing people to access land for livelihoods despite such actions contradicting official policy, allows local officials to project an image of themselves as generous and concerned rather than one that reflects state incompetence (Li, 1999b). I argue that the return of residents to Dusun Simbar led the state to alter their territorial strategy

and after just six months they permitted habitation of Dusun Simbar and use of the land surrounding the main Timbang Crater again. This 'compromised rule' (Li, 1999b) was also witnessed on the slopes of Mount Merapi where sustained community-led resistance forced the state to re-evaluate their position (Laksono, 1989). The contestation of hazardous territories is likewise demonstrated in Donovan et al.'s (2012c) study of local and expert struggles and negotiations over the delineation of the 'safe zone' on the Soufriere Hills Volcano in Montserrat.

While initially depopulating and then indirectly encouraging the re-settlement of hazardous land, I argue that territorialisation and the transmigration program also brought unintended benefits to some of Dusun Simbar's residents. Firstly, it allowed land poor or landless farmers from nearby villagers or those returning from the transmigration site to acquire more land than they otherwise could have. The acquisition of more land and subsequent upward class mobility, provided some farmers with greater capacity to recover from disturbances and this has reduced their vulnerability to future eruptions. While some land owners suffered by selling their land at a reduced price, if successful, the newly acquired land in South Sumatra could offset this loss.

Secondly, the transmigration program unexpectedly established the networks needed for some residents to diversify into agricultural activities outside of Java. A few households, who have family remaining in Palembang as a result of the transmigration, have also bought rubber plantations there. These are managed by their extended family and the profits are sent back to Java. This investment has spread financial risk and provides an alternate form of income if potato prices drop or crops fail. When rubber prices were high in 2011 and 2012 this proved to be a very economically beneficial activity for some households. However, with rubber prices currently low, this investment is not as lucrative as it was once. It was also common to hear of young men from Dusun Simbar travelling to Palembang to work on the plantations of their extended family. This occurred particularly when a household experienced recurrent crop failures. The increasing role of multi-

local livelihoods as an adaptation measure to vulnerabilities has also been studied amongst transmigrants in South Sumatra's Lampung Province (Elmhirst, 2012). By maintaining livelihoods across geographical locations, rural farmers are able to respond to vulnerabilities (Ellis, 2000), a finding also supported by the Dieng example. Furthermore, many of those who remained on in South Sumatra following the transmigration reportedly met financial success there, and for these people their vulnerability to volcanic hazards has certainly been reduced[23].

I argue that the relationship between territorial control and conditions of vulnerability to natural hazards is therefore complex and embedded in historical processes. The state led territorialisation of hazardous land that facilitated transmigration both increased and reduced local vulnerabilities. To reiterate, vulnerabilities increased as a result of the eventual resettlement of hazardous land and the economic loss associated with leaving possessions and productive land in Java to begin anew. Furthermore, those who chose to return to Java paid their own way and suffered the financial hardship of rebuilding. Yet, the transmigration program also reduced vulnerability for some by temporarily creating an affordable land market during which time marginalised farmers could acquire land. In the Dusun Simbar example, transmigration also unintentionally reduced vulnerability by allowing some farmers to spread their financial risk across agricultural ventures. These findings, alongside the discussion of the previous chapter, reveal the many economic benefits that can be gained through the utilisation of hazardous land. Yet, despite these livelihood opportunities, the push for transmigration and state management of hazardous land in the Dieng Plateau has persisted. As the following section will now discuss, this processes relies on representations of volcanic eruptions as 'crises' requiring state intervention and control.

[23] Despite these advantages it is important to reiterate that nearly 40 years ago 149 people died by passing through the fields below the main Timbang Crater. As there were no survivors from Kepucukan I was thereby unable to study the construction of vulnerability from the perspective of this village. However, the heavy loss of life demonstrates this significant risk associated with occupying this hazardous land.

5.2.2. Eruptions as 'crises' requiring state control

As discussed above, the need to relocate communities away from volcanic slopes in the interest of 'public safety' has validated state intervention in volcanic highland areas throughout Indonesia (see Dove 2010; Dove 2008; Laksono 1988; Pannell 1999). As a result, waves of relocation away from Central Java occurred following volcanic eruptions throughout the 1960s to 1980s. These relocations continued despite the known risks in transmigration sites or the fact that relocation often unfairly disadvantages the poor and their livelihoods (Dove, 2008; Dove, 2010; Wilson et al., 2012; Whiteford and Tobin 2004).

While the discussion above has focused on the 1979 transmigration program, the re-territorialisation and relocation of 'at-risk' communities has long been a feature of the Dieng Plateau (Figure 15). Kitchin and Dodge (2007) argue that the production of maps involves a constant process of re-territorialisation; they are 'transitory and fleeting, being contingent, relational and context dependent' (p. 1). The boundaries delineating which areas are safe and dangerous in Dieng have likewise evolved with time. When walking through fields whilst conducting fieldwork activities we often came across sites of *rumah bekas*. These were the remains of past settlements that have now been returned to farmland. Farmers commented that when cultivating their fields they would sometimes pull out the remains of past buildings buried within the soil. As Figure 15 displays, many of these relocations were conducted following eruptions that resulted in heavy loss of life from the 1930s onwards. These relocations occurred so far in the past that I was unable to corroborate the extent to which they were enforced. However, the total destruction of villages suggests that even if they were coercive, the loss of homes and temporary damage to fields caused by each eruption, means that at least some of them must have been easier to enforce than the 1979 Dusun Simbar experience.

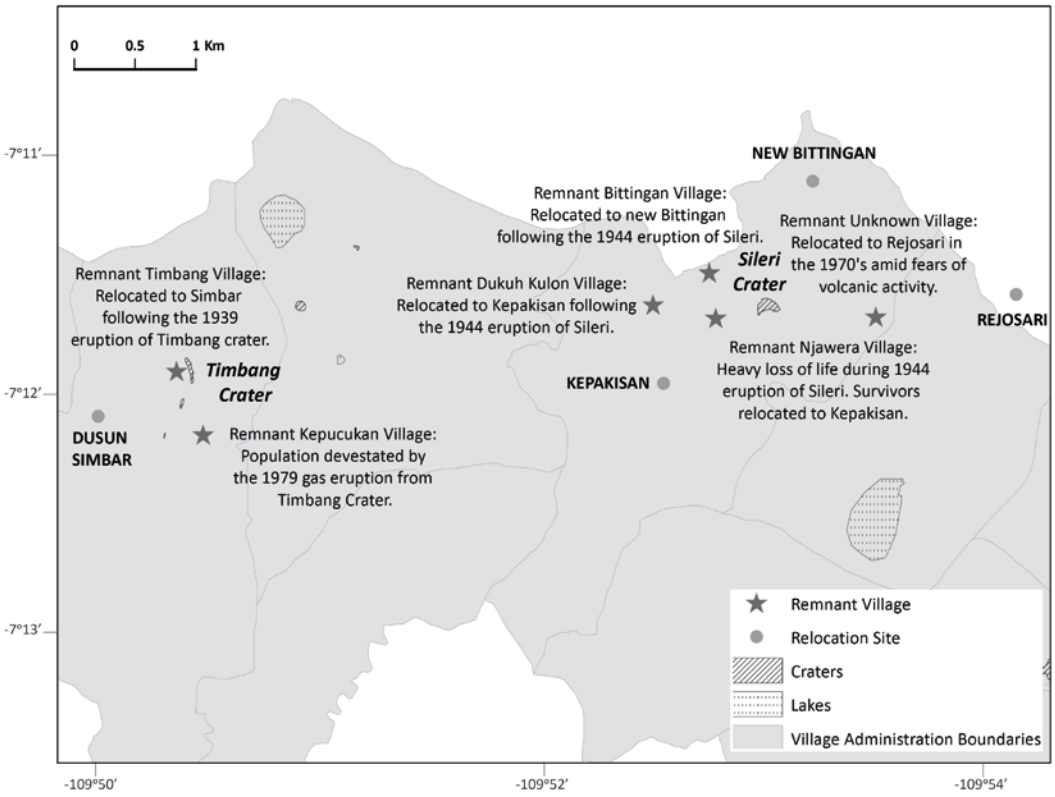

Figure 15. The location of past and present villages affected by volcanic hazards and state territorialisation strategies in the past. The stars mark villages that have been destroyed and/or relocated and the circles mark the location where villagers have resettled. It is likely that many more villages marked by *rumah bekas* exist throughout the Dieng Plateau and this map represents only those we discovered during fieldwork (source: author).

While today in Indonesia, eruptions are no longer used as catalysts to enlist participants for transmigration; I argue that they still instigate state intervention and control over land during emergency response and post-disaster activities. When the main Timbang Crater effused gas in 2011 and 2013, BPBD drove in with their orange trucks, sirens blazing, to evacuate residents from Dusun Simbar. Informants reported that they 'created panic as they ordered the community to run while ringing a siren like an ambulance' (Interview 31, male aged 26, Dusun Simbar, 4/12/15). Dusun Simbar is located 700 m to the west of the main Timbang Crater and while

unlikely to be immediately affected due to the properties of CO_2 gas[24], residents were nonetheless forced to leave immediately. For a period of one month after the eruption BPBD deployed staff to man the newly constructed three-storey high Timbang Observation Tower built by the National Disaster Management Agency (BNPB) (Figure 16). From this post, farmers were accosted for trying to enter their fields, irrespective of whether the sought after fields were located in close proximity to the crater or gas flow. While many residents resisted[25], the state has attempted to exclude farmers from their land following these eruptions. One informant reflected on the annoyance of not being able to enter her fields and maintain her livelihood post eruption:

> I was often angry with the *Bagana*[26] team. I was stubborn and I wanted to go to my fields. So that when it was time to apply the pesticides, I still went to the fields. I was told by the officials that it was dangerous; however, I still went to the fields because if I didn't apply the pesticides my crops would fail (Interview 7, female landowner aged 38, Dusun Simbar, 18/12/15).

State-led rhetoric surrounding the need to intervene and relocate people away from volcanic craters represents what Roe (1995) refers to as a 'crisis narrative'. In Roe's (1995) words these 'crisis narratives are the primary means whereby development experts and the institutions for which they work claim rights to stewardship over land and resources they do not own' (p. 1066). Combined with the 'development' focused narrative promoted by the New Order Regime (Li, 1999b), this state-led rhetoric justified intervention and control over 'hazardous' land resources in Dusun Simbar. Pannell (1999) argues that narratives of humanitarian assistance often veil

[24] CO_2 is denser than air and hangs low to the ground, generally below 1 m in height. Its high density means that it flows in a downhill direction following topographic depressions.

[25] This balancing of livelihood and volcanic risk is explored more fully in the following Chapter 6.

[26] *Bagana* is a volunteer emergency management organisation. While the staffs manning the tower were *Bagana* volunteers at this time, their actions were overseen and directed by the Banjarnegara BPBD.

state driven territorialisation strategies. Her study of the forced evacuation of the Wortay in Eastern Indonesia demonstrated how environmental phenomena, such as volcanic eruptions, are painted as destructive to human well-being and a legitimate precursor for state order (Pannell, 1999). These narratives both support and validate state territoriality strategies, and as the Dusun Simbar example demonstrates, can both contribute to, and alleviate, local vulnerabilities.

Political responses to the 1979, 2011 and 2013 gas effusions stem from the state's representation of volcanically active land as unpredictable, dangerous, and in need of government control. In 1979 this justified recruitment to the transmigration program, and in 2011 and 2013 it validated the authority and control of the BPBD and BNPB in the area, witnessed most prominently by the construction of the branded (and in my perspective rather domineering) BNPB Timbang Observation Tower (Figure 16). Bankoff (2001) argues that 'vulnerability' is a predominantly western oriented discourse employed to label large areas of the globe unsafe with victims in need of remedy by technocratic expertise. While the Dieng example demonstrates that vulnerability is not only a western construct, elements of Bankoff's argument are evidenced in Dieng. For example, rendering the population vulnerable, not only in terms of volcanic hazards but also as part of Java's rural poor, allowed the central government to justify transmigration following the 1979 eruption. And more recently, portrayal of residents as victims justified state-led technocratic solutions (i.e. the BNPB funded Timbang Observation Tower) and land access restrictions immediately following the 2011 and 2013 eruptions. While these activities have most likely saved lives, they also contributed to vulnerability by inadvertently facilitating the redevelopment of land surrounding the main Timbang Crater and through isolating the community from genuinely participating in DRR activities (the technocratic style of governance favoured by the BPBD is discussed in greater detail in Chapter 7).

Figure 16. The BNPB and BPBD Timbang Observation Tower. This tower was constructed following the 2013 eruption to physically monitor gas emissions from the Timbang Crater Complex and provide warnings. However, by late 2015 the tower had yet to be equipped with any warning or technical equipment. Furthermore, the inside of the tower was scattered with rubbish and doors broken. A fence restricting local access was built around the tower in late December 2015 and *WhatsApp* conversations with the BPBD staff (pers. comm. 14/03/16) revealed more plans to install a seismograph and alarm system (source: author).

5.2.3. Territorialisation and the making of the Dieng hazardscape

The discussion above argues that state territorialisation strategies have interacted with the production of local vulnerabilities. While these strategies have been justified under the guise of humane intervention and 'development', they have also responded to political agendas such as building support for the transmigration program. This isn't to say that evacuations

and relocations are never justified. Indeed these state actions regularly save lives and many past eruptions have proven their importance (see Mei et al., 2013; Newhall and Punongbayan, 1996; Wilson et al., 2012). Rather, the approach taken above demonstrates that the process of territorialisation, through which state claims to land are made following eruptions, bears important considerations for vulnerability. However, these claims may be locally contested causing the state to alter their position (see also Li, 1999b; Wadley, 2003). Furthermore, local recipients can accrue unintended benefits through these plans such as access to what can become productive livelihoods in the outer islands, or the purchase of more land locally (see also Peluso, 2005; Wadley, 2003). Overall, I argue that analysing the concept of 'territoriality' through politically driven representations of hazardous space provides a framework through which to obtain a nuanced and historically embedded picture of vulnerability in Indonesia's volcanic landscapes.

My interpretation of the hazardscape demonstrates how political representations of risk (Collins, 2009; Mustafa, 2005), enacted through territoriality (Rebotier, 2012), can significantly influence local conditions of vulnerability. In particular, the way local and political claims to land are made and negotiated historically affects who owns what land and at what risk. However, in the Dieng example political representations of hazardous land have had both positive and negative outcomes on local conditions of vulnerability (Figure 17). This conclusion confirms the utility of the access model, while demonstrating how it can be enhanced through considering territoriality strategies as part of a broader and more politically informed 'hazardscape'. While territoriality has been linked to vulnerability frameworks elsewhere (Donovan et al., 2012b; Rebotier, 2012), this chapter demonstrates how this concept is of particular use in the context of Java's volcanoes, many of which are sites where the state has historically enacted transmigration as a mechanism to shift people away from hazardous geographies.

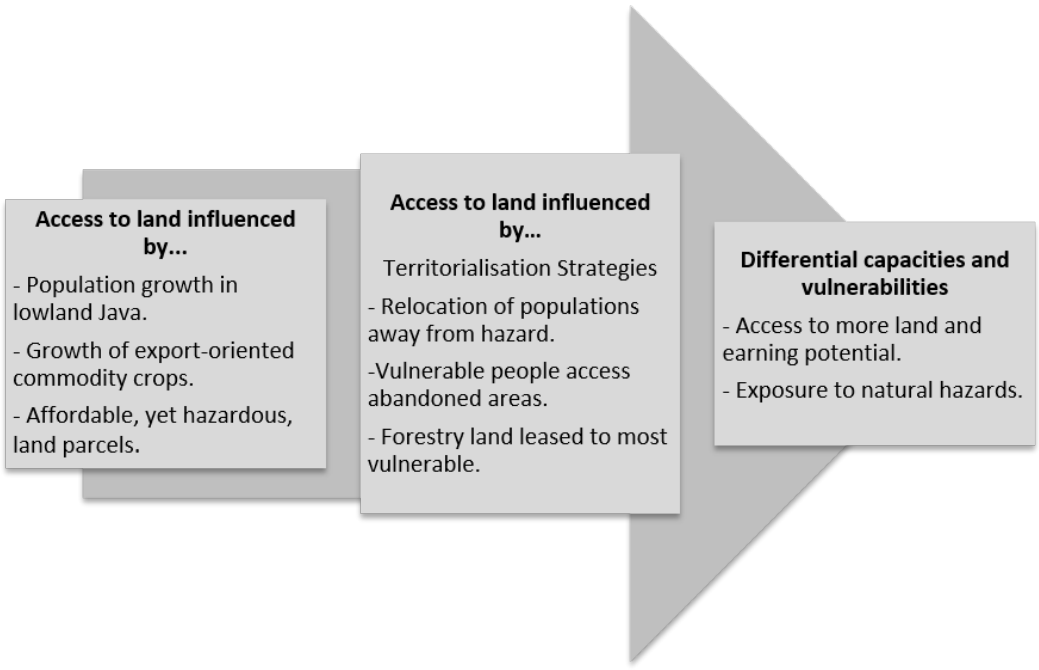

Figure 17. A schematic explanation of the construction of vulnerability and capacity in Dusun Simbar drawing on the access model (Wisner et al., 2004) and concept of territorialisation (Peluso, 2005; Vandergeest and Peluso, 1995). Vulnerability is explained as an issue of access to land influenced by population growth, the cultivation of export commodity crops and state territoriality strategies.

5.3. Chapter conclusion

The chapter above has argued that the construction of vulnerability is a complex process with the utilisation of hazardous land bringing opportunity alongside disadvantage (Figure 17). Three political ecology approaches used to understand vulnerability have been applied, namely the access to resources model (Wisner et al., 2004), territoriality (Peluso, 2005; Peluso and Vandergeest, 2001; Vandergeest and Peluso, 2005) and the hazardscape (Mustafa, 2005). Drawing on these frameworks, vulnerability is firstly described as a product of colonial and New Order Regime policies that promoted the growth of export oriented commodity crops, lowland conscription to the cultivation system, and population growth – all of which contributed to smaller sizes of lowland land holdings and upland migration (Boomgaard, 1999; Hefner, 1990; Li, 1999a). Within the plateau itself, local

patterns of land distribution have led to the poorest people often farming the most hazardous areas, including land surrounding Timbang and Sileri Craters and Forestry land on the upper slopes. While access to this land has provided an easier point of entry to the land market, those occupying this hazardous land also suffer the greatest impacts in the event of an eruption or landslide.

By incorporating the concept of territorialisation into the hazardscape, I have described how the state spatially demarcated land as hazardous with aims to recruit people into the then politically significant transmigration program of the 1970s. However, this state-led transmigration also inadvertently facilitated re-occupation of the most volcanically hazardous land and by failing to evacuate people from the area of greatest risk, increased vulnerability for some by exposing them to more frequent crop failures due to volcanic eruptions. However, it also reduced conditions of vulnerability for those who were otherwise landless and could use this land as an interim 'stepping stone' towards the acquisition of more land. Additionally, vulnerabilities were reportedly reduced for those families who persisted in South Sumatra following the transmigration. As will be elaborated on in the following chapter, these processes have also influenced how farmers have been able to capitalise on the coming potato boom.

However, while revealing many of the processes that have led to vulnerability, the analysis above has not yet sought to address the impact current livelihood processes have on conditions of vulnerability. The largely structural and historical analysis of this chapter resembles what Rigg et al. (2016a) conceptualises as 'inherited' forms of vulnerability, as compared to the newer and produced forms that are associated with integration into the modern economy. The present chapter has laid the foundations to understand vulnerability, which will be expanded on in the following livelihoods and knowledge chapters in an attempt to present a more contemporary and holistic view of volcanic risk.

6. Livelihoods and agrarian transformation in the Dieng Plateau

By highlighting the socio-economic advantages associated with farming the volcanic highlands, the previous chapter demonstrates that rather than being 'forced', some people have actively pursued livelihoods in the Dieng Plateau for their profitability. This chapter builds on the previous historical and political-ecology oriented approach, to explain vulnerability in the context of an agrarian transformation and its influence on local livelihoods and capacity to manage the impact of natural hazards. While livelihoods perspectives are commonly applied within disaster research (Alexander et al., 2006; Gaillard et al., 2009; Kelman and Mather, 2008; Sanderson, 2000), agrarian studies are infrequently drawn upon. Within this chapter, I will demonstrate that concepts drawn from research on agrarian transformations can complement livelihoods perspectives in disaster research, and provide greater detail and insight into the local and regional processes that encourage people to farm hazardous land. Rigg (2007) argues that a livelihoods perspective 'places people back at the centre of attention and explanation, endowing them with a degree of agency to struggle against, take advantage of, and resist or rework their political, economic, social and environmental milieu' (p. 29). The approach of this chapter thereby moves between micro- and macro- scale processes to capture the impact of a crop boom on localised vulnerabilities in a volcanically hazardous area.

The forthcoming chapter responds to my second research question, which is concerned with how current agricultural practices, primarily the transformation of livelihoods in the Dieng Plateau from the mid-1980s when potatoes became the staple crop, have increased and/or reduced conditions of vulnerability to volcanic hazard. The chapter begins by describing this agrarian transformation in the context of a crop boom (see Hall, 2011a; Li, 2014; Mahanty and Milne, 2016). Here, I address the socio-economic conjunctures that facilitated the boom and its impact on land and labour arrangements. I then focus on the localised environmental repercussions of

the potato boom, including soil degradation and the overuse of agrochemicals. I discuss the district government's response to these claims of environmental degradation, arguing that the state's reactionary and often-restrictive policies can also lead to conditions of vulnerability (Forsyth and Walker, 2008). Finally, I combine studies that address the local impacts of agrarian change (Rigg, 2007; Rigg and Vandergeest, 2012) with both Dorward et al.'s (2009) and Chambers and Conway's (1992) livelihoods frameworks, to describe how potatoes have altered, and in many circumstances reduced, conditions of vulnerability for many farmers. This chapter will argue that Dieng's agrarian transformation, beginning in the mid-1980s as tobacco was replaced by the intensive cultivation of potatoes, has influenced patterns of prosperity, environmental sustainability and ultimately vulnerability to natural hazards.

6.1. The potato boom

The emergence of commodity crop booms is a feature of many of the agrarian transformations experienced across Asia in recent times (Belton et al., 2017; Hall, 2011a; Li, 2014; Mahanty and Milne, 2016; Munster, 2015; Vandergeest, 2008). Studies of crop booms throughout Southeast Asia describe the socio-economic and environmental conjunctures that have led to certain booms (Li, 2014; Mahanty and Milne, 2016). In the forthcoming section I likewise describe how the ready uptake and quick proliferation of the potato in the Dieng Plateau is linked to the historical setting of the past tobacco days, the techniques learnt from travelling farmers and traders, an increase in domestic and regional demand, and the biophysical characteristics of the potato itself. This resultant agrarian shift, from a landscape of tobacco interspersed with subsistence crops to one dominated largely by potatoes, led to new livelihood processes and outcomes that have ultimately influenced conditions of vulnerability and is ongoing today.

6.1.1. *Jaman tembakau*: The tobacco era

The comparatively harsher conditions of life experienced during the almost two centuries long historic tobacco era, equipped Dieng's farmers with an eagerness for a higher earning potential. From the early 1800s until the mid-1980s tobacco was Dieng's primary crop (Boomgaard, 1999). During this time merchants of Chinese descent (known as the *Tionghoa*[27]) arranged the buying and selling of the tobacco at market (see also Hefner 1990 for a similar arrangement in East Java). Landholders took loans from the merchants to purchase the seeds and fertilisers needed to grow tobacco, and due to this debt were required to sell their tobacco to the same merchants at prices local informants complained to be unfair. The difficulty of life during the tobacco days was made clear during many interviews in the field and frequent referrals to the time as '*sangat sengsara'* (very miserable) were made. Informants complained that due to the debt held to the *Tionghoa* merchants, money was scarce, schooling infrequent, and homes basic – made of bamboo with dirt floors. Alongside tobacco, farmers grew crops for personal consumption of which maize, ground into a fine powder known as *nasi jagung* (corn rice), was a staple. Farmers also maintained acacia trees provided by the state Forestry Department (Berenschot et al., 1988) and used this wood to heat homes and cook meals. One female landowner explained the tobacco days with the following:

> Life here was very miserable in the past. In the tobacco days many people were indebted to the Chinese. So when they harvested their crop they had to sell it back to the Chinese at a low price. We couldn't not sell it back to the Chinese because we already had a debt. Aside from that it took one year to get a tobacco crop, while the harvest size wasn't guaranteed. Nowadays harvesting potatoes is quick, after just three months we can harvest. Before in the tobacco era we had just enough for food only. Children only went to primary school, and many

[27] Local residents in Dieng refer to Indonesian's of Chinese descent as *Orang Cina*, meaning Chinese people. The name officially preferred by this group is *Tionghoa* and while infrequently used outside of Jakarta, I will apply it in this thesis (except when directly quoting respondents) as the term *Orang Cina* is often deemed offensive.

didn't go to school at all because there wasn't the money to pay for the fees (Interview 52, female aged 50, Kepakisan Village 12/11/15).

The scarcity of money during the tobacco period was exacerbated by the restricted direct access most farmers had to markets and the relatively slow growing cycle of tobacco crops. To overcome this, some older farmers mentioned during interviews that at times they would carry their pre-dried and shredded tobacco by foot to Wonosobo or as far as Semarang to fetch a fairer price (a distance of 30 and 100 km respectively). However, most producers relied on the *Tionghoa* who had access to horse and carriages, and later automobiles, to transport the tobacco to Semarang for eventual export (Boomgaard, 1999). While the debt arrangements held with the *Tionghoa* resulted in a reduced farm sale price, Boomgaard (1999) argues that this arrangement also sheltered small-scale producers from international market fluctuations. During interviews, the slow growing cycle of tobacco was also central to local descriptions of the era as 'miserable'. In Dieng, tobacco can only be harvested every nine months due to the lack of direct sunshine, after which time the overcast climate then delays the process of drying the leaves, which takes a further three months and the use of indoor fires. Farmers complained that this long production cycle and low sale price did not provide adequate cash flow to tie themselves over financially until subsequent harvests.

6.1.2. The example set by Bandung's travelling vegetable traders

Potatoes first entered Dieng's highlands via travelling farmers and vegetable traders from the Bandung regency in West Java. Smallholders in the Pangalengan highlands of Bandung dominated Indonesia's potato production during the 1980s and 1990s (Adiyoga et al., 1999); however, as land availability and yields declined these farmers searched for additional land to utilise. After scoping the suitability of Dieng's climate and soil on trade journeys, the Bandung farmers leased land from tobacco growers to plant potatoes. These migrant farmers were called *orang merantau*, people who leave their homeland to seek economic opportunity elsewhere. They met

instant success in Dieng and with the trade ties already established with West Java they were able to easily sell their potatoes at a profitable price.

Frustrated by their limited cash flow and enticed by the higher earning potential of potatoes, local tobacco farmers were eager to trade crops. Initially they leased their land; however, soon they realised that greater earnings could be made through cultivating potatoes themselves. One older resident who profited considerably from the potato boom explained this change:

> I first planted potatoes in 1985 when they arrived. For me, I am grateful that I have enough for everyday needs. I have enough food. I no longer count my money as I have much more than I had before. When potatoes first came, I had to rent land to plant them. Now I can use my own land. I have also done the Haji and I am grateful that I already have a car. In the old days, I taught, came home from teaching and went straight to the fields (Interview 9, male aged 71, Dusun Simbar, 23/10/15).

Dieng's farmers learned crop cultivation practices directly from their Pangalengan counterparts; they also benefitted from the trade routes already established between the highlands of Central and West Java and the seed stock developed locally in Pangalengan. The important role spontaneous smallholder migration plays in initiating crop booms has been noted elsewhere in Thailand (Hall, 2011a) and Cambodia (Mahanty and Milne, 2016), and the Dieng example supports these findings. As the success of the potato expanded, local farmers recognised their value, and with rising agricultural land prices many of the initial farmers from West Java were squeezed out of the land rental market and they returned home. By originally leasing rather than selling their land, Dieng's farmers were then in a position to capitalise on the cultivation of potatoes themselves – a situation that continues today.

6.1.3. An increasing appetite for potatoes

The ongoing success of the potato boom in Dieng is also connected to both regional and domestic demand. Indonesia's potato exports to other Southeast Asian countries grew in the 1980s and early 1990s, yet by 1995 these exports fell partly in response to an increase in domestic demand (Adiyoga et al., 2001). During my period of fieldwork none of the potatoes produced were being exported and all were consumed domestically. While much of the crop boom literature focuses on production for an export market (Hall, 2004; Li, 2014), Belton et al. (2017) demonstrate that domestic demand can also drive agrarian transformations. Access to fast foods has increased the domestic demand for potato chips in Indonesia, especially in urbanised areas, while a market for small potato crisp production has arisen in rural areas (Adiyoga et al., 1999). Domestic supermarkets are also purchasing larger quantities of bulk potatoes in response to this change in diet (Umberger et al., 2015).

The high reputation of potatoes grown in the Dieng Plateau held throughout Java's market places has also increased the domestic demand for this product. Dieng's potatoes are considered such good quality that the wholesale markets in Jakarta will spread Dieng's potatoes amongst those produced in other regions to improve the aesthetic value and sale price of each bag. Two varieties are predominantly grown in the area, namely Granola and Atlantic. Granola is used for home and restaurant cooking and frying, while Atlantic is used for the industrial production of potato chips. The best harvests are large, firm, slightly yellow, thick-skinned, easily crisped once fried and can be stored for a long period of time. As Dieng's potatoes are most likely to possess these qualities, they have an advantage at harvest time and according to informants, a successful crop will generally guarantee a reasonable sale price.

The sale of potatoes occurs through small-scale traders from Dieng or larger traders and wholesale buyers from Wonosobo, Jakarta or Surabaya. Generally a trader transports the crops from the farmer's home to market. However, a few with access to trucks (rented or owned) may take their

harvest directly to *Pasar Induk* in Jakarta for sale. Just as Umberger et al. (2015) found for the sale of potatoes in West Java, there are generally various intermediaries between the farmer and the final sale of potatoes at market. However, farmers are no longer indebted to, or reliant upon, merchants as occurred during the tobacco period. Farm-gate prices during my period of research reported to range from IDR 4,000 to up to 10,000[28] (AUD 0.37 - 0.94) per kilogram and farmers noted that they only needed to wait a few days before someone would buy their crop. While most sell soon after harvest, those who have the space and financial reserves may store their potatoes until prices are most favourable.

6.1.4. What makes a potato?

The desire to move beyond tobacco production, the example provided by the Bandung farmers, and the increased regional and domestic demand for potatoes, all fuelled the expansion of the potato industry in Dieng. The final conjuncture that has contributed to its success lies in the material characteristics of the potato itself. Various authors have demonstrated that the biophysical properties of a cash crop influence the social and economic effects of a boom (Li, 2002; Munster, 2015; Mahanty and Milne, 2016). Scott (2002) argues that the material properties of the potato have facilitated its profitable exploitation by small landholders throughout Asia, Africa and Central America. In comparison to other staple crops, potatoes produce more calories per hectare, have a higher edible yield, and require less water input per unit of calorie (FAO 2009; Scott, 2002). They have a short growing cycle, allowing profits to be recovered at regular intervals and are grown profitably on small land parcels of less than one hectare throughout Asia (Azimuddin et al., 2009; Scott, 2002). Potatoes are also inherently well suited to the biophysical and climatic conditions found in the Dieng Plateau. At 1,600 to 2,100 m above sea level the plateau provides a cool climate with rich and fertile volcanic soils to sustain potato crops. This soil has accumulated and

[28] This large range is influenced by domestic potato prices and the size and quality of potatoes harvested. For example, potatoes that sell for IDR 4,000 are small (and often partially green) and generally used as seed stock, while the higher value is reserved for the larger potatoes.

had its nutrients renewed through the weathering of volcanic ash deposited during historic periods of volcanism (Dahlgren et al., 2004; Lavigne and Gunnell, 2006). However, there are specific risks associated with growing potatoes, most notably their sensitivity to disease and the subsequent high capital and labour input requirements (these issues are discussed in sections 6.2 and 6.3 below).

During conversations with informants in the field, the short growing cycle was frequently noted part of the appeal to growing potatoes. As they can be harvested in just over three months they provide a quick return for the investment. This short growing cycle proved especially attractive to the tobacco farmers who in the past had waited for yearly earnings. Furthermore, it facilitates access to short duration small loans from family, neighbourhood groups and banks. These loans are generally repaid shortly after the harvest to avoid an accumulation of debt. Informants explained that the short growing cycle of potatoes allows them to better manage their cash flow and earnings, often enabling investment in equipment, more crops and land, and quick recovery from losses in the event of crop failure. Due to these characteristics, Dieng's farmers have little interest in growing other cool climate crops such as tea, coffee or returning to tobacco other than for personal use, as one informant stated:

> Maybe a coffee plantation would do well here. But the community, myself included, don't want to grow coffee and wouldn't even if we were asked to. Because you have to wait a long time for the fruit, you need three years. Compare this to vegetables that are quick, in just three months we can harvest (Interview 64, male aged 55, Kepakisan Village, 3/11/15).

The short growing cycle of the potato has also encouraged farmers to grow other vegetables with a similar growth cycle. These vegetables include cabbages, carrots and spring onions and are often planted for one growing cycle per year. The reasons behind this were linked to both cost and the local understanding that crop rotation will improve potato yields. While these

other vegetables require less capital, pesticides and labour inputs than potatoes, they also carry a higher level of risk. The price of carrots can fluctuate dramatically – when prices are good carrots can prove a very promising crop, but low prices can cause significant financial loss. Cabbages, grown extensively in other high and mid slope regions throughout Java, can also fetch a very low price depending on demand elsewhere. Many farmers in Dieng have let cabbages rot in the fields when the price has been too low to warrant paying the labour to harvest. Potatoes are seen as the more reliable choice, and if two to three good crops can be secured a year, this leaves space for another, albeit more risky, vegetable crop. Carrots, cabbages and spring onions are thus important accompaniments to the potato boom.

As discussed above, potatoes are a relatively capital and labour intensive crop to grow (Scott, 2002; Scott and Suarez, 2012). In Dieng, the best harvests require preparing the soil with chicken manure, building ridges and furrows, applying plastic mulch, staking the plants, daily watering (relying on pipes and diesel pumps at nearby crater lakes) and manual harvest. Furthermore, they carry a high sensitivity to disease including late blight, bacterial wilt, other viruses and pests (de Putter et al., 2014). As potatoes are a vegetative crop meaning tubers are saved to replant the next crop, diseases are retained and yields can reduce over time (Fugile et al., 2006). In Dieng, potatoes are grown for up to four to five cycles before the seed stock is replenished allowing disease to proliferate in the meantime. Purchasing seed is costly, particularly so for disease resistant varieties, and poorer farmers can be forced to replant disease-ridden seeds more frequently. Disease not only reduces yields but it also necessitates the application of costly pesticides, which increases labour demands. Better access to disease resistant potato varieties thus remains a top priority for potato farmers in Indonesia (Rasmikayati and Nurasiyah, 2004; Umberger et al., 2015) and throughout Asia more generally (Fugile et al., 2006; Fugile, 2007), a finding also supported by the Dieng case study.

The four conjunctures outlined above describe how potatoes came to dominate agricultural practices, land use and agrarian relations in the Dieng

Plateau. Introduction of the potato, and the accompanying other cool climate vegetables, provided a means to escape the perpetual debt relations held with tobacco merchants[29]. Increased demand for the potato alongside its material characteristics, which are inherently well suited to Dieng's environment, encouraged its proliferation in the region. However, while the potato increased living standards for many, it also altered land and labour arrangements, primarily increasing the value of each. The impact this agrarian transformation has had on land and labour arrangements and how they relate to vulnerability is discussed below.

6.2. Dieng's land and labour arrangements

With the potato boom, land affordability, labour arrangements, and modes of agricultural production have been transformed. Specifically, the potato has contributed to a steady increase in the price of land, an increase in the cost of wage labourers, a rise in leasing and sharecropping arrangements, and an increased reliance on formal sources of credit. These changes and the impact they have had on conditions of poverty, rural differentiation and vulnerability in the Dieng region are discussed below.

6.2.1. Land ownership and inheritance practices

Before describing the transformation of land and labour arrangements during the potato boom, I will first provide some background into practices of land ownership and inheritance in the Dieng Plateau. Agricultural land is predominantly inherited or bought outright, with inherited land divided equally amongst offspring without discrimination between sons and daughters (see also Geertz 1961 for lowland Java and Hefner 1990 for the Tengger highlands in East Java). My household survey of Dusun Simbar revealed that a total of 68 per cent (n = 54) of land owning households manage inherited land, 18 per cent (n = 14) have bought land outright, and 14 per cent (n = 11) manage a combination of both inherited and purchased

[29] However, as I discuss in section 6.2 below, new modes of credit have arisen alongside the potato.

land. While Brown (2003) notes that in Java only one third of land titles are in a female's name, she also acknowledges that this does not automatically mean female property rights are compromised. This research did not reveal an inequality in land ownership or inheritance rights between the sexes and both men and women can and do own land. Formal land titles are usually in the name of whichever spouse inherited the land, yet in accordance with Javanese tradition this land is equally owned and protected as such (UN Women, 2011).

The average size of a land holding per household in Dusun Simbar is about half a hectare. My household survey revealed that 64 per cent (n = 79) of households are direct landowners and that 86 per cent (n = 68) of these households own less than one hectare of land each (Figure 18, see also Appendix 4). Sharecropping and rental arrangements are common and a total of 37 per cent (n = 46) of households access land this way (often still in combination with inherited land plots). While 36 per cent (n = 45) of households are landless, 71 per cent (n = 32) per cent of these households still access land through rental or sharecropping arrangements. The remaining 10 per cent (n = 13) of households neither own land, nor participate in sharecropping or rental arrangements. During the household survey, eight per cent (n = 10) identified themselves primarily as '*buruh tani*' (farm labourers).

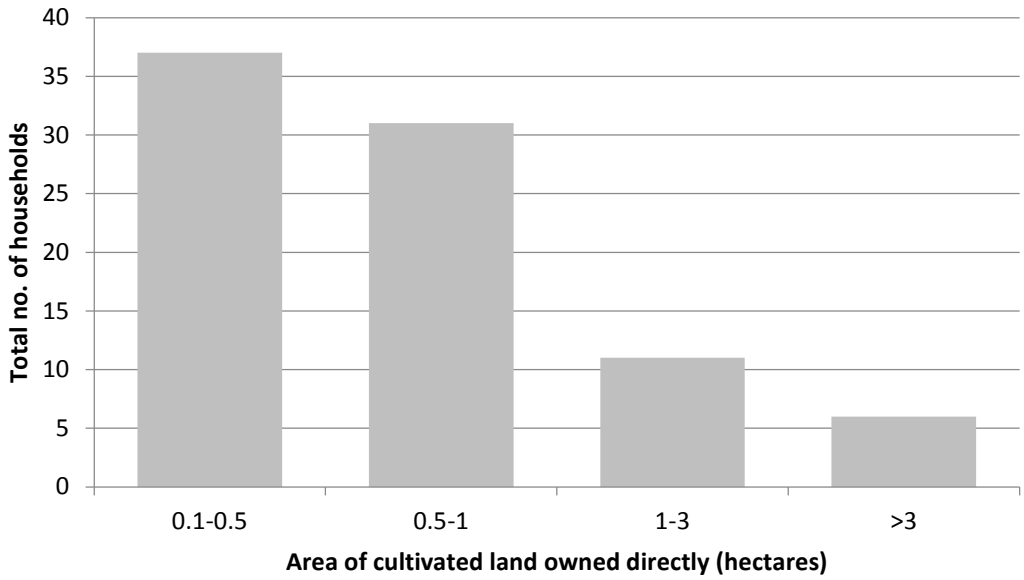

Figure 18. Area of land ownership (in hectares) amongst households that directly own cultivatable land in Dusun Simbar (source: author's household survey).

A local representative from the National Land Office (*Badan Pertanahan Nasional, BPN*) estimated that 60 per cent of land parcels in Dieng are legally titled (pers. comm. BPN Banjarngeara, 27/10/15). This finding was supported by my research in Dusun Simbar. As many land titles are not legally titled, the village government keeps a more complete record of land ownership and issue a *Letter C* document as proof of land ownership and receipt of land tax payment. The Letter C Book (*Buku Letter C*) lists the size and classification of land holdings for land tax collection purposes (Regional Development Levy, *Luran Pembangunan Daerah*). Mugniesyah and Kosuke (2007) describe the importance of the Letter C Book in defining land inheritance and ownership rights in a Sundanese village, and my fieldwork in the Dieng Plateau concurs with their findings. Residents in Dieng use this *Letter C* document for resale purposes and to take out small agricultural loans from BRI (*Bank Rakyat Indonesia,* the People's Bank of Indonesia). I was told that there is little local incentive for small landowners to legally title land due to the drawn out administrative process and costs involved. Farmers also have access to small sources of formal credit without this title.

Furthermore, parents commented that they didn't want to burden their children with the administrative task of changing the name of the title after their land is inherited. While the lack of legal land titles increased vulnerability in post-tsunami Aceh as land owners sought to reclaim their damaged land (Fitzpatrick, 2008), currently it does not appear to be increasing vulnerabilities in the Dieng Plateau.

6.2.2. Land affordability

During my period of fieldwork, land affordability was raised as a concern amongst my informants. This is linked to the expansion and success of vegetable crops alongside population growth that is causing the fragmentation of land holdings. Informants noted that the introduction of potatoes in the mid-1980s rapidly increased the price of land. In East Java, Roche (1988) likewise found that from the period of 1984 to 1985 the profits associated with growing highland vegetables were 1.5 to 5 times higher than those associated with wet rice irrigation in the lowlands. In Dieng, some farmers took advantage of the high earnings of the early potato days and used their profits to acquire more land before land prices rose too significantly. Informants described this process occurring from the mid-1980s to early 1990s and some of these fortunate farmers now have landholdings of four to six hectares. While this contributed to upwards class mobility for some, the remaining 86 per cent (n = 68) of landowners in Dusun Simbar currently own less than one hectare of land, and many much less than this again (Figure 18).

In Dusun Simbar, land was reported to sell for between IDR 200,000,000 (AUD 18,743) and IDR 500,000,000 per hectare (AUD 46,857). While data on land prices over time was not available during my period of fieldwork, informants reported that land prices have risen steadily in recent years. The high price of land recorded here is in keeping with other studies of land value in Java. For example, in Central Java the cost of one hectare of irrigated rice land is valued between IDR 100,000,000 (AUD 9,371) and IDR 1,500,000,000 (AUD 140,570) (AKATIGA and White, 2015), and in West Java this figure

reaches up to IDR 1,000,000,000 (AUD 93,732) (Ambarwati et al., 2016). Land values are now so high that selling land in Dieng is unusual, and it is increasingly difficult for farmers to purchase new land.

Land inheritance and fragmented land parcels were noted as causes of concern for parents. In the Dieng Plateau, parents aspire to provide their children with a home, and if possible also a field, when they marry. Smaller land holdings due to division between siblings and the high price of land are making this task increasingly difficult. Drawing on examples from South Asia, Niroula and Thapa (2005) argue that land fragmentation through inheritance is 'detrimental to land conservation and economic gain' (p. 358). They argue that small holdings, of less than one hectare in area, do not provide enough to meet daily needs and that they also encourage the over-intensification of farming practices causing a reduction in soil fertility. While in Dieng the deep and fertile soil and high annual rainfall makes one hectare of land more productive than it is in other landscapes, future profits may still be at risk due to decreasing land-holding size (see also Hazell et al., 2010; Rigg et al., 2016b; World Bank, 2007).

The tightening of the land market since the mid-1990s has been felt particularly hard in the village of Pekasiran. While I was unable to obtain an estimate of landownership per household in this village, informants related reduced land availability to local economic and social problems. According to the village head, approximately 100 households have left Pekasiran to work on oil palm plantations in Kalimantan. While many of these households have since returned or plan to return and purchase land in the village, others have permanently settled in Kalimantan. During interviews, the neighbouring villages of Sumberejo and Kepakisan (which are not yet experiencing the same extent of these land pressures) complained of the higher levels of crime found in Pekasiran. In particular, they warned me that newly harvested potato crops need to be guarded at night so that Pekasiran locals don't steal them. While I recognise the subjectivity of these rumours, BPS data nonetheless shows that Pekasiran has twice the amount of households

classified as poor (or *rumah tangga miskin*[30]) than the surrounding villages (8% (n = 392) as compared to 3.7% (n = 194) in Sumberejo and 3.5% (n = 96) in Kepakisan Village) (BPS, 2011). While the exact correlation between land ownership and socio-economic outcomes for Pekasiran is beyond the scope of this study, it is likely that land ownership is affecting rates of poverty, outmigration, and vulnerability. The Pekasiran Village Head explained the situation with the following:

> In the past the population was still small. There were about 500 hectares of land for farming, and about 500 households. Now with the increase in population some of this land has been taken to build settlements. And every year the population increases. For example my parents owned 10 hectares of land and had five children. So every child got two hectares of land. Then if I had five children this two hectares of land would need to be divided by five. So the earnings from the land decline. Finding enough profit here has become harder, so people have decided to leave. If we look at those who have left and come back, they bring back money so that they can buy some fields or build a home. However, if they stayed here it is likely they wouldn't be able to buy anything at all (Interview 68, male aged 47, Pekasiran Village, 3/10/15).

Despite these findings, impediments to land ownership in Dusun Simbar are not as critical as the situation described in Pekasiran. In Dusun Simbar a total of 89 per cent (n = 110) of households manage some land (through direct ownership or leasing/sharecropping arrangements) and this has had a significant impact on labour class relations, as will be discussed below.

[30] Indonesia classifies poor household based on economic assets, expenditures and educational achievements. A very poor household is one with inadequate living conditions (in Dieng a marker for this was bamboo walls/roof and dirt floors), an income that is used solely for food consumption and inability to access health care other than community health clinic (*puskesmas* or *jamkesmas*) (World Bank, 2011).

6.2.3. Wage labourers

During the household survey of Dusun Simbar only eight per cent (n = 10) of households selected farm labourer (*buruh tani*) as their primary livelihood activity. While the proportion of landless households is still significant at 36 per cent (n = 45), many of these partake in rental or sharecropping arrangements, leaving a total of just nine per cent (n = 13) of households without access to any land. To place this data in some context, White's (1997) study of Girijaya Village in West Java found that 73 per cent of households listed themselves primarily as landless farm labourers. Informants noted that higher rates of land ownership have resulted in a scarcity of wage labourers, which has in turn increased the cost and demand of labour. The demand for farm labourers was explained by one informant:

> More and more people need labour now. So labourers here can get work every day. At the moment farm labourers are expensive, it's different to what it was like for me earlier as a labourer. I was paid only a little and rarely had work (Interview 7, female aged 38, Dusun Simbar, 18/12/15).

The standard daily wage for farm labourers throughout the plateau is just IDR 25,000 for women and IDR 35,000 for men (AUD 2.34 and 3.28 respectively); however, in Dusun Simbar the need for labour has seen this standard rate largely replaced by the *borongan* system. Under this piece-rate arrangement labourers are paid for the work they conduct that day; for example, the amount of seeds planted or potatoes harvested. This arrangement regularly sees labourers paid at least IDR 50,000 (AUD 4.69) for a standard day's work. The highest wages are earned by the *tukang pikul*[31] who can earn up to IDR 100,000 per day (AUD 9.38) for the strenuous task of carrying the harvested potatoes from the fields. One retired farmer explained the benefits to this system:

[31] A *tukang pikul* conducts the most strenuous task of a farm labourer. This involves carrying two full baskets of harvested potatoes hung from a piece of bamboo over one shoulder. These baskets can weigh 80 kilograms in total and men who could carry this weight were seldom without work or bragging rights.

> Things are better for the farm labourers now. From what I see, farm laborers are more successful because they use the *borongan* system. Farm laborers earn more under the *borongan* system than being paid a daily rate. These days' farm laborers have been able to build their own homes and they are more successful than land owners (Interview 24, female aged 67, Dusun Simbar, 9/11/15).

While the quote above represents just one opinion, it was still common to hear that landless labourers in Dusun Simbar have comparatively good wages[32] and a constant supply of work. It can therefore be argues that this group of people experience low vulnerability to natural hazards because they do not directly incur the loss of crop failure during gas effusions. As the demand for labourers is high, they also reported not suffering work shortages in the immediate aftermath of eruptions, working on fields a safe distance from the crater. The high cost of labour in Dusun Simbar has also led to a situation wherein most landowners work as labourers for others during the times their own fields are in order. This livelihood diversification strategy also occurs when landowners need to recover losses after a crop failure. In Dusun Simbar, local labourers are given preference over workers who may travel in from neighbouring Pekasiran or Batur, as they are perceived to be harder working and more honest.

My discussion of land and labour arrangements above posits that the potato boom has not lead to the deep differentiation of class that Li (2014) argues occurred during the cocoa boom, which began in the early 1990s in highland Sulawesi. While some farmers have certainly profited more than others, based on the informants' recollections of their experiences, I argue that incomes and living standards were broadly raised, and in Dusun Simbar even able-bodied landless labourers have benefitted. The reasons behind this are related to the relatively more equitable and often generous distribution of

[32] Wiggins and Keats (2014) record a median daily wage rate at UDS 2.67 (AUD 3.33) for rural wage labourers in Central Java. While the strenuous tasks that earn the most under the *borongan* system may not be available each and every day, wages paid in Dusun Simbar nonetheless frequently exceed this value.

land in Java's highlands (Alexander and Alexander 1982; Hefner, 1990) and the high production value of potatoes (Azimuddin et al., 2009; Scott, 2002). Furthermore, the scarcity of labourers and higher rates of access to land in Dusun Simbar is an outcome of the historic transmigration program already discussed in Chapter 5, which through permanently resettling half of Dusun Simbar's population in the late 1970s, also provided an opportunity for those farmers who returned to purchase larger land holdings. However, while many have benefitted from Dieng's agrarian shift, the *borongan* system means that strong and able-bodied (predominantly males) have a higher earning potential than women and the elderly. Furthermore, this latter group can be disadvantaged even if they own land outright as they are more likely to partake in less favourable sharecropping arrangements, as discussed below.

6.2.4. Leasing and sharecropping arrangements

Both leasing and sharecropping arrangements were discussed during interviews in the field as strategies to capitalise on, or overcome the risks associated with, potato farming. If successful, these arrangements are used to recover losses following crop failure or as a stepping-stone to procure the savings needed to purchase more land. Similar to a study of the Minahasa highlands in North Sulawesi, these arrangements can provide entrepreneurial landless farmers with a reasonable earning potential and the opportunity for self-employment (Platten, 2007). Sharecropping arrangements are conducted under various schemes, the most common known locally as *paroan* and *superlima*[33]. In short, landowners and land users will bring various resources to the table such as land, pesticides or seeds, and divide the earnings according to how much each party provided. While the *paroan* system sees the equal division of profits, *superlima* generally favours the investor and occurs most commonly when land is owned by the elderly or

[33] For the *paroan* system one party typically provides the land and fertiliser and the other the seeds, agrochemicals and manpower. This arrangement is more equitable and the earnings are divided in 2. For the *superlima* system one party invests the seeds, fertiliser, agrochemicals and man power and another party provides the land. The landowner receives one fifth of the earnings and the remaining four fifths go the other party.

female household heads, who are unable to manage it themselves. Suryanata (1994) found that in the highlands of East Java these arrangements occur when a landowner does not have the capital or skills to utilise their own land, ultimately leaving the landowner with a reduced earning potential. In addition to these sharecropping arrangements, some land is rented directly from large landowners, the village council, or Department of Forestry at pre-determined yearly rates. As already discussed in Chapter 5, this land is often positioned in close proximity to active craters or on the upper steep slopes, and is more prone to the impacts of natural hazards.

6.2.5. Credit and capitalist relations

The potato also altered economic relations and vulnerability in the Dieng Plateau, primarily through access to credit. Mahanty and Milne (2016) argue that the cassava boom in Cambodia's borderland deepened capitalist relations and led to an erosion of choice over modes of production for small landholders. While the potato, through greater access to markets and credit, has likewise deepened capitalist relations in Dieng, it has not necessarily led to the loss of choice witnessed in Cambodia. Upland communities in Java have been involved in the production of export commodity crops such as tobacco and coffee from the early 1800s onwards (Boomgaard, 1999; Hefner, 1990). In comparison to the tobacco period, I posit that the potato appears to have increased control over crop production and marketing options. Farmers are no longer in debt relations with tobacco merchants and thus have more autonomy over the sale of their harvest. While they are still subject to domestic potato prices, the high demand for Dieng's potatoes means they are rarely forced to sell to the first interested buyer. Furthermore, some landowners have the means to store potatoes until prices rise or are able to transport them to regional marketplaces to gain a higher price directly.

The potato has, however, increased access to, and reliance on, formal and informal sources of credit. As potatoes are a very resource intensive crop to grow (Scott, 2002), the capital required to initially plant is often borrowed. Based on my survey of 124 households in Dusun Simbar, 89 per cent (n =

110) claim to regularly borrow money from the bank, a local organisation, family or neighbour. A total of 29 per cent (n = 36) of households borrow money from the bank at least once per year, 27 per cent (n = 34) from family, 21 per cent (n = 26) from local organisations, and 19 per cent (n = 24) from neighbours. Often households will borrow from a variety of these sources each year. Reliance on credit allows farmers to secure the capital needed to plant potatoes and the short growing cycle of the potato allows profits to be recuperated and the loan to be repaid before accruing too much interest.

While access to these means of credit has given farmers greater control over their activities, it has also created issues in the event of multiple crop failures. One crop failure allows the loan to still be repaid with the profits of a subsequent crop before excessive interest is accrued; however, multiple failures may require more drastic means to repay bank loans such as temporary out-migration to corporate rubber and palm oil plantations in Kalimantan and Sumatra or in very rare circumstances, the sale of land (this is discussed further in Section 6.4 below).

Overall, the discussion above has described how the potato has influenced land availability and modes of agricultural production. I argue that while many farmers have benefitted from this agricultural shift, they are also exposed to new vulnerabilities associated with rising land prices, land fragmentation, reliance on credit, and as will be discussed below, issues of land degradation.

6.3. The environmental impact of the potato boom

The agrarian transformation and livelihoods literatures are also concerned with the impact 'booms', or particular livelihood activities, have on long-term issues of environmental degradation. To understand how these processes interact with conditions of vulnerability, the forthcoming discussion will focus on the environmental impacts of the potato boom and the district government's response to claims of the associated environmental degradation. I highlight limitations to the way these issues are constructed

and acted on (see Batterbury et al., 1997; Forsyth and Walker, 2008), overall arguing that some of the official environmental degradation rhetoric, and the policies it leads to, can also increase local vulnerabilities. This discussion provides greater local context to my second research question, particularly the processes governing, or acting to overcome, vulnerability following the potato-led agrarian transformation.

6.3.1. An overview of current land degradation issues in the Dieng Plateau

Land use relations changed drastically with the introduction of the potato and other cool climate vegetables, and many authors claim these changes have caused significant issues of land degradation throughout highland Java (Carson, 1989; Magrath and Arens, 1985; Rudiarto and Doppler, 2013). When visiting the Dieng Plateau it is hard not to notice the intensity at which the landscape is being cultivated. Steeply inclined slopes are covered in terraced plots, predominantly planted with potatoes followed by cabbages and carrots and only the very peaks of the plateau are off limits and locked into Forestry owned land. Year round mono-cropping is a standard practice, with trees sometimes grown around the edge of fields to stabilise terraces and/or mark land ownership boundaries. While this system maximises profit it is also tied to certain environmental impacts, specifically erosion and downstream sedimentation, deforestation, and the overuse of agrochemicals as discussed below.

Erosion and downstream sedimentation

During the mid-1980s the problem of erosion in highland Java gained domestic and international political attention. The World Bank and United States International Agency for Development in collaboration with the then Indonesian Department of Research and Agricultural Development (*Badan Penelitian dan Pengembangan Pertanian*) launched various projects aimed at both measuring the quantity and impact of soil erosion and the trialling of erosion controlling programs such as terracing. Documents produced during this period report that soil loss from potato fields in West and East Java

equalled 100 tonnes/hectare/year (Carson, 1989) and that the downstream cost of this upland erosion amounted to between USD 340 and 406 million per year[34] (Magrath and Arens, 1985). While the reports concede many limitations and uncertainties, they have nonetheless provided a backdrop to the way the issues of environmental degradation in the Dieng Plateau are understood today. Nowadays, the Wonosobo district government estimates erosion in Dieng at 160 tonnes/hectare/year (Interview 85, Spatial Planning Officer, Bappeda Wonosobo, 24/09/15), while other studies have calculated a value closer to 300 tonnes/hectare/year (Rudiarto and Doppler, 2013).

During interviews with district government officials the erosion problem in Dieng was related to perceived poor land use management practices on behalf of Dieng's small-scale farmers (Interview 78, Spatial Planning Officer, *Bappeda* Banjarnegara, 27/10/15; Interview 85, Spatial Planning Officer, *Bappeda* Wonosobo, 24/09/15). In particular, the shallow root structure of potatoes and other cool climate vegetables, when combined with a practice of continual planting with no fallow between, are argued to destabilise and erode sediments. Terracing techniques are also implicated in the problem and while some attempt at terracing is generally always made, the utilisation of steeper slopes means that terraces on the upper slopes are built at very steeply inclined angles (Figure 19). It is argued that these practices exacerbate erosion, causing the depletion of highland soils and sedimentation of lowland rivers (Carson, 1989; Hefner, 1990; Rudiarto and Doppler, 2013).

[34] These estimates were based on the maintenance cost of irrigation, reservoirs and harbours. It is difficult to determine how much of the sediment load was and is actually caused by human induced erosion as opposed to the naturally high sediment loads found in tropical rivers.

Figure 19. An example of terraces built at steeply inclined angles due to the slope of this patch of land. Note the small slip of land in the middle right (source: author).

While erosion is most certainly occurring in highland Java, the values provided above appear extremely high and raise questions concerning their limitations. The studies of Forsyth (1994, 1995, 1996) and Forsyth and Walker (2008) argue that similar erosion narratives in upland Thailand are fraught with significant limitations. Some of these limitations are also reflected in Dieng's erosion estimates provided by Rudiarto and Doppler (2013). For example, this work applies the universal soil loss equation, which is best suited to the measurement of sheet erosion in the dust bowl of America rather than the monsoonal highlands of Southeast Asia (Forsyth and Walker, 2008), and relies on a standard crop management variable that overlooks practices such as terraces and planting trees around fields. In Thailand, as erosion narratives apportion blame to the actions of a minority of highlanders as opposed to state policies, they are politically expedient and rarely questioned (Forsyth and Walker, 2008). In Central Java, Lukas (2014) similarly found that blaming farmers for the erosion problem is one sided.

Contrary to popular opinion, rather than farmland the most erosion prone land includes the sites of historic confrontations between the state, farmers, and the forestry department (Lukas, 2014). In the absence of compelling scientific measurements, it is therefore difficult to understand the extent to which erosion is enhanced through land management practices rather than naturally occurring processes in the Dieng Plateau (see also Forsyth, 1994; 1995; 1996).

During discussions with farmers themselves, erosion was never raised as a serious concern. In fact, the Indonesian terms for erosion (*erosi*) and landslide (*tanah longsor*) were used interchangeably and neither flagged as having a significant impact on farming outcomes. Farmers were more concerned by pests and the need to apply agrochemicals and fertilisers to secure good crop yields. When erosion and landslides were discussed they were linked to isolated heavy rainfall periods or to Kepakisan's 2014 earthquake event that destabilised soil on steep slopes. Following the Thailand floods of 2011, Walker (2011) argued that the severity of the event was primarily caused by exceptionally high rainfall. While this thesis does not advocate frameworks that overlook the social dimension of disasters, a similar sentiment to that found in Walker's article was observed in the perspective of many farmers in the Dieng Plateau. Erosion was primarily seen as a consequence of heavy rainfall washing soil from steeply sloped fields, generally occurring just once a year during the climax of the wet season. This erosion was observed through sedimentation of the drainage channel that ran through Dusun Simbar. Contradictory to the erosion estimates and concerns of the district government, the slower and ongoing process of erosion of topsoil was never mentioned as a significant problem by local farmers. This is not to say it isn't occurring but rather that the issue is as yet unobserved by, or holds a lower priority for, potato farmers in the Dieng Plateau.

Deforestation

Deforestation is frequently linked to issues of environmental degradation in highland areas. While it was raised as an issue affecting erosion during conversations with Banjarnegara district government staff, no clear estimates of deforestation are currently available. BPS data records that forest area in the Batur subdistrict has remained unchanged at 1062.30 hectares from the years 1988 to 2011. Using Landsat imagery Rudiarto and Doppler (2013) estimate that forested area in the adjacent Kejajar subdistrict reduced by 42 per cent from 1991 to 2001 and that agricultural areas increased by 10 per cent during the same period. While this study provides an indication for Dieng, the analysis was conducted for much of the mid-slope region of Wonosobo and omitted the vast majority of the Dieng Plateau. According to Pudjoarinto and Cushing (2001), images of the plateau itself taken from the late 1920s to early 1930s actually show less vegetation on the slopes than can be found today, possibly reflecting the intensification of agricultural development at that time and the creation of protected state forests throughout Java in the 1960s (see Peluso, 1992).

Measuring deforestation in Dieng is complicated by the apparent dynamic boundary between forest and farmland. Interviews revealed that farmers have been using Forestry land since at least the 1940s, with periods of deforestation (sometimes through deliberate forest fire) followed by periods of farming and then reforestation. This process is ongoing today; during fieldwork we saw both Forestry land opened for farms and Forestry land under regeneration. While deforestation may be measureable and noticeably significant on the middle slope regions, it is difficult and yet to be accurately measured on the upper slopes of the plateau itself. These findings support Adger et al.'s (2001) argument that popular deforestation narratives are often simplified and overgeneralised so that they become 'illegible' at the local level. Deforestation is something farmers are also hesitant to talk about, as they don't wish to implicate themselves or others, in any illegal activity. Despite these difficulties measuring deforestation, it still bears important implications for the sustainability of livelihoods, as evidenced in Dusun

Simbar's claims of reduced water quality following illegal burning of forests in the neighbouring district of Batang (see Chapter 5, section 5.1.2).

Agrochemicals, fertilisers and crop yields

Arguably the most noticeable environmental issue in the Dieng Plateau today is the excessive use of agrochemicals and fertilisers. During fieldwork discussions some farmers reasoned that their excessive use of agrochemicals is due to the fact that the 'land is already damaged (*tanah sudah rusak*)'. This process is observed through declining crop yields, and combated through the application of chicken manure, phosphorus and a complex mix of agrochemicals. As discussed previously, potatoes are inherently vulnerable to a host of diseases and Dieng's farmers are in a perpetual battle against them, routinely spraying with pesticides and fungicides (known locally as *obat*). During the rainy season most farmers will apply pesticides on a daily basis to ward against disease, while in the dry season this *obat* may be applied only every few weeks. The excessive use of pesticides causes local reports of skin irritations and prohibits the export of potatoes internationally as the chemical residue exceeds the amount permitted by most countries. The perceived relationship between land degradation and the crop yield situation was explained by one farmer:

> In the past we could harvest one tonne of potatoes from one quintal of seed potatoes. But now harvesting six quintals from each quintal of seed potatoes planted is seen as a good outcome. The soil has been damaged and we now need to use more chemicals (Interview 32, male aged 31, Dusun Simbar, 8/12/15).

While the state predominantly view the dependency on agrochemicals as a direct consequence of farmers poor land management practices over time, such as intensive mono-cropping with no fallow period, some farmers take a contrary perspective and implicate the state's control of seed stock to the increased use of agrochemicals. Prior to 2004 farmers had easy access to high quality seed potatoes imported from Australia, the Netherlands and Germany. However, in 2004 Indonesia implemented strict importation

restrictions following the identification of a pest (the red nematode) in an import (Natawidjaja et al., 2007). The Central and West Java provincial governments then began to develop their own locally made potato varieties in collaboration with farmers groups. However, these seed potatoes produced by the Ministry of Agriculture are known by farmers to contain disease and are too expensive for most farmers to invest in (Marks, 2012). Farmers therefore continue to plant new crops from the tubers of old crops for up to five growing seasons. A study by Fugile et al. (2006) found that around 85 per cent of the Indonesian potato farmers they interviewed relied on this informal mechanism of seed potato supply. Difficulties accessing affordable and disease free seed means that stocks are infrequently replenished allowing the proliferation of disease. Some farmers in the Dieng Plateau claim that this has increased their dependency on agrochemicals. This situation was most clearly articulated by one informant of Dusun Simbar:

> Before seed potatoes were directly imported from Germany, the Netherlands and Australia. Now seed potatoes cannot be imported because the government is making their own of very poor quality. As a result farmers need to add many things like chicken manure and agrochemicals to produce a potato crop (Interview 19, male aged 59, Dusun Simbar, 8/12/15).

While local farmers and state views hold that land degradation (or alternatively a lack of access to disease resistant seed stock) is reducing yields, this is not reflected in Batur's yearly production values of potatoes and cabbages. BPS data shows that the production of potatoes and cabbages remains high with the years 2012 and 2014 producing the largest quantities on record (Figure 20). This data may be explained in a few ways. Firstly, that there has been an expansion in total area farmed; secondly that farmers are actively fighting soil erosion and fertility problems through the input of fertilisers and agrochemicals; and/or thirdly that estimates of declining yields due to poor land management practices have been somewhat

overemphasised. Regardless of the explanation, it is clear that agrochemicals are now an integral component to successful farming in the Dieng Plateau.

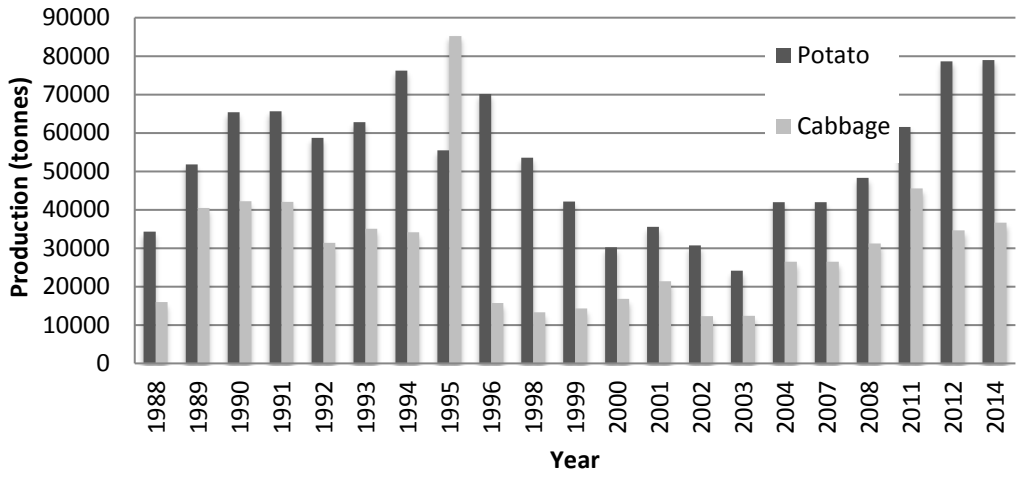

Figure 20. Production of potato and cabbages in the Dieng Plateau (Batur subdistrict) from the year 1988 to 2014 (Source: *Kecamatan Batur dalam rangka,* BPS 1988-1996; 1998-2004; 2007-2008; 2011-2012; 2014). Note this graph shows total production and not crop yields per area of farmland.

6.3.2. State response to claims of environmental degradation

As highlighted by Hall (2011a), the heavy impact crop booms have on land degradation can encourage governments to attempt to halt or even 'turn back' the boom (p. 526). Likewise, the environmental impact of potato farming has instigated intervention by the two district governments responsible for the vast area of the Dieng Plateau (*Kabupaten* Banjaranegara and Wonosobo). These district governments rely on alarmist rhetoric to describe land degradation in Dieng, providing large erosion rates and referring to the situation as having reached a 'critical' status (Figure 21). As Forsyth (1994, 1995, 1996) and Forsyth and Walker (2008) also found in upland Thailand, much of this rhetoric is driven by the ecological significance highland areas have on lowland and downstream environments. This significance is reflected in Banajarnegara's spatial planning map produced by the spatial planning unit of *Bappeda*. In this map the majority of land

currently used for small-scale agriculture is classified as 'Protected area that provides protection to downslope areas' (Figure 22). This broad classification overlooks the importance of small-scale agriculture in Dieng, favouring conservation as the main functionality of the land. While the map currently has no legal standing, it has facilitated conservation programs aimed at combating erosion, such as *carica* planting, agroforestry and terrace stabilisation. However, as will be discussed below these programs apportion blame towards the actions of small-scale farmers and in doing so can adversely influence local conditions of vulnerability.

Figure 21. Presentation slide sourced from the Spatial Planning Unit of *Bappeda* Wonosobo (Interview 85, Spatial Planning Officer, Bappeda Wonosobo, 24/09/15). The text reads, 'In the Dieng region the land status is critical as a result of the intensive cultivation of crops year round. The level of erosion in the region has reached 160 tonnes per hectare per year, reaching 8 times more erosion than 6 years ago'.

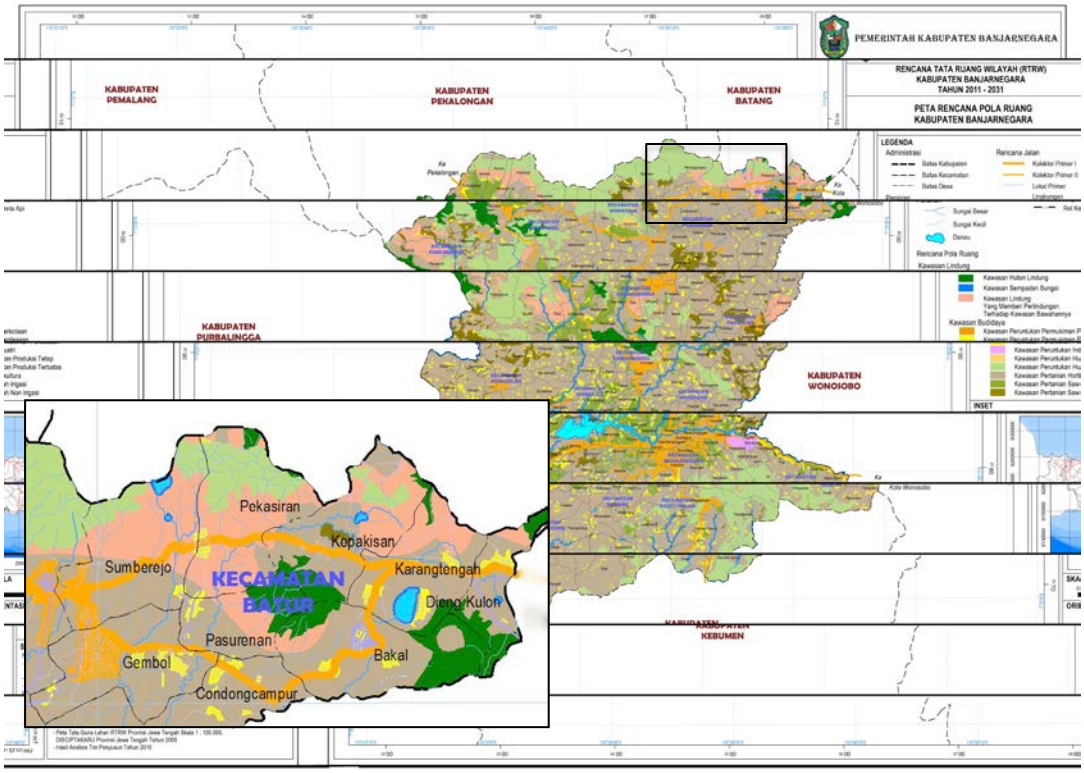

Figure 22. *Bappeda* Banjarnegara's spatial planning map. The Dieng Plateau is enlarged in the bottom left. The pink area that makes up much of this area is classified as '*Kawasan lindung yang memberi perlindungan terhadap kawasan bawahannya*' meaning 'Protected area that provides protection to downslope areas'.

The unquestioned 'critical' status of Dieng's environment is also perpetuated within the domestic media. One article published in August 2014 by the National Geographic of Indonesia reported that '*Kondisi tanah di Dieng semakin kritis*' meaning 'the condition of the land in Dieng has reached a critical status'. This article goes on to link poor land use practices to continual vegetable propagation and the overuse of agrochemicals (National Geographic Indonesia, 2014). In February 2017 heavy rainfall instigated a landslide that blocked the flow of the Serayu River and the cause of this flood was then attributed to what is commonly referred to as '*Kerusakan lingkungan Dieng*' or 'Dieng's damaged environment' (see Wibisono, 2010). While current land use practices likely contributed to the severity of this event, landslides are a natural feature of highlands, particularly in regions with high seasonal rainfall and active volcanism (see also Forsyth 1994,

1995, 1996). Yet, when questioned by a *Kompas* reporter the head of Public Works, Water Resources and Spatial Planning in Central Java (*Dinas Perkerjaan Umum, Sumber Daya Air dan Penataan Ruang Jawa Tengah*) attributed the landslide primarily to deforestation and changed land use practices (Nurdin, 2017). He quoted that:

> Although potatoes are a part Dieng's agriculture, this must be considered with the conservation needs of the land and water. This is important so that landslides and floods do not become threats.

This rhetoric of environmental crisis perpetuated within the government, academic literature and media, has encouraged and legitimised many of the Banjarnegara district government's agricultural and re-greening programs in Dieng. As discussed above, the shallow root structure of potatoes and the continual cycle of planting with no fallow period are often blamed as the cause of the erosion problem (Interview 78, Spatial Planning Officer, *Bappeda* Banjarnegara, 27/10/15; Rudiarto and Doppler, 2013). Many attempts have thereby been made to redirect farming practices towards coffee, eucalyptus, *carica* and other fruits with deeper and more permanent root structures. To date farmers have resisted these alternatives as none have proven to rival the economic gains made through potato farming. One program conducted by *Bappeda* and the Ministry of Environment and Forestry in collaboration with the UNDP (United Nations Development Program), involved initiating a series of reforestation efforts in Dieng based on the principles of agroforestry. This has overseen the planting of soil stabilising plants, primarily eucalyptus, around the edges of fields. Tree cover between fields has increased during the past five years as a result of this program and in this sense it is a success. However, the future of these trees remains uncertain as many farmers stated that they initially planted the trees under the impression that they could sell the leaves to a eucalyptus oil factory that was to be built by the district government in the area that did not eventuate. Furthermore, many other farmers we spoke with in Dieng claimed that the trees shade their potatoes and reduce yields.

Another initiative advocated by the district government to reduce erosion, and 'turn back' (Hall, 2011a, p. 526) the potato boom, is the planting of *carica*. *Carica* is a cool climate papaya variety originating from the highlands of Central America that is promoted as the *makanan khas*[35] of the Dieng Plateau and marketed in processed form to domestic tourists. Yet, the economic potential of the *carica* is contested from the perspective of the district government and local farmers. While farmers in Dieng complain that there is a limited market to sell their *carica*, the district governments of both Banjarnegara and Wonosobo promote it as a more environmentally beneficial alternative to potatoes. During conversations with staff at the Bappeda office in Banjarnegara the productivity potential of *carica* was emphasised. I was told that three kilograms of *carica* fruit can be harvested from each tree every 15 days and that the price per kilogram can reach IDR 5,000 (AUD 0.47). Furthermore, in 2014 the *Bupati* (Regent) of Wonosobo claimed in the national media that the earnings made from *carica* are equal to that of potatoes (Maharani, 2014).

However, locally *carica* is not seen as a viable economic alternative and farmers claim that the amount of *carica* produced in Dieng surpasses the amount bought by domestic tourists. Farmers often spoke of not being able to find a buyer for their *carica* or it not being worth the effort to pick. It may sell for just IDR 1,000 (AUD 0.09) per kilogram, though often less. Furthermore, *carica* requires processing before consumption, either fried into a dry chip or through soaking and boiling in sugared water. Not all farmers are thus established or willing to process the *carica* into an edible form. This finding concurs with Barbier (1990) who likewise found that upland farmers throughout Java are unlikely to adopt erosion control measures unless they can see a strong incentive in doing so. As stated by one grower of *carica*:

[35] Food snacks originating from specific areas, known as *makanan khas* or 'special foods', are purchased as souvenirs by domestic tourists and represent an important industry in Indonesia.

> I don't pick the *carica* that's planted around the edges of my fields. I just leave it there to rot. Harvesting the *carica* is useless, the price is just 1,000 rupiah, or sometimes just 500 rupiah per kilogram (Interview 62, female aged 40, Dusun Serangan, 3/11/15).

In addition to the lack of a reliable market for *carica*, it is also known to interfere with the productivity of potato crops. Many farmers resist growing *carica* as they feel it limits the land they have available for vegetables, restricts sunlight and funnels rainwater. Another farmer explained this process:

> *Carica* leaves are wide so that they funnel the rain water onto the potato plants and the potato plants below become rotten. Aside from that they also block the potatoes from sunlight. *Carica* would be better grown in their own fields just for *carica*, or at least far away from other plants. Here people rarely plant *carica*, because it disturbs the potatoes (Interview 25, male aged 50, Dusun Simbar, 9/11/15).

While the agroforestry and *carica* plantings are argued locally to not secure adequate profits, not all state initiatives unduly disadvantage farmers. One program already implemented in Kepakisan Village with plans of expansion into Pekasiran, is that of terrace stabilisation. While terracing is a standard practice in Dieng, the terraces are rarely reinforced and are often constructed at overly steep angles. A simple practice of securing netting to the wall of the terrace as shown in Figure 23 below can reduce erosion whilst still allowing enough area for potato farming.

Figure 23. A terrace rehabilitation program implemented in the village of Kepakisan by the Banjarnegara Department of Environment and Forestry (*Kementrian Lingkungan Hidup dan Kehutanan*) in 2015. Note the mesh netting stabilising the terrace and the line of tamarillo (foreground) and *carica* (background) bordering the newly planted potato field (source: author).

Despite the environmental degradation rhetoric and the various state-led programs to combat it, potato and other cool climate vegetable farming in the Dieng Plateau has not been curbed. Immediate economic rewards are given greater weight by farmers than issues of environmental degradation, real or over-emphasised. This finding is unsurprising considering the economic change that occurred since the introduction and intensification of potato farming. In a good growing season a potato farmer in Dieng can invest IDR million (AUD 188) and earn IDR 20 million (AUD 1,876) at harvest, resulting in a monthly income of IDR 6 million (AUD 563)[36]. This is above the salary earned by many public servants (between IDR 1.4 million (AUD 131) and IDR

[36] This is a typical good case scenario obtained during interviews with farmers in late 2015. It varies considerably depending on the season and market price of potatoes. Farmers can earn more or less than this amount.

5 million (AUD 469) per month)[37]. A common view held within the district government is that the farmers are overly concerned with their profits. In the words of one official from Bappeda in Banjarnegara, 'the community don't care about the environment, they just think about their household finances and needs' (Interview 78, Spatial Planning Officer, *Bappeda* Banjarnegara, 27/10/15). With some potato farmers earning more than many low to mid-level government officials, there is little wonder that conservation solutions implemented by the district government are not always overly sympathetic to what is perceived as already fortunate local economic conditions. Furthermore, these earnings allow farmers to passively resist state programs and continue with their current modes of agricultural production.

I argue that environmental programs initiated by the district government overlook the economic value of vegetable farming and the benefits it has brought. Furthermore, they place the responsibility for environmental conservation in the hands of small-scale vegetable farmers who they encourage to grow crops for the greater environmental good, yet to their own economic disadvantage (i.e. *carica* and agroforestry). As demonstrated in other contexts, these state programs are often built from the un-critical acceptance of environmental degradation orthodoxies that are fraught with significant limitations (Batterbury et al., 1997; Forsyth and Walker, 2008). This finding bears significant implications for vulnerability and provides a more contextualised analysis of the environmental impact of the potato crop boom. If farmers lose profit from planting what the district government endorses as erosion-controlling crops, they will also have fewer financial reserves to adequately cope with disturbances and crop failure in the future. However, if they continue with what is perceived as the less 'sustainable' cultivation of potatoes and other vegetables they acquire more financial savings and assets and are better able to respond to livelihood pressures, including volcanic eruptions. The forthcoming discussion will now focus on

[37] Salaries are based on 2015 rates available at: http://www.asn-id.org/2015/08/inilah-tabel-daftar-gaji-pnsasn-tahun.html. Accessed online 8/05/17. However, many public servants supplement their income through allowances to attend workshops, conferences and field trips.

how this chapter's analysis of the potato boom, including the critique of the state's response to environmental degradation, provides a complex and informed analysis of vulnerability to natural hazards in the Dieng Plateau.

6.4. Potatoes as a pathway out of vulnerability

The discussion above has described how potatoes came to dominate local livelihoods in the Dieng Plateau and the changes they have made to environmental, social and economic relations. The forthcoming section will now discuss how potatoes have brought a degree of prosperity that has reduced local vulnerabilities to volcanic and other natural hazards. This section combines the sustainable livelihoods literature of Chambers and Conway (1992) and the livelihoods perspective research of Rigg and Vandergeest (2012), with Dorward et al.'s (2009) 'hanging in', 'stepping up' and 'stepping out' schema, to conceptually organise the many livelihood processes occurring in Dieng. Dorward et al.'s (2009) schema is used in preference to the assets model predominately utilised in livelihoods research as it provides a flexible framework that recognises the dynamic nature of livelihood assets and the many aspirations of the poor (Dorward et al., 2009; Pritchard et al., 2017; Scoones, 2015).

The role the potato has played in reducing conditions of vulnerability is not only a result of its suitability to the Dieng context, but also a consequence of the adaptability shown by potato farmers as they facing livelihood pressures (hazard induced or otherwise). Recognising this capacity and adaptability acknowledges the ability of farmers to innovate and survive under challenging conditions (Davies, 1996; Netting, 1993) and is central to Chambers and Conway's (1992) sustainable livelihoods approach. During fieldwork we uncovered the many and varied strategies used by Dieng's farmers to overcome the causes of vulnerability that impact on their livelihoods. Drawing on a community workshop and conversations with farmers in the field, the three main livelihood pressures that were discussed included crop failure, decreasing crop yields and fluctuations in vegetable prices. Table 6 lists the many mitigation and adaptation measures farmers

utilise to overcome these livelihood pressures. In this table, mitigation involves reducing the severity of livelihood pressures, while adaptation involves adapting to changes. While various components of potato farming are framed as 'unsustainable' by the district government (as discussed previously in section 6.3.2), in the forthcoming discussion I argue that potatoes have also enhanced the local capacity needed to implement the mitigation and adaptation measures that allow farmers to manage, and overcome, livelihood pressures. In the process, many of Dieng's farmers have been able to 'step up', some to 'step out', while leaving others 'hanging in'.

Table 6. Some of the livelihood pressures faced by farmers with their associated mitigation and adaptation measures. *Note that the mitigation and adaptation measures marked with an asterisk are usually reserved for the wealthier farmers.

Livelihood pressures	**Mitigation measure**	**Adaptation measure**
Crop failure (volcanic eruption, climatic or pest induced).	Practice of planting vegetables with a short life cycle (3 months). Harvest crops before the strong winds arrive (Feb-March). Apply pesticides. Invest in water pipes and diesel pumps.*	Sharecropping arrangements. Access to bank loans. Temporary out-migration. Draw on savings. Rely on additional fields.* Income diversification (trading household items, labouring for others, driving).
Decreasing crop yields.	Apply chicken manure. Source higher quality seed potatoes.*	Income diversification (propagation of new seed varieties, marketing of agrochemicals).
Vegetable price.	Plant out of sync with crop patterns in West and East Java.	Store potatoes until price increases.*

6.4.1. 'Stepping up': *Jaman kemakmuran* or the era of prosperity

Access to new markets and the new modes of agricultural production associated with the potato, have increased productivity and the profits earned by small-scale farmers in the Dieng Plateau. Dorward et al. (2009) describe this process of 'stepping up' as the accumulation and expansion of assets and productivity. The success of the potato was articulated by one elderly informant in the field who noted that 'all the permanent homes here are the result of potatoes' (Interview 59, male aged 102, Kepakisan Village, 12/11/15). Another successful farmer from Sumberejo Village articulated this process of 'stepping up' as we stood in his fields listening to how his life changed after he became a potato farmer. He stated in contrast with the past tobacco days, 'for me, this era is prosperous beyond belief (*kemakmuran yang sangat luar biasa*)' (Interview 43, male aged 60, Sumberejo Village, 10/12/15).

During fieldwork it became clear that potato farming is still an aspiration through which to achieve success in the Dieng Plateau. This was particularly evidenced by the many teenagers and young adults we spoke with who choose to remain in the area to farm over seeking work or education in urban areas. We met one young couple, both university graduates previously holding professional jobs in Solo, who chose to return to Dieng and a rural farming life. Their story contradicts the popular notion of 'outmigration' from rural areas (Barbier, 1990; Rigg 2006) and reaffirms the role of the potato as a means of 'stepping up'. When we asked this couple why they came back to Dieng and if they missed work in the city they replied:

> Before my husband had to move around in his professional role and he didn't want to. My husband and I were also bored working in an office; we were bound by work hours. Aside from that, my mother-in-law was here at home alone. So we came back to accompany her in the home and to work the fields. I don't want to go back to the city. I want to stay here. I want work that's more relaxed and not dictated by a

company (Interview 52, female aged 29, Kepakisan Village, 12/11/15).

These findings demonstrate that agricultural livelihoods can still be profitable; a theme that is also elaborated on in Rigg and Vandergeest (2012). Their series of longitudinal case studies describes the many and varied ways rural communities have found, and then sustained, prosperity throughout Southeast Asia. Contrary to a perceived loss of peasants from the modern economy, overall this body of work found a 'continued vitality of rural and peasant life' (Rigg and Vandergeest, 2012, Chapter 1, p. 7). My household survey of Dusun Simbar supports this finding and revealed that 89 per cent (n = 110) of households still rely on potato farming as their primary source of income. However, while Peluso et al. (2012) and Sumedi (2012) describe how in the nearby districts of Blora and Batang families rely on electronic remittances earned through off-farm work in urban centres, potato farming is still the primary means through which farmers have been able to 'step up' in the Dieng Plateau.

For many, this process of 'stepping up' has occurred progressively through the purchase of land and assets. Informants noted that this process includes stages of labouring, renting and participating in sharecropping arrangements, until the eventual purchase of land is possible. The more land a farmer owns, the greater their ability to then draw on additional assets including water pipes (often a joint venture including other wealthy farmers), automobiles to transport crops from the fields, higher quality seed potatoes (either purchased or propagated oneself), and greater confidence to draw on bank loans and make investments. Some farmers can also afford to store a harvested crop until prices are the most beneficial and will scout out which crops are being grown in East Java to maximise the future market potential of their own crops. The accumulation of these assets contributes to prosperity or good fortune (known locally as *rejeki*). One female farmer explained this process as she progressed from labourer to successful landowner:

> The important thing is that you try. In the beginning I didn't own any land. I had a little bit of money and used it to rent some land. After harvest if I had any money left over I would use the money to rent more land. For money to buy food each day I would work other people's land. I would manage my own fields after finishing work in other people's fields (Interview 7, female aged 38, Dusun Simbar, 18/12/15).

As this landowner bought her first fields in close proximity to the main Timbang Crater, they were bought at a favourable rate. She then sold this land, and using her earnings, purchased land elsewhere in a safer and more productive location. Now she owns land in Dusun Simbar as well as a rubber plantation in South Sumatra that is managed by family members (a direct consequence of the historic transmigration program). She also owns a utility vehicle to transport harvested crops from her fields and draws on bank loans to expand her assets further.

Potatoes continue to provide significant economic opportunity for the majority of farmers, including the many able-bodied labourers who can earn reasonable wages. As previously discussed, the Dieng example contrasts with studies of crop booms elsewhere, which have led to the formation of excessively deeply stratified rural classes (see for example: Akram-Lodhi and Kay 2010b; Bernstein, 2010; Li, 2014). However, while the above has demonstrated how many have 'stepped up' due to potato farming, it would be naïve to suggest that all farmers have benefitted equally. Chambers and Conway (1992) argue that a livelihood is equitable when it provides a more equal distribution of assets, capabilities and opportunities especially to the 'most deprived' (p. 4). Despite the economic gains made by many farmers, new risks have emerged alongside the potato and these have left some farmers 'hanging in' as described below.

6.4.2. 'Hanging in': Exceptions to patterns of decreased vulnerability

While potatoes have provided a pathway for many to 'step up', I posit that not all farmers in Dieng have benefitted to the same degree. 'Hanging in' refers to those who maintain their livelihoods in adverse socio-economic conditions whilst failing to get ahead (Dorward et al., 2009). Evidence of farmers 'hanging in' in Dieng was evident during my fieldwork. It occurs for some following successive crop failures, which encourage the temporary out-migration to Sumatra or Kalimantan. It also occurs for those in less favourable socio-economic situations, such as female-headed households. Concerns about the sustainability of potato farming, if they eventuate, may also push more people into this 'hanging in' category.

The analysis above (see section 6.2) describes the significant economic transformations that accompanied the potato boom, allowing many farmers to extract themselves from the debt relations held with tobacco merchants, increase their financial assets and gain greater control over their modes of agricultural production. However, despite these gains, the potato has also introduced new forms of livelihood vulnerability, which have periodically pushed certain farmers into Dorward et al.'s 'hanging in' category (see Table 6). The potato is both a capital and labour intensive crop to grow and is vulnerable to a host of diseases (de Putter et al., 2014; Fugile et al., 2006; Scott, 2002; Scott and Suarez, 2012). As discussed above, cultivation often depends on borrowing funds from the bank or neighbourhood organisations. Consequently, if crops fail in succession due to disease, farmers are left with significant debts to repay. One informant explained how he eventually lost the credit he had borrowed to plant potatoes as he struggled to keep financially afloat:

> In 1999, I initially borrowed the capital to plant from the governments' then farmers credit scheme (*Kredit Usaha Tani*)…. After my crop failed once I still planted again. For one and a half years I experienced ongoing crop failure. Until I just had four million rupiah left in capital. With just four million rupiah I tried to plant again. I was

> determined, I said to myself if I lose the four million rupiah I will stop being a farmer, but, if my crop doesn't fail I will get married. At that time my crop didn't fail and finally I married. After I married, I planted potatoes again, after being married my crops were just ok. I could buy this home and my own fields. However after a few years my crops failed again and everything was lost, including all my fields. All I had left was my home. At the moment, little by little I am renting land to plant potatoes again (Interview 13, male farmer aged 38, Dusun Simbar, 9/11/15).

The newer forms of vulnerability introduced alongside the potato are also compounded by the fact that the labour required to ensure crops remain disease-free is costly, even more so for households who are less physically able to undertake the strenuous labour themselves. Water demands are also high, and farmers who are able to invest in, or pool their resources collectively to purchase, pipes are less vulnerable than the smaller landholders who depend on recurrent rainfall patterns.

In order to overcome some of the new livelihood risks that have accompanied the potato, one common situation I encountered in the field was the temporary relocation of farmers to Kalimantan or Sumatra following progressive crop failures. However, this specific type of livelihood diversification contrasts to the scenarios painted in Dorward et al. (2009) and Rigg and Vandergeest (2012), which focus on diversification away from agricultural production. Instead, this type of plantation-based migration is predominantly temporary, allowing indebted farmers time to recuperate losses and plant again, or landless farmers to acquire the savings to purchase new fields. Hall (2011a) also notes the ongoing presence of waged labour migration throughout Southeast Asia, remarking that despite general trends of de-agrarianisation, migration towards the agricultural frontier continues. In Indonesia, this type of migration represents a contemporary form of transmigration (Potter, 2012). One informant explained the benefits accrued through this form of livelihood diversification:

> I worked in an oil palm plantation in Kalimantan for nine months. I went to earn money and gain experience. Beforehand I experienced multiple crop failures so I went to Kalimantan to earn more capital ….. I was paid enough to repay the relocation costs and earn the capital to replant here again (Interview 49, 30/10/15, male farmer aged 40, Kepakisan Village).

The hazards literature has long demonstrated that women and the elderly face greater vulnerabilities within society (Anderson, 1994; Enarson and Meyreles, 2004). As potatoes are a capital and labour intensive crop to grow, the strenuous nature of the work, combined with the piece-rate *borongan* system, has contributed to a disparity in income earning potential for women and the elderly. Unable to temporarily migrate, landowners within this group will often partake in sharecropping arrangements, which divide profits to favour the investor over the landowner (see section 6.2.4 above). Rather than disadvantaging labourers the most, as much of the agrarian literature demonstrates (see Bernstein, 2010), it is women and the elderly who either own land they cannot afford to manage, or are unable to labour for others, alongside the households who suffer progressive crop failure, that are most likely to be left 'hanging in'.

Chambers and Conway (1992) argue that a livelihood is sustainable when it can overcome livelihood pressures (or in their terms 'shocks and stresses') now and into the future, while also enhancing the capacities and assets that future livelihoods depend on. While it is difficult to predict how potato farming will look in 10 years' time, current issues of sustainability may increase the proportion of households who are left 'hanging in'. Two pertinent issues affecting future sustainability were raised during the period of fieldwork namely: soil fertility and the fragmentation of land parcels as they are passed onto offspring. Both of these processes have the potential to reduce earnings and may adversely affect future livelihood outcomes. However, as Rigg and Vandergeest (2012) caution, such gloomy predictions do not always eventuate. A key component of livelihoods analysis is the recognition that people are able to rework their livelihood circumstances

relying on adaptive capacities (as shown in Table 6). As Rigg et al. (2016b) remark, the rural smallholder is 'remarkably persistent and surprisingly resilient' (p. 199). I likewise posit that the agency and innovation of Dieng's potato farmers to overcome issues of environmental degradation and small landholdings should also be considered in future predictions of sustainability.

6.4.3. 'Stepping out': Livelihood diversification

Dorward et al. (2009) describe the process of 'stepping out' as the accumulation of assets through farming which are then used as a launch pad to diversify into other activities with greater rewards. While examples of this kind of livelihood diversification were observed during my fieldwork in the Dieng Plateau, it was not the main goal of most farmers. Livelihood diversification into more profitable activities predominantly involved trading potatoes, developing and/or propagating new seed varieties, marketing agrochemicals and selling food staples and household items. A total of 23 per cent (n = 28) of households were shown to partake in these kinds of livelihood diversification activities. For the majority, these activities supplemented rather than replaced potato farming entirely. In addition, two households own and manage land beyond Java, one managing one hectare of palm oil and one managing four hectares of rubber plantation, both located in Sumatra. This land was acquired through the accumulation of potato profits and is managed by extended family members living nearby as a result of the historic transmigration program.

The most lucrative livelihood ventures we found people diversifying into include vegetable trading and the propagation of disease free seed potatoes. The few respondents we spoke with who had decided to pursue these alternate paths did so as because the potential earnings outweigh the results earned through tending one's fields alone. However, significant capital is first needed and so past success as a potato farmer is normally a prerequisite. Furthermore, many of these farmers still own land yet can afford to have it managed by labourers while they invest in alternate livelihood options. A

prominent theme to Rigg (2006, 2007) and the collection of essays found in Rigg and Vandergeest (2012) is the importance of off-farm activities to the continuation of rural life. While some of the activities undertaken in Dieng are technically off-farm, they are predominately still agriculturally focused[38]. In contrast to studies elsewhere in Java (Peluso et al., 2012; Sumedi, 2012), farming is still the main focus of livelihood activity, even if some activities don't require labouring the fields oneself. So while livelihood diversification is occurring, these livelihoods are still predominantly linked to the land. This finding argues that potato farming still supports good incomes and has served to reduce the vulnerability of many farmers.

6.4.4. Understanding vulnerability to natural hazards through the lens of agrarian transformation

My integration of the sustainable livelihoods and agrarian transformation frameworks above provides an in-depth, and locally contextualised, analysis of how crop booms influence conditions of vulnerability. However, while the potato alleviated much local vulnerability, it also introduced new forms associated with this modern mode of crop production. Following the approach of Rigg et al. (2016a), in Figure 24 I have summarised the vulnerabilities and capacities that emerged prior to, and following, the potato boom. This figure combines the largely inherited vulnerabilities described in the previous Chapter 5 with those that arose, and/or are presently overcome, in the Dieng Plateau. The processes involved in the construction of vulnerability and capacity as described in this chapter, add significant nuance to Chapter 5 by recognising the adaptive and innovative practices undertaken by farmers as they manage and overcome conditions of vulnerability in today's agrarian environment.

[38] In the village of Dieng Kulon (outside my study villages), tourism over the past five years has had a marked impact on the community and villagers have opened 'homestays' and food stalls to service this growing market. However, tourism has not had a significant impact in the villages of Sumberejo, Pekasiran or Kepakisan where this study was conducted.

The current chapter has contributed to disaster literature by demonstrating how agrarian studies can present useful insights into the vulnerabilities faced by farming communities over time. Importantly, agrarian studies provide an analytical framework to understand who is benefiting the most from agrarian change and who is being left behind and why. As disasters frequently impact upon the most vulnerable in the most damaging ways (Wisner et al., 2004), analytical approaches that reveal livelihood processes and outcomes for this group are highly valuable. Yet, as rural integration with market forces can bring about increased vulnerabilities (Li, 2014; Rigg et al., 2016a), many past agrarian studies have adopted a neo-Marxist perspective to arrive at conclusions of deeply stratified class relations (Akram-Lodhi and Kay, 2010b; Bernstein, 2010; Li, 2014). In comparison however, the specific conjunctures of the potato boom, as described above, demonstrate that gains have been broadly distributed across my study area, with many farmers (albeit not all), benefitting from this agrarian transformation. Moreover, local land relations and the demand for farm labourers have ensured landless labourers (if able bodied) are also earning reasonable profits at least in Dusun Simbar. I argue that overlooking the significance of the potato-led transformation and its impact on local living standards, would have risked the in-depth analysis of livelihoods provided above, and omitted the important insights gained by linking micro-processes with the wider structures that shape vulnerabilities (see Scoones, 2015).

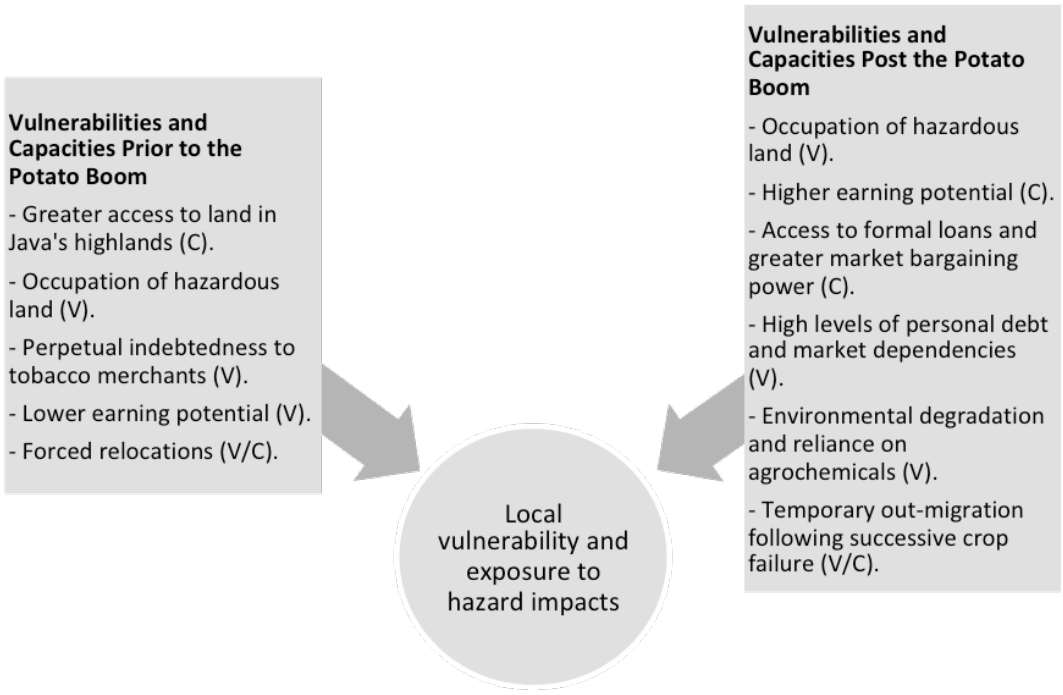

Figure 24. A summary of the processes that have generated or mitigated vulnerabilities prior to, and following, the potato boom in the Dieng Plateau. Capacities are marked with a 'C' and vulnerabilities with a 'V'.

6.5. Chapter conclusion

This chapter has argued that while by no means a livelihood panacea, potato and other cool climate vegetable farming activities remain a priority and source of significant income for many farmers in the Dieng Plateau. By analysing the potato crop boom and combining this with a grounded view of livelihood outcomes, I have demonstrated that potato farming livelihoods are continuing to thrive despite claims of critical land degradation and the threat of volcanic eruptions. This conclusion is arrived at by unpacking the 'conjunctures' of the potato boom (see also Li, 2014; Mahanty and Milne, 2016), its impact on land degradation and subsequent state imposed land management policies (Forsyth and Walker, 2008), and by describing local livelihood outcomes and how they interrelate with vulnerabilities (Chambers

and Conway, 1992; Dorward, 2009; Dorward et al., 2009; Rigg and Vandergeest, 2012). This approach demonstrates how explanations of vulnerability can be enhanced through integrating sustainable livelihoods and agrarian transformation frameworks.

Wisner et al. (2004) argue that: 'It is becoming increasingly clear that sustainable livelihoods cannot be supported by natural resource-based activities (primarily agriculture) in many parts of the world' (p. 79). This preconceived bias concerning what constitutes a sustainable livelihood is prevalent within the disaster management community and is informed by the type of environmental degradation orthodoxies I have discussed in section 6.3 above. However, within this chapter such assumptions have been challenged and farmers depicted as actively combating issues of land degradation and in many situations continuing to farm profitably. While I do not suggest that these practices are perfect or that they will continue indefinitely into the future, they do reveal the contested nature of sustainability. This theme is expanded on in the following chapter wherein the often-contradictory priorities for disaster risk reduction held by local farmers and the district government are analysed using a framework of locally contextualised disaster knowledge.

7. Disaster knowledge: Local and expert perspectives and practice in the Dieng Plateau

The previous two chapters have described the political ecology of vulnerability to natural hazards in the Dieng Plateau, focusing specifically on the role played by access to land, territoriality, agrarian transformations and livelihoods. This chapter elaborates on a number of key themes raised earlier, including how livelihood realities and styles of risk governance can influence DRR outcomes. Drawing its epistemological foundations from the argument that knowledge is produced and embedded in a local context (Goldman, 2007; Turnbull, 2000), the forthcoming chapter will describe the construction of, and interaction between, local and expert disaster knowledge and the actions it informs in the Dieng Plateau. Rather than a study of quantitative risk perception, this chapter describes the way disaster knowledge has been built and acted on, both by local farmers and the prominent state organisations responsible for DRR in the area. Rebotier (2012) argues that to successfully reduce vulnerabilities we need 'a grounded analysis of how risk is lived, experienced, and given meaning by the different actors involved' (p. 393). This chapter responds to this call, presenting a view of both local and expert disaster knowledge, while arguing that they are not opposite 'irrational' subjective versus objective systems.

The forthcoming chapter addresses my final research question, which is concerned with how the local and expert-led construction and implementation of disaster knowledge influences conditions of vulnerability. I begin with a description of local disaster knowledge; focusing firstly on how livelihoods influence risk-taking behaviour, followed by a discussion of local interpretations of the meaning of volcanic disasters. Notably, local knowledge is presented as a hybridised system, incorporating both lessons from scientific modes of observation alongside worldview and livelihood realities (see Agrawal, 1995; Berkes et al., 2000; Nygren, 1999). I then extend this 'local' approach to describe how disaster knowledge is constructed and acted on from the perspective of 'expert' state institutions, specifically the

Banjarnegara District Disaster Management Agency (BPBD) and the Centre for Volcanology and Geological Hazard Mitigation (PVMBG). As studies of expert disaster knowledge are limited, especially beyond the field site of Montserrat (see Donovan, 2017; Donovan et al., 2012b; 2012d; Donovan and Oppenheimer, 2015), this discussion also draws on Li's (2007; 2011) description of how development programs in Indonesia are rendered as technical problems, and Jasanoff's (1987, 1990, 2003, 2007) analyses of the contested nature and the inherent uncertainties of expert risk assessment. The chapter concludes that while the local and expert disaster knowledge systems operating within the Dieng Plateau are locally contextualised and thus unique, they are not binary opposites. While the implications of these findings for disaster management are alluded to throughout this chapter, a full discussion of their policy significance is reserved for the following Chapter 8.

7.1. Local disaster knowledge: Interpretations of, and response to, volcanic hazards

As the literature review of Chapter 2 described, local communities in hazard prone areas often possess their own source of knowledge concerning the cause and consequence of disasters (see for example Bankoff, 2004; Dake, 1991; Donovan et al., 2012a; Hoffman, 2002; Kasperson et al, 1988; Laksono, 1988; Paine, 2002; Shannon et al., 2011; Slovic, 1999). However, while already an established concept within the local ecological knowledge literature (Agrawal, 1995; Berkes et al., 2000; Goldman, 2007; Nygren, 1999; Turnbull, 2000), few of these studies adequately address the locally contextualised and hybrid nature of local disaster knowledge (however, for some counter examples see Schlehe, 2010; Shannon et al., 2011; Rigg et al., 2005). Drawing on field observations, formal and informal interviews, and a community workshop, the forthcoming section describes the local construction and practice of disaster knowledge in Dusun Simbar. I begin by demonstrating how livelihoods both shape and are shaped by disaster knowledge, before describing how volcanic eruptions are interpreted and

responded to. This analysis combines the descriptive approach applied in past studies of volcanic, tsunami and earthquake events throughout Indonesia (for example Bachri et al., 2015; Donovan et al., 2012a; Gaillard et al., 2008; and Shannon et al., 2011), with arguments pertaining to the hybrid and contextualised nature of knowledge more generally (for example Agrawal, 1995; Berkes et al., 2000; Nygren, 1999).

The term 'local' is applied to describe the locally embedded disaster knowledge and the practices it informs in Dusun Simbar. It is used in preference to 'traditional' and 'indigenous' knowledge firstly to avoid engaging in controversial debates over who is indigenous in Indonesia[39], but more importantly to acknowledge that this local knowledge is not fixed in tradition but is rather constantly evolving and influenced by outside processes including modern and scientific ways of knowing (Berkes et al., 2000). As local knowledge in this example represents knowledge that has been passed down through generations orally, developed through recent experience, observation, and the integration of scientific sources, the term 'local' reflects this heterogeneity.

7.1.1. Rational risk-taking: The role of livelihoods

The need to maintain a livelihood is at the forefront of local ecological and disaster knowledge in many societies. As argued by a plethora of authors, people in hazard prone areas generally do not prioritise the geophysical hazards that DRR agencies typically deal with and instead focus on the problems of everyday life that are often linked to their livelihoods (Bachri et al., 2015; Donovan, 2010; Donovan et al., 2012a; Gaillard, 2008; Haynes et al., 2008a; IFRC, 2014; Lavigne and Gunnell, 2008; Mei and Lavigne, 2012; Seitz, 1998; Usamah and Haynes, 2012). As I demonstrate below, local livelihood needs shape, and are shaped by, local disaster knowledge. Drawing on

[39] Dieng's farmers do not identify themselves as indigenous and many are the descendants of lowland Javanese. My use of the term 'local' rather than indigenous also relates to Indonesia's official stance that all Indonesian citizens, other than the *Tionghoa* (despite many being in Indonesia for centuries) are '*pribumi*' (sons of the land) and as Suharto famously articulated, are equally indigenous (Li, 2000).

fieldwork interviews, a household survey, and community-based workshop, I will demonstrate how livelihoods interact with local disaster knowledge and mitigation practices in Dusun Simbar.

Data obtained from the household survey I conducted in Dusun Simbar revealed that very few farmers expressed a consistent fear of the threat posed by the Timbang Crater Complex. A total of 72 per cent (n = 90) of the 124 households surveyed reported that they are rarely afraid of poisonous gas, worrying about it only when there is a large event. Ten per cent (n = 12) reported worrying about the gas on a weekly basis, nine per cent (n = 11) worry about it only sometimes and another nine per cent (n = 11) reported that they never worry about it at all. While a large proportion of households own or rent land that has been affected by poisonous gas in the past (37%, n = 45), only 22 per cent (n = 10) of these households reported that they are either only sometimes or frequently concerned by it happening again. Overall, 93 per cent (n = 115) of households feel that Dusun Simbar is a safe place to live.

The lack of concern farmers expressed in relation to the poisonous gas reflects the significant role livelihoods play in shaping a local system of disaster knowledge. This local disaster knowledge functions to allow livelihoods to continue without fear, whilst also providing a means to practically minimise the risk associated with potato farming (see section 7.1.2 below for further discussion). As demonstrated in both Chapters 5 and 6, potato farmers in the Dieng Plateau can reap significant financial rewards from intensively farming this landscape. The hazardscape of Chapter 5 outlines the economic and political processes through which farmers have come to utilise hazardous land, while Chapter 6 outlines the significant financial rewards gained through partaking in these activities. Knowledge of, and response to, volcanic disasters is both shaped by, and accommodates, these important livelihood demands. Risk is understood as something that can be mitigated, so long as these mitigation efforts don't impinge too heavily on livelihood needs. One farmer in Dusun Simbar explained this concisely with the following:

> Indeed, people from Simbar are not afraid of the gas. If they were afraid and ran away what then would become of their life? Their finances rely on working in the fields. If the fields are not looked after their crops will fail. If they cannot harvest, how can they meet their needs? So when the gas came out and Simbar's people were evacuated they still went to the fields during the day to take care for their crops. In the evening they then returned to the evacuation camp (Interview 31, male farmer aged 26, Dusun Simbar, 04/12/15).

The outcome of the workshop we held in Dusun Simbar further demonstrated the extent to which livelihoods influence the local construction and practice of disaster knowledge. During this workshop, participants were asked to rank the threats facing their community in order of significance. The threats that were identified and ranked at the top were those that impact most heavily on livelihood outcomes. Of particular note is that strong winds and general crop failure rated as worse threats than poisonous gas[40] due to their more frequent recurrent interval and significant impact on potato crops (Table 7). This is despite the fact that strong winds rarely lead to evacuation orders and have never caused human casualties in Dusun Simbar. These findings further demonstrate how the practical, concrete aspects of earning a livelihood in the Dieng Plateau shape the construction and practice of disaster knowledge.

[40] As participants were aware of my interest in natural hazards it is possible that hazards feature higher in the table than they otherwise would have, if for example, my interests were in healthcare.

Table 7. A table listing threats and coping mechanisms developed by 10 community representatives (5 male and 5 female) from one RT (*rukun tetangga*, the smallest village administrative unit comprising approximately 70 households) in Dusun Simbar.

Threat	**When it occurs**	**How it's handled**
1. Strong winds.	January to March.	Try to time your harvest before the winds arrive.
2. Crop failure.	Dry season (July to October) or during strong winds.	Pump water from Sidringo Lake; reduce household spending.
3. Poisonous gas.	When the crater effuses gas.	Evacuate to a safe place; don't enter fields in the evening or during overly foggy/overcast conditions.
4. Drinking water shortages.	July to October.	Store water beforehand; borrow water from neighbouring Dusun Serang.
5. Cold and flu.	Anytime.	Watch your health.
6. Landslide.	When there is lots of rain.	Plant trees and clean the drains.
7. Floods.	November to April.	None.
8. Diabetes.	Anytime.	Reduce consumption of sugary foods.

The findings of this workshop were also validated during opportunistic conversations with farmers in the field. One informant noted that:

> Every year there are definitely strong winds. They destroy all crops. Sometimes cabbage seedlings will be uprooted. We just accept it (*pasrah saja*) because strong winds cannot be prevented (Interview 32, male farmer aged 31, Dusun Simbar, 04/12/15).

The substantial livelihood threat posed by these winds in comparison to local perceptions of the risk of poisonous gas, was again elaborated on by another informant:

> Yes, I have experienced failed crops because of strong winds. If we compare strong winds to poisonous gas, winds are the most dangerous. This is because we already know the path gas will take. Aside from that, gas isn't certain. It rarely occurs. Wind is different, every year it will definitely appear (Interview 40, male farmer aged 28, Dusun Simbar, 05/12/15).

While winds are generally viewed as a greater overall threat, within Dusun Simbar itself, differing economic statuses of households was shown to influence risk-taking activities following gas eruptions. In line with other studies conducted in Indonesia, the Philippines and Montserrat (Donovan, 2010; Donovan et al., 2012a; Gaillard et al. 2008; Haynes et al., 2008a; Lavigne et al., 2008; Mei and Lavigne, 2012), many farmers in Dusun Simbar admitted to entering their fields before official warnings were lifted following the 2011 and 2013 gas events. Data obtained during the household survey revealed that the period of time farmers stayed away from their fields following these events varied considerably from a few days to two months[41]. Those who admitted to entering the fields shortly afterwards reported using alternative unaffected roads to reach their land or waiting until the middle of the day when the sun and winds are strongest to dissipate the gas. Importantly, this group stated that they could not afford the financial loss of leaving their fields unattended. While farmers with larger land holdings are more likely to be able to draw on their savings, alternate forms of income, or harvests from other fields located far away from the crater; it is the smaller landholders, working the more affordable land in close proximity to the crater (see Chapter 5) who are willing to take the greater risks (see also Haynes et al., 2008a).

[41] It is possible that this value does not reflect what actually occurred following the 2011 and 2013 events. Households may not have wished to disclose their economic necessity to disobey state orders and enter the fields earlier than reported.

The findings presented above posit that farmers in Dusun Simbar rationalise the threat posed by the Timbang Crater Complex for the achievement of livelihood goals. This argument is supported by Paine's (2002) 'no-risk thesis', which argues that people who live in high-risk environments and are aware of their risk choose to psychologically repress it for achievement of an ultimate goal. Likewise, Dibben (2008) argues that communities living on the slopes of Mount Etna, Italy, cognitively reduce their perception of the risk in order to feel that their habitation of the area is not maladaptive. Closer to Dieng, a study of risk perception in Turgo Village on Mount Merapi, found that while the district government focuses exclusively on events that occur during an actual eruption, villagers focus predominantly on the periods between eruptions when livelihood demands take precedence (Dove, 2008). Various other studies have also shown that communities in 'expertly' defined high risk areas perceive themselves as better able to manage the risk than others, a phenomenon known as the 'unrealistic optimism basis' (Gregg et al., 2004; Sjoberg, 2000; Weinstein and Klein, 1996). While this thesis is not a study of cognitive risk perception, these aforementioned studies support the argument for a local counter-definition of risk that is able to encourage the continuation of farming in a potentially hazardous environment.

The Javanese have a long and documented history of coping with, and overcoming, crises such as volcanic eruptions. This is clearly evidenced through the continual occupation and adaptation of livelihoods on the slopes of Merapi despite centuries of eruptions (Donovan, 2010; Dove and Hudayana, 2008; Laksono, 1988). It is also demonstrated in the many ways the Javanese have altered livelihood activities to overcome political and economic crises throughout history (Nawiyanto, 2013). Rather than 'passive victims', Nawiyanto (2013) argues that the Javanese have been 'relatively dynamic in finding opportunities for sustaining and, if possible, improving the socio-economic conditions of their households' (p. 146). This agency and adaptability is also reflected in local interpretations and response to gas eruptions from the main Timbang Crater. Rather than passively accept the risk, farmers rely on local disaster knowledge, including that which will be

discussed in greater detail below (see section 7.1.2), to partake in activities that minimise the risk of harm to themselves and their livelihoods.

In agreement with many other social volcanology studies conducted around the globe (see Bachri et al., 2015; Donovan, 2010; Donovan et al., 2012a; Gaillard et al., 2008; Haynes et al., 2008a; Lavigne et al., 2008; Mei and Lavigne, 2012), I argue that risk-taking behaviour, and the local disaster knowledge this draws on, in Dusun Simbar is largely controlled by economic necessities. However, when these findings are read in the context of the previous two chapters they also demonstrate that despite the high risks, Dieng's farmers actively pursue these livelihoods for their great financial gains. Rather than being explicitly 'forced' into taking such risks, I argue that Dusun Simbar's potato farmers choose to engage in these activities due to the high economic rewards involved. This finding is further exemplified by the fact that despite gas eruptions posing a greater threat to lives and a more prolonged impact on livelihoods, the more frequently occurring winds that damage crops on a yearly basis are perceived as a greater threat. However, while risks are certainly taken, those that can be mitigated are managed through the use of local disaster knowledge, as will be elaborated on below.

7.1.2. Local interpretations and response to volcanic gas events in Dusun Simbar

While conducting my fieldwork, I encountered two separate, yet co-existing streams of thought representing local interpretations of, and response to, volcanic gas events in Dusun Simbar. While many farmers claim that when facing the threat of volcanic gas they ultimately submit their fate into God's hand, they also accurately understand the geophysical processes involved in the release of gas and pay heed to physical warning signs. In the discussion below, I have conceptualised these knowledge constructs into two frameworks. The first draws on science and observation and views volcanic hazard as a manageable risk that can be anticipated for, and safely responded to. The second draws on religious interpretations and views the volcanic hazard as ultimately beyond one's realm of control. These knowledge

constructs co-exist and reflect the plural nature of local disaster knowledge (see also Schlehe, 2010; Shannon et al., 2011; Rigg et al., 2005). As will be demonstrated below, this interpretation aligns with Adeney-Rosakotta's (2016) study of religious response to the 2006 Bantul earthquake, where he argues that: 'Tradition, religion and science are not necessarily experienced as contradictory symbol systems, but rather as complementary and integrative' (p. 29).

First construct: The observation and mitigation of volcanic gas

When we first made contact with residents from Dusun Simbar, we were immediately warned about the threat associated with the Timbang Crater Complex. Local residents are both expected to understand this risk, and to educate and inform outsiders such as we were. One of the first interviews we held was with an elderly man who had witnessed the impact of the 1979 event first hand. This man was seen as an authority on the topic, and we were quickly ushered into his open fire kitchen to learn from his experience. He spent the better part of an hour explaining the events of 1979, including how gas erupts and moves across the landscape. His explanation of the gas contained knowledge gained from scientific explanations and his own personal observations:

> This is what I say. If there is an earthquake don't go near the area around Timbang Crater. Because if there is an earthquake the gas will emerge. Like when Mount Galunggung erupted in 1980, Timbang Crater also became active. In overcast weather you can detect if the crater is active. If the smoke doesn't move and doesn't rise then it's poisonous gas. If the sun rises and hits the gas it will be lost. In 1979 there was a professor who said that gas only rises 80 cm from the ground; however, I am 165 cm tall and was still hit by the gas (Interview 9, male farmer aged 71, Dusun Simbar, 20/10/15).

The knowledge that was so readily shared during our initial encounters reflects a view that volcanic gas can be observed and mitigated. This knowledge, and the practical mitigation efforts it informs, draws on local

wisdom, everyday observation of crater activity and scientific information. Overall, we found a comprehensive understanding within residents of Dusun Simbar. This knowledge held that: i) the appearance of the smoke (i.e. its colour and whether it rises or hangs to the ground) contains clues of its toxicity, ii) topographic depressions downslope of the main Timbang Crater can become conduits for gas in the event of an eruption, iii) the Timbang Crater Complex should be avoided in dark, overcast or foggy conditions, iv) fields should be evacuated in the event of an earthquake, and v) evacuations should proceed in a westerly direction to avoid encounters with additional craters (Table 8). This knowledge is placed-based and eminently practical, helping people understand and manage the risks associated with their livelihood activities.

All informants we spoke with held at least a basic understanding of the threat associated with the Timbang Crater Complex (Table 7). At the very least informants knew to evacuate towards the west during an earthquake, while at the other end of the spectrum some informants could explain the geophysical processes associated with the crater and its gas in great detail. Statements like 'we know about poisonous gas, it flows like water' (Interview 17, 27/11/15), 'if the sun has already risen then the gas will disappear and just the smoke remains' (Interview 3, 09/10/15), and 'the sulfur white smoke that rises isn't dangerous' (Interview 9, 23/10/15) were frequently presented during interviews. This knowledge is not just gained from scientific information passed via BPBD or PVMBG (as discussed below), but it is also learnt through direct observations of crater activity. Farmers observe activity in the main crater as they enter and leave the fields; paying particular attention to the gas clouds movements.

Table 8. Local explanations of volcanic gas, alongside associated mitigation activities, observed in Dusun Simbar during my period of research.

Local explanations of volcanic gas and associated mitigation activities	**Observation**	**Scientific Information**	**Local Wisdom**
While CO_2 gas is colourless, the appearance of the secondary gases it erupts alongside can contain clues of toxicity. For example, if the cloud rises to the sky it is sulfur and 'non-toxic'[42], while if it hangs low to the ground a dense layer of CO_2 may lie beneath the visible gases necessitating evacuation.	✓	✓	
CO_2 gas is denser than air and so accumulates within, or flows in the direction of, downslope depressions. These topographic depressions should be avoided year round.	✓	✓	✓
As CO_2 gas dissipates when it is hit with sunlight, fields should be avoided in dark, overcast and foggy conditions.	✓	✓	✓
CO_2 gas can emerge with earthquake activity, necessitating evacuation.	✓	✓	✓
Following earthquake activity, you should evacuate in a westerly direction.			✓

Scientific explanations of poisonous gas have been incorporated into Dusun Simbar's disaster knowledge system primarily through the activities of the PVMBG. While an explanation of the pathways through which the PVMBG disseminate their information is provided below (see section 7.2.2), their presence in the Dieng Plateau through the Dieng Volcanic Observatory provides locals with easy access to hazard information. Senior staff (such as Pak Surono, as will be discussed below) will also visit the field following eruptions and are known to share their knowledge informally during conversations with local farmers. They also run formal '*sosialiasi*' programs aimed at educating people about how to detect and respond to gas events.

[42] While the sulfur gases start to pose a significant health risk in concentrations of greater than 30 ppm (D'Alessandro, 2006), the concentrations found in the main Timbang Crater are generally non-threatening.

This knowledge is respected in Dusun Simbar, as clearly evidenced in the way it has shaped local interpretations of gas events (Table 7).

While many cosmological explanations for volcanic eruptions exist throughout Java (Bachri et al., 2015; Donovan, 2010; Donovan et al., 2012a; Dove, 2010; Laksono, 1988; Schlehe, 2010), scant evidence for such interpretations were found in Dusun Simbar. During interviews we often probed for reasons behind the effusion of gas, for example, is it supernatural and/or sent as punishment? Are there any myths or folklores associated with the crater? This line of questioning was generally answered with the same response: the gas is a natural geological process that occurs due to movements in the Earth's crust. The one exception to this was an acknowledgement made by a few elderly people that residents of Dusun Simbar once believed the crater to be haunted by poisonous spirits (*hawa racun)*. However, they were also quick to comment that this belief is no longer held. One elderly resident spoke of a haunted market place situated in the now relic Timbang Village, adjacent to the main crater. This market was known as *Pasar Logendeng* and once visited could not be returned from. He linked this marketplace to the destruction of Kepucukan Village in 1979; however, the causal relationship between the two events was unclear during our discussions. Furthermore, I was unable to corroborate this story with other residents, young or old. Younger informants commented that the community now follows a more orthodox form of Islam that has superseded these earlier *Kejawen*[43] beliefs.

While no clearly maintained mythologies or folklores were found in association with the Timbang Crater Complex, oral tradition has long held the belief to evacuate towards the west in times of trouble. Dusun Simbar is located on the western edge of the volcanically active Dieng Plateau and thus travelling towards the east would lead to encounters with other volcanic

[43] *Kejawen* or *Kebatinan* is a Javanese belief system that combines elements of animism, Hinduism and Buddhism with Islamic teachings. Beatty (2009) describes the transformation of a village in East Java from *Kejawen* to more orthodox Islam through the influence of *pesantrens* located in Cilacap on the north coast of Java. While well beyond the scope of my fieldwork, the responses from informants concur loosely with Beatty's (2009) study.

craters, including Timbang. Informants from Dusun Simbar stated that they have known to evacuate west for generations, long before the 2011 and 2013 eruptions. This knowledge has been passed down for generations, and while it has kept them safe from poisonous gas and other volcanic activity, for the people of Kepucukan it contributed to the heavy loss of life as they evacuated in 1979. As observed by an eyewitness and rescuer during the 1979 event:

> In 1979 I evacuated with my family and we sheltered in Batur. According to our beliefs if anything happens we must go to the west. This belief was also held in Kepucukan, so the people from Kepucukan all ran to the west. When actually the poisonous gas was to their west. The people of Kepucukan were in a difficult position because if they tried evacuating in the other direction there was a hot lahar, and if they went to the west there was poisonous gas (Interview 9, male farmer aged 71, Dusun Simbar, 20/10/15).

The local knowledge and practice of evacuating towards the west reflects a spatial understanding of hazardous localities; a finding also highlighted during the participatory workshop held in Dusun Simbar. Using satellite imagery as a guide, participants were asked to draw spatial maps of the location of craters and dangerous zones in relation to Dusun Simbar. The maps drawn during this workshop were spatially and scientifically accurate: the location of gas effusion points and the direction of gas flow were clearly and accurately positioned (Figure 25). However, there is a notable point of contrast between these maps and the map officially produced by PVMBG. The primary difference is that residents of Dusun Simbar restrict the dangerous zone to the actual route the gas has taken in the past, while the PVMBG extend this area, incorporating Dusun Simbar and much of Sumberejo Village (see section 7.2.2 below).

Figure 25. The participatory mapping workshop held in Dusun Simbar. The first image shows participants sketching the poisonous gas hazard zones over satellite imagery, while the second image displays the final map. The red denotes the path of the gas, the squares are the locations gas may effuse from and the green marks a safe evacuation route (source: author and Dusun Simbar participants).

I argue that local knowledge of the Timbang Crater Complex has been built through the transmission of oral traditions, the continual observation of the main crater, and scientific explanation partly informed by PVMBG. The majority of Dusun Simbar's residents can recognise warning signs, and many can also accurately describe the physical properties of CO_2 gas. While Davis and Wagner (2003) have emphasised the importance of finding 'local knowledge experts', in Dusun Simbar the local disaster knowledge discussed above is widely shared, and I found it to be incorporated into the daily practice of nearly all residents. While elderly residents can certainly explain historic eruptions and subsequent migration processes in greater detail, these stories have been shared with newer generations and are now locally held as common knowledge.

Second construct: Eruptions as beyond worldly control

Co-existing alongside the scientific and observation based interpretations of the Timbang Crater Complex described above, residents of Dusun Simbar also view their ultimate safety as resting in the hands of a higher power. This knowledge was discussed and recorded during many conversations held with farmers as we asked how and why they continue potato farming despite the known risks. The forthcoming section will focus on this knowledge and the behaviour it leads to, drawing on conversations from the field around the concepts of '*pasrah*' and '*takdir*' (meaning 'submit to one's fate' and 'fate' respectively, Echols and Shadily, 2014). While a study of local belief systems is beyond the scope of this thesis, an understanding of disaster knowledge from the perspective of 'at risk' communities cannot be adequately developed if the worldviews influencing knowledge constructs are ignored (Chester, 2005; Chester et al, 2008), an assertion particularly true in the Dieng Plateau, which is a Muslim majority community.

During conversations in the field, informants frequently used the terms *pasrah* and *takdir* to describe how they live without fear in potentially hazardous environments. Both terms have their routes in Islamic teaching with *pasrah* meaning to surrender to God's will, while *takdir* means to meet

one's fate or destiny (Prawitasari-Hadiyono et al., 2010; Zaumseil and Prawitasari-Hadiyono, 2015). After adhering to the volcanic risk mitigation measures discussed in the previous section, informants frequently quoted that if they are to die, it is their *takdir* (fate) ordained by God. As the success of the measures they take to avoid disaster are seen to ultimately depend on God's will, it is wisest to *pasrah* (submit). This concept was explained particularly clearly by one informant:

> People here understand that disasters occur at the hand of God. So we have already surrendered to it (*pasrah*). We don't know for sure when disasters will occur, they can happen anywhere, not just here (Interview 49, male farmer aged 40, Kepakisan, 30/10/15).

I posit that these Islamic concepts of *pasrah* and *takdir* allow farmers to both make meaning from, and live with, the uncertainty posed by volcanic hazards in Dusun Simbar. Drawing on fieldwork conducted following the 2006 Bantul earthquake in Central Java, Zaumseil and Prawitasari-Hadiyono (2015) likewise demonstrate that adhering to the concept of *pasrah* provides psychological preparation and resiliency to face future disaster events[44]. In Dusun Simbar, by transferring ultimate responsibility from the individual to the divine, the concepts of *pasrah* and *takdir* provide farmers with the psychological resiliency to enter fields in close proximity to the crater and to return to their livelihoods soon after a large gas event. Various other authors have studied how belief systems have been shown to build disaster resiliency by helping to create social cohesion, overcome anxiety, promote psychological recovery and by acting as a conduit for disaster education (Cashman and Cronin, 2008; Chester et al., 2012; Gaillard and Texier, 2010; Kwilecki, 2004; Mitchell, 2003; Prawitasari-Hadiyono et al., 2010; Schmuck, 2000; Taylor, 2001; von Vacano and Schwarz, 2014; Wisner, 2010). As articulated by the IFRC these beliefs 'enable people to live with risks and make sense of their lives in dangerous places' (IFRC, 2014, p. 8).

[44] The references to *pasrah* and *takdir* that I cite here were obtained after I finished my fieldwork and had begun writing this section of my thesis.

The concepts of *pasrah* and *takdir* do not, however, supersede knowledge of disaster prevention or lead to indifferent or hostile attitudes towards such programs. While fatalism is often used to describe the impact religion has on risk-taking behaviour, Dekens (2007) and Schmuck (2000) have argued that this perceived fatalism does not equal passive resignation. In studies of flood prone areas in Nepal's Himalayan region and the chars of Bangladesh, both authors found that while the cause of events is attributed to God, people do all they can to prepare for, and resist, flood impacts. Dekens (2007) argues that this acceptance of floods does not suggest apathy and similar conclusions are drawn for the Dieng Plateau. One can *pasrah* or submit to God's will whilst still participating in evacuation or precautionary practices such as avoiding the fields in overcast conditions, during the evening or early morning[45]. The risks that can be managed locally are done so, while those beyond human control are transferred to a higher power. *Takdir* is not passive acceptance but, as Geertz (1960) describes, is applied 'only to those occurrences clearly outside any possibility of human control' (p. 151). One resident explained how he surrenders to God's will whilst also experiencing fear and evacuating in the event of a disaster:

> No, I am not afraid because everything is arranged by God. If one day a disaster suddenly occurs and I am able to save myself, then I'll be saved. But, if I cannot save myself that means it's my destiny (*takdir*) to die. Every day I just feel normal, I just surender to God (*pasrah*). But when the gas is released then I'm afraid and I will evacuate (Interview 24, male farmer aged 67, Dusun Simbar, 09/11/15).

While some studies describe how Islamic societies in the Middle East and Indonesia have framed disasters in terms of retribution for religious immorality (Akasoy, 2007; Dove, 2010; Alshehri et al., 2013), local disaster knowledge in Dusun Simbar does not widely recognise disasters as a form of punishment from God. The gas eruptions from the Timbang Crater Complex

[45] Those informants who did admit to entering the fields during dangerous conditions linked their risk taking behaviour to economic necessity rather than the concepts of *pasrah* or *takdir*.

are largely understood as a natural event rather than as a God sent punishment. In fact no informants in Dusun Simbar attributed volcanic eruptions as a consequence of communal wrongdoings. This contrasts to the nearby village of Kepakisan where a few informants made claims that the 1955 Legetang landslide and 1949 eruption of Sileri Crater were sent as retribution for the impacted villagers' lack of adherence to Islam. This included cohabitation before marriage, gambling and missing prayers. Importantly, this blame was levelled towards the actions undertaken in another village rather than one's own. This hesitancy to blame one's own community for the occurrence of a disaster has been observed elsewhere in Indonesia. Adeney-Risakotta (2009) and von Vacano and Schwarz (2014) found that victims of the 2004 tsunami in Aceh and 2006 earthquake in Bantul, respectively, did not attribute the disasters to people's sins as doing so would ascribe guilt to their lost loved ones. Furthermore, Ghafory-Ashtiany (2009) asserts that Islamic religious texts never mention earthquakes or disasters in the context of God's wrath and this may also explain the local reluctance to make such claims.

In summary, local disaster knowledge views the impact of volcanic eruptions as the work of God, though not necessarily brought about as punishment. I argue that this knowledge leads people to accept and submit to their fate and has been constructed from the realisation that there are limits to what can be done to prevent the impact of eruptions. This finding concurs with Bankoff (2015) and Bankoff and Hilhorst's (2009) work in the Philippines, which argues that the idea of secure and stable life devoid of natural hazards is a myth. Of importance, however, is that this knowledge does not actively encourage the disregarding of official warnings or local mitigation measures. Rather, it is an accompaniment to disaster preparedness, providing the emotional resiliency that allows farmers to continue with their livelihood activities despite the inherent hazardousness of doing so.

A hybrid understanding of volcanic disasters

The discussion above argues that local interpretations of, and responses to, volcanic disasters reflect the amalgamation of knowledge derived through livelihood realities, science, daily observation, oral tradition, and worldview (Table 9). These knowledge sources inform local views of the Timbang Crater Complex as both manageable on a daily basis but also as ultimately beyond human control. Religious belief minimises fear and allows farmers to make meaning from the gas events, while local wisdom and an understanding of geophysical processes allows farmers to prepare for, and take appropriate action during an eruption. This hybridised local knowledge is a rational system and prerequisite for successful and resilient farming in the Dieng Plateau.

Table 9. Local volcanic disaster knowledge constructs Dusun Simbar alongside some of the contributing factors and subsequent risk reduction practices they inform.

Knowledge construct	**Contributing factors**	**Local practices drawing on knowledge**
Volcanic disasters can be mitigated through observation and preparedness.	▪ Scientific information. ▪ Local wisdom/common sense. ▪ Oral histories of past events. ▪ Livelihood needs and priorities.	▪ Staying away from the fields during overcast conditions or during the evening/early hours of the morning. ▪ Evacuating if there is an earthquake. ▪ Avoiding the road and depressions/fields located downhill of the main crater. ▪ Evacuating towards to the west.
Volcanic disasters are beyond the realm of human control.	▪ Religious interpretation, *pasrah* and *takdir*. ▪ Livelihood needs and priorities.	▪ Emotional resiliency to continue living and farming near active craters.

Berkes et al. (2000), Nygren (1999) and Shannon et al. (2011) all argue that plural or hybridised knowledge contradicts dominant views that local and scientific wisdom contradict one another, an assumption that is particularly evident in the DRR knowledge field. As Schwarz (2014) argues: 'The accepted international framework of risk management assumes an opposition between an objective explainable environment and a biased subjectivity' (p. 303). The Dusun Simbar example, however, presents a counter example wherein objective scientific explanations co-exist alongside subjective (yet educated and informed) decisions to take risks near an active crater. Similar findings have been observed elsewhere in Indonesia, reflected in studies on local interpretations of tsunami and earthquake hazard in Bengkulu, Sumatra (Shannon et al., 2011), and the 2006 Bantul earthquake (Schlehe, 2010). Furthermore, as Rigg et al.'s (2005) study of scientific and local Thai explanations following the 2004 Indian Ocean Tsunami testifies, these plural interpretations are not mutually exclusive but rather form 'part of a continuum of explanation' (p. 377).

During my experience conducting interviews in Dusun Simbar and entering the land in close proximity to the main Timbang Crater, I came to respect and understand the practicality of this hybrid local disaster knowledge system. I admit that my first visit to the Timbang Crater Complex was a little daunting. Rather than the clear barricades and warnings we would expect for a less extreme hazard in Australia, the main crater can be approached directly. On one visit, I carried my one-year old daughter on my back and consequently this visit was very short. Yet my perception of the risk lessened when I was in the company of other local farmers who knew the crater well. Moreover, if the sun was shining, we stayed topographically higher than the crater, and observed that the gas was steadily rising, I felt reasonably safe. Just as the local farmers use this local knowledge to justify continued access to their livelihood activities, I relied on it to justify my access to land that I knew was hazardous to conduct interviews. The contrast is, however, that I knew my visits were short lived and ultimately non-compulsory.

The discussion above concludes that residents of Dusun Simbar possess a clear understanding of the risks associated with farming land near the Timbang Crater Complex. However, those farmers who are most in need of securing and maintaining their livelihood take the greater risks. This local knowledge system reflects livelihood priorities, and draws on local wisdom, oral history, scientific information and religious belief. Local and scientific wisdom mitigate the risk, while belief in *pasrah* and *takdir,* which transfers ultimate responsibility from the individual to the divine, allows farmers to continue farming hazardous land without fear. The local disaster knowledge presented above is thereby a plural or hybridised system, with expert and local definitions of risk co-existing rather than contradicting one another. Overall, the risk of volcanic eruption is not seen as the most pressing concern for the community and residents feel they have adequate systems in place to manage it on a daily basis. While various studies and authors have already noted that DRR is not a main priority for many communities (Cannon, 2015; IFRC, 2014), this realisation is still overlooked in many state implemented disaster programs. The forthcoming section will thereby describe state perspectives on disaster knowledge, focusing specifically on the Banjarnegara branch of the BPBD and the PVMBG.

7.2. Expert disaster knowledge: Local governance and scientific perspectives

While an increasing volume of studies have described local disaster knowledge, there is still a scarcity of work that critically discusses the factors influencing state perspectives on DRR, especially within Indonesia (for some examples from the Philippines and Montserrat see Bankoff and Hilhorst, 2009; Donovan, 2017; Donovan and Oppenheimer, 2015; Donovan et al., 2012a; 2012d). The discussion below addresses this gap and responds to the second component of my final research question, by describing how expert disaster knowledge and practice is also a product of, and embedded within, the institutional environments and disciplinary backgrounds of certain government agencies. Specifically, I look at the type of bureaucratic and

scientific knowledge that exists within two of Indonesia's government organisations primarily involved in disaster management, the BPBD and the PVMBG. While BPBD are mandated with the task of preparing communities for, and responding to, disasters, PVMBG are responsible for monitoring Dieng's craters and issuing the relevant warnings.

The forthcoming section draws on interviews, direct field observations and a broad range of primary and secondary literature to describe this expert disaster knowledge and the DRR approaches it informs in the Dieng Plateau. I begin by describing how technocratic styles of governance (Li, 2007, 2011b) and decentralisation (Djalante et al., 2012; Grady et al., 2016; Hening, 2014; Williams, 2011) influence the construction of disaster knowledge, and sometimes hinder the success of DRR programs. These processes are particularly evident in the knowledge and programs favoured by the BPBD. I will then discuss the role of the PVMBG in producing and disseminating knowledge of volcanic hazard zones. This discussion relates to the critical approach of Jasanoff (1987), and describes the limitations and orthodoxies of scientific methodologies, such as risk assessments and hazard mapping. I then argue that while the interaction between hazard science and policy is weak in the Dieng example, local disaster knowledge is positively informed by the work of hazard scientists. Overall, the discussion highlights the contextualised nature of expert disaster knowledge and the pathways through which it informs, or is informed by, local knowledge.

7.2.1. *Badan Penanggulangan Bencana Daerah (BPBD):* The Regional Agency for Disaster Management

Before I describe the type of disaster knowledge and DRR practices favoured by BPBD, I will provide a brief background to the establishment of these district level agencies and their national and provincial level counterparts. The decision to install BPBDs at the district level and provincial level, alongside BNPB at the national level can be linked to the fallout of the 2004 Indian Ocean tsunami. Following the catastrophic impact of this tsunami in Aceh, and the subsequent endorsement of the UNISDR's 2005 Hyogo

Framework for Action, Indonesia came under increased pressure to more effectively manage and respond to disasters (Djalante et al., 2017). In 2007 the Disaster Management Law (*UU 24/2007 Penanggulangan Bencana*) was passed, recognising the state's responsibility in disaster prevention and emergency management. A major feature of this law is a focus on providing proactive rather than reactive approaches to disaster management (for an example of reactive disaster management see the relocation of Dusun Simbar in 1979 as discussed in Chapter 5). The formation of the national coordinating body, BNPB, alongside the BPBD to oversee local DRR programs, was in response to this need.

The creation of BPBDs at the district government level is also an outcome of Indonesia's decentralisation policy, which aims for local, rather than central government led protection of citizens (Hening, 2014). While the establishment of a BPBD at every district government is not strictly mandatory, the uptake of these agencies has increased rapidly in recent years. BNPB statistics reported that only 22 out of 497 districts nation-wide had a BPBD in 2010; however, this figure rose to 144 districts in 2011, and later to 399 districts in 2014 (Hening, 2014; Djalante et al., 2012). District level BPBDs draw their revenue primarily from the district budget (*Dana Alokasi Umun*) allocated by the central government; however, they sometimes receive extra funds from private donors or the provincial BPBD and national level BNPB to implement special programs (*Dana Alokasi Khusus*). While the BPBD are mandated to conduct both disaster preparedness and response activities, below I will argue that the majority of the activities undertaken by BPBD Banjarnegara are oriented towards the more technocratic tasks associated with emergency response. While good emergency response is undeniably crucial to saving lives, focusing on this aspect alone does not reflect the international emphasis on reducing underlying conditions of vulnerability (see Djalante and Thomalla, 2012) nor does it align with the emphasis on disaster prevention outlined in Law 24/2007. Furthermore, it overlaps with the activities conducted by the National Search and Rescue Agency (*Basarnas*), as I will discuss below.

Technocratic knowledge and governance: Training and emergency response

Training, and the *sosialisasi*[46] of disaster knowledge to local communities, is a core mandate of BPBD activities. During my period of research in Banjarnegara I attended various training events held by the BPBD. On arriving at these events I was immediately greeted by a bright orange, BNPB gifted and heavily branded, utility truck parked strategically in front of the entrance to the venue. BPBD staff would arrive early, wearing search and rescue uniforms consisting of orange pants and shirts, black boots laced to below the knee, and radios attached to their left shoulder. Members of the military (*Tentara Nasional Indonesia, TNI*), dressed in operational uniforms, were also found wandering around the venue before the workshop began. If the training was for the *Linmas* (village appointed community police) they would arrive dressed in their official khaki *Linmas* uniforms. Otherwise, the participants arrived in everyday clothing. When the participants had arrived in sufficient numbers, often dribbling in by 9.30 - 10 am despite an official start time of 8 am, the official proceedings began. I was always kindly welcomed, and as a "foreign DRR researcher" I appeared to contribute to the official tone of the workshop. For example, I was often asked to formally introduce myself to the participants and was given a place at the front of the room with other official government representatives.

The workshops opened on a very official note, sometimes with a welcome address from a senior government official or in one instance, the *Bupati* (Regent of the Banjarnegara district). Participants stood for Indonesia's national anthem followed by BNPB's anthems. With the official opening concluded, the morning would proceed with presentations from BPBD staff that outlined their organisational structure and the meaning of disaster preparedness and community resilience. Following prayers and *nasi kotak* (lunch boxes), the afternoon's activities would then proceed. During these afternoons, BPBD staff typically demonstrated a variety of skills including

[46]*Sosialisasi* is an Indonesian adaptation of the word 'socialisation'. In the context in which the Indonesian government or NGO's most commonly apply it, it refers to community outreach programs that aim to educate people about disasters or general development related issues.

how to operate radio systems, evacuate and bandage injured victims and build makeshift shelters. Participants practiced these skills, often in the context of a disaster scenario, and this generally proceeded with a degree of disorganisation from the BPBD and confusion on behalf of the participants. Finally, a radio system would be gifted to each village to be activated only in the event of an emergency. The workshops generally concluded with far less formality than the opening, many of the participants having already slipped quietly away.

While these district government training sessions are supposedly 'participatory', in practice there are many processes influencing who is involved and why. Attendees are usually selected by the village leader and always paid *'uang saku'* (pocket money) by the BPBD to attend. Participants are normally a part of, or a member of an organisation falling under, the village council apparatus. While joining a village level organisation may occur out of enthusiasm or what was described in the field as a '*sifat sosial*' (social consciousness), members also gain better access to financial institutions, land resources and political representation within the village and generally comprise the 'village elite' (Sutiyo and Nurdin, 2015). As a result, participation in training sessions is mandatory and the same group of people will attend most of the training offered by different government authorities. As one *Linmas* member stated during a BPBD disaster preparedness event, he felt the training was simply a '*buang waktu'* (a waste of time) (Interview 82, *Linmas* representative, 02/12/15), but as a member of the *Linmas* he had no choice other than to attend.

The technocratic approach undertaken by the BPBD in conducting these training sessions bears resemblance to Li's (2007; 2011b) analysis of The World Bank funded development projects in Indonesia. Li (2007) argues that in order for a community to be governed it is first rendered technical, legible and calculable. The disaster training sessions conducted in villages throughout Banjarnegara likewise follow this prescribed formula. In order to minimise the risk of volcanic eruption, the problem is rendered a technical one to be mitigated through the provision of expert disaster knowledge and

programs. As Li (2011b) notes, these development programs are controlled by their institutional requirements to 'render problems such as poverty and violence technical and manageable and act on them by means of expert prescription' (p. 117). BPBD's emphasis on developing 'disaster management teams' also resembles Li's (2007; 2011b) analysis on the role of formalising 'groups' within a community for the overall obtainment of development outcomes. As these formalised groups can be funded, counted and evaluated (Li, 2007; 2011b), they serve to legitimise both the activities and very existence of the BPBD. Yet, as I discuss below this technocratic approach often leaves vulnerability reduction unattended.

In addition to training others, BPBD spend a large portion of their time and budget training their own staff and their team of volunteers. This training generally focuses on increasing their internal capacity and technical skills to respond in the event of an emergency. They frequently conduct simulations where they rescue victims from rivers, construct mess hall tents, put out fires and test their emergency communication systems. The head of operations in Banjarnegara BPBD referred to his staff as '*sangat profesional*' (extremely professional) in the practice of search and rescue, and this was clearly a source of great pride for the organisation (Interview 76, BPBD official, Banjarnegara, 14/12/15).

The construction and practice of disaster knowledge within BPBD also mirrors the unfolding of recent disaster events. Following the eruptions of the main Timbang Crater in 2011 and 2013, BNPB and BPBD jointly managed the construction of a large observation tower to monitor crater activity. However, this tower, while official in appearance, does not seem to provide the community with much use, other than as quoted by one informant 'a place for children and chickens to play' (Interview 31, female farmer aged 60, Dusun Simbar, 04/12/15). Similarly, following the landslide in Jemblung in December 2014 (a village located 20 km from Dusun Simbar), renewed efforts were focused towards reducing landslide hazard throughout the district of Banjarnegara. This saw an increase in the construction of retaining walls, the relocation of villages, installation of landslide early warning

systems and investment in detailed landslide hazard maps financed by the BPBD. While these events have spurred the BPBD to necessary and important action, they also appear to encourage the formulation of technocratic and engineered solutions to the hazard in question. In this regard, BPBD's activities can be viewed as reactionary rather than in line with the precautionary approach current disaster scholarship argues for (Djalante et al., 2012; Thomalla et al., 2006; Wisner et al., 2004).

I argue that the technical focus of BPBD's training sessions contributes to an assumption that disaster losses can only be mitigated through the competent provision and use of technical equipment, and training programs supported by the BPBD. While it is expected that the information gained during training will be later shared with other village residents, lack of direct involvement from all villagers widens the gulf between the BPBD and the villages in which they work. Furthermore, the participants do not reflect the entire village community; in fact attendees are always a part of the village elite – including village officials, RT leaders (*Rukun Tetangga* or Neighbourhood Association) or Family Empowerment and Welfare Movement members (*Pembinaan Kesejahteraan Keluarga,* PKK). Attending these training sessions labels the attendees as more capable than other village members. I was often told during interviews in Dusun Simbar that if I wanted to learn more about the Timbang Crater Complex and disaster management that I should speak to certain members of the village elite who had attended such trainings. When I did speak to these individuals it quickly became clear that their knowledge did not exceed other village members, and that they viewed their position within the so-called 'village disaster management team' adjourned during the periods of time the Timbang Crater Complex is deemed safe.

Without disagreeing entirely with the use of training sessions and technical equipment to manage hazards in volcanic areas, I caution that a heavy focus on technocratic solutions alone leaves less space for the development of programs aimed at vulnerability reduction. However, technocratic approaches to disaster management do enable certain important developments such as the search and rescue (SAR) operations (see Poteyeva

et al., 2006) that the BPBD and their team of volunteers both simulate prior to, and run in the event of, an emergency. While some critics argue that their capacity in this respect is still significantly lacking (Interview 81, Head of IFRC Banjarnegara, 21/12/15), and an overlap of roles with *Basarnas* exists, focusing on these skills is nonetheless important in areas like Banjarnegara where timely responses to landslides, floods and volcanic eruptions are required. However, the BPBD's technocratic style of governance falls short in combating the underlying conditions of vulnerability that Djalante et al. (2012) argue are increasing the impact of disasters throughout Indonesia. Furthermore, I posit that it overlooks Indonesia's commitment to vulnerability reduction as outlined in Disaster Management Law 24/2007.

The historic background to the BPBD and the process of its staff selection has contributed to the technocratic knowledge favoured by the organisation. Firstly, it needs to be acknowledged that the BPBD are a very young organisation. Established in 2008, with Banjarnegara's office opened in 2011, it should be no surprise that they are still establishing best practices to reduce vulnerabilities and respond to disasters. The organisational culture is also influenced by BPBD's umbrella organisation, BNPB who have inherited many ex-military personnel. The former head of BNPB (Syamsul Maarif) was a military general (TNI) and the recent head (Willem Rampangilei) was a navy officer (TNI-AL). Senior management within the Banjarnegara branch also believe they were transferred to the department (selected by the District Regent or *Bupati*) because of their experience in the *Kecamatan* (subdistrict government office) where they received training with the *Linmas* and TNI. They were also members of the Student Regiment (*Resimen Mahasiswa*) during their university studies where they were again trained by the military. Furthermore, BPBD merged with the former District Unit for Disaster Response Coordination (*Satlak*) whose specific mandate was emergency disaster response. This historical background means they have inherited a reactionary and hierarchical, command and control culture.

The discussion above argues that the knowledge that underpins BPBD's activities is technical and hierarchical, viewing disaster mitigation as an

expert's domain. This focus on technocratic governance is an outcome of their historic process of formulation, staff selection and subsequent capacity strengths and limitations. While a focus on technocratic DRR governance may not lead to the integrated and holistic management of disaster risk (Cardona, 2004), it nonetheless enables some aspects of disaster management. As will be discussed below, community-based DRR is an approach that seeks to step away from technocratic approaches to combat vulnerabilities within a community.

'Community-based' DRR wisdom

Global DRR efforts are increasingly rooted in community-based approaches (Maskrey, 1989; Twigg, 1999; Wisner et al., 2004). Shaw (2012) argues that community-based DRR (CBDRR) can 'enable people to express their real needs and priorities, allowing problems to be defined correctly and responsive measures to be designed and implemented' (p. 4). While this CBDRR wisdom is spoken of, and partly reflected in the work of the Banjarnegara BPBD, the majority of BPBD's community training, or '*sosialisasi*', still relies on transmitting technical knowledge to participants who are obliged rather than volunteer to attend. This section will focus on the obstacles that restrict the BPBD's ability to translate this CBDRR knowledge into meaningful actions at the local level. These obstacles include the institutional and budgetary incentives and constraints the BPBD operate within, and the immense scale of the work that is required to conduct CBDRR well.

Publications produced by international development organisations provide a vocal and influential voice within the global DRR community. In the Indonesian context this is most clearly demonstrated in BNPB's regulation (*Peraturan 2012/No 1*) pertaining to 'Disaster Resilient Villages' (*Desa/Keluruhan Tangguh Bencana*), which closely follows the wording of the International Federation of Red Cross/Crescent's capacity and vulnerability toolbox (IFRC, 2007). It calls for the building of villages that have the 'ability to manage threats in their area and are able to coordinate community

resources to reduce losses while increasing capacity to reduce disaster risk' (BAB IIA, p. 16). This regulation has overseen the establishment of the '*Desa Tangguh*' program in Banjarnegara and throughout various other districts in Indonesia. The 'resilient villages' rhetoric stemming from this program was reflected during many conversations with BPBD Banjarnegara staff. I was often told that the community are the ones who understand the nature of certain hazards the best and that they are the ones who should take ownership over their own CBDRR activities (Interview 77, BPBD officials, Banjarnegara, 30/10/15 and continued on 14/12/15).

The Banjarnegara BPBD often deliver the *Desa Tangguh* training sessions in collaboration with the Indonesian Red Cross (*Palang Merah Indonesia*) and from the year 2015 until mid-2017 they had conducted a total of 17 training sessions with villages across Banjarnegara. The activities are split across the two organisations, with the Red Cross facilitators applying a more hands on participatory approach, running sketch mapping, seasonal calendars and risk ranking exercises. As with the preparedness training sessions discussed above, the participants of these workshops include village officials and RT leaders. However, they are also more likely to include representatives from the PKK in an attempt to boost female participation. While the *Desa Tangguh* program supports the aims of Law 24/2004 to address underlying vulnerabilities rather than focus on technocratic solutions, I argue that there are some problems with its implementation and follow-up locally.

One of the core principles of the *Desa Tangguh* program relies on the implementation of a local disaster management team. This team is to identify hazards within the community, lead mitigation measures and act as the first line of response in the event of an emergency. The activities conducted by this team are ideally self-initiated and should draw on resources already available within the village. However, once the training sessions have been completed little to no follow up is conducted between BPBD and these teams. When we asked about these teams in villages that had already received training (such as Dusun Simbar), I was generally told that the team was '*tidak aktif*' (inactive) outside the period of time during which an eruption takes

place. Even if follow-up was to occur and local disaster mitigation needs were identified, BPBD's budgetary constraints significantly limit the extent of activities that can be implemented. Furthermore, as already discussed in the previous chapters, DRR is not generally a priority for villagers, meaning that village resources are unlikely to be directed towards such projects.

The CBDRR rhetoric used by the BPBD does not always translate into community identified DRR programs. One of the clearest examples of this is BPBD's relocation of Duren village, an isolated settlement set amongst sengon[47] forest 20 km south of the town of Banjarnegara, or 60 km south west of the Dieng Plateau. It was once located below a very steep slope with a substantial landslide risk. In 2015, using funds from the National Bank of Indonesia (BNI), BPBD 'relocated' the village to the top of a nearby hill, built new townhouse style homes and a large retaining wall to stabilise the slope. However, the newly built homes are hot, exposed to wind and sun, and do not contain the adjoining barns that residents rely on for livestock rearing. As animal husbandry is an important livelihood activity for this village, residents have simply decided to occupy both their old and new abodes, rearing livestock in their former homes whilst still partially living in the new. This relocation, which was conducted without in-depth collaboration with the community involved, has therefore done little to reduce landslide risk as residents are still frequenting the hazardous zone. The literature is full of examples like this, where locals have not been involved in the decision-making process and relocation sites subsequently do not provide adequate livelihood provisions (Donovan, 2010; Donovan et al., 2012a; Mei and Lavigne, 2012; Seitz, 1998; Spiekermann et al., 2015; Usamah and Haynes, 2012).

Similarly, despite participants of the participatory workshop held in Dusun Simbar defining strong winds as a key threat (Table 6), the BPBD have not yet worked with local farmers in an attempt to mitigate this issue. So while the processes that impinge most significantly on livelihood outcomes, such as

[47] Sengon (*Paraserianthes falcataria*) is a fast growing tree found in local small-scale timber plantations throughout Java.

strong winds, are perceived locally as greater threats, these do not typically form the basis of state intervention. Instead the state is more likely to focus on the more sporadic, yet extreme hazards such as poisonous gas. This tendency for the state to focus on extreme events, rather than those associated with everyday life has also been observed in the management of risk on the slopes of Mount Merapi (Dove and Hudayana, 2008; Dove, 2010).

The difficulty of implementing global CBDRR wisdom in Banjarnegara is also restricted by the budgetary arrangements in which the BPBD operate. In post reformation Indonesia, all government spending needs to be clearly defined and accounted for at the beginning and end of each year. This process and the inflexibility of the resulting budget, whilst improving accountability, also limits community involvement. The provision of training sessions, or '*sosialisasi*', provides a quantifiable outcome to measure BPBD's impact and secure future budget from the Regional Revenue and Expenditure Budgetary Body (*Anggaran Pendapatan dan Belanja Daerah, APBD*). Yet there is no flexibility in this budget to respond to unforseen community defined programs. While the BPBD may secure additional funds directly from BNPB, through civil society organisations, or other government departments requesting specialised training, these programs generally follow the requests of the funding organisation and are therefore also not community driven.

I argue that despite the presence of the CBDRR policy narrative, much of the Banjarnegara BPBD's activities are still emergency response driven. This finding is not surprising and is in line with Li's analysis of the technocratic modes of governance that seek to measure and quantify local processes to achieve program success indicators (Li, 2007; 2011b). Unlike CBDRR, emergency response provides an avenue for activities that are easy to run, define and measure impact. Furthermore, they build on the existing skills and capabilities of BPBD's employees and fit within budgetary requirements. Building a disaster resilient community on the other hand is subjective, requires flexibility, and is difficult to measure impact and audit. These findings support Manyena et al. (2013) who also argue that despite the prevalence of community-based narratives in global DRR frameworks, few

countries have actually moved beyond this rhetoric to address local vulnerabilities. However, BPBD's focus on technocratic governance is also a causality of Indonesia's decentralisation program. While handing greater resources and autonomy to district government bodies, decentralisation has also contributed to the funding and capacity limitations that hinder the effectiveness of the BPBD, as discussed below.

Influence of decentralisation

Decentralisation forms the institutional backdrop to the way knowledge has been created, and the type of activities it continues to inform, within the Banjarnegara BPBD. Indonesia began its important task of decentralising government in 1999 after decades of autocratic and centralised rule. The 1999 Decentralisation Laws (*UU 22/1999* and *UU 25/1999*) transferred all sectors of governance, except those considered strategic, to the authority of the regions (Resosudarmo, 2004). While decentralisation of DRR governance has the potential to create strong public accountability and align the interests of people and their governors (Williams, 2011), in Indonesia it is often constrained by local capacity limitations, funding and a lack of accountability (Anantasari et al., 2017; Das and Luthfi, 2017; Scott and Tarazona, 2011). Below I will argue that these shortcomings of decentralisation have also contributed to the technocratic and emergency response style of disaster knowledge favoured by the Banjarnegara BPBD.

Limited internal capacity and budgetary constraints are identified as key factors inhibiting BPBD's effectiveness (Djalante et al., 2012; Grady et al., 2016; Hening, 2014), a finding also validated during my period of fieldwork with BPBD Banjarnegara officers. While decentralisation places authority in the hands of the districts, finding people with the skills to effectively manage this authority at the district level is difficult. This situation is evident for the BPBD, whose newness, budget limitations and lack of political status make it a less desirable government position, deterring the most capable applicants (Grady et al., 2016). In particular, the infancy of the organisation means senior directors are inexperienced, having only been in the job for a

maximum of eight years, with most of the branches younger than that again. The lack of a long-term and established credibility on behalf of the BPBD also means that district governments are hesitant to hand over needed funds (Grady et al, 2016; Hening, 2014). This situation is further exacerbated by BPBD's status as a non-essential and non-priority agency. Darwanto (2012) reported that in 2012 Indonesia used 0.69 per cent of its budget for DRR activities. To place this number in some context, Japan regularly spends to up to 5 per cent of its annual budget on DRR related activities (Kellet and Sparks, 2012). Various authors argue that within Indonesia greater spending on DRR, particularly at the local level, is still required (Djalante et al. 2012; Grady et al. 2016; Hening 2014).

An additional limitation associated with decentralisation involves lack of clarity and delineation of government roles at the district level. In Banjarnegara, this regional autonomy has contributed to a situation where both the BPBD and *Basaranas* provide emergency response operations. *Basarnas* is a national agency with Banjarnegara's closest headquarters situated on the northern coast of Semarang. While geographical distance makes a partial case for the BPBD to manage their own emergency response unit, the arrangement nonetheless reflects overlap in government functions. As Hadiz (2004) argues, this overlap is the result of how the implementation of decentralisation causes 'confusion about the distribution of power and authority between different levels of government' (p. 705). Furthermore, and while purely speculative, it is plausible that a clearer delineation of roles between *Basarnas* and the BPBD could release the additional funds and resources needed to better implement CBDRR projects aimed at vulnerability reduction.

While decentralisation facilitated the establishment of district level BPBDs, the interplay of institutional competition within the context of decentralisation has hindered the effectiveness of DRR outcomes. This is particularly true of CBDRR, which requires long-term commitment and the implementation of flexible programs that can adapt to changing circumstances (Maskrey, 1989; Mercer et al., 2008; Schipper and Pelling,

2006; Twigg, 2004). Due to these limitations, the focus of the organisation, as observed in the Banjarnegara office, is directed towards technical training in emergency response and evacuation. Addressing underlying conditions of vulnerability through CBDRR would require more budget, closer collaboration with other departments and the authority to implement broader development programs. This is unlikely, as the BPBD do not contain the staff capacity or political standing to argue for such programs.

To summarise, in the discussion above I have argued that BPBD Banjarnegara's disaster knowledge and practice system is based around a technocratic understanding of volcanic hazard. This knowledge is facilitated through the institutional context in which the BPBD operate and the subsequent funding and capacity limitations that hinder the BPBD from tackling deeper issues of vulnerability. This technocratic style of governance (if done well) does, however, facilitate emergency response, which is a crucial aspect to saving lives during a disaster event. Yet the BPBD are not the only government body taking a technocratic view of volcanic risk in the Dieng Plateau. The following section will now focus on another largely scientifically focused agency involved in volcanic hazard management in the Dieng Plateau, the Centre for Volcanology and Geological Hazard Mitigation.

7.2.2. *Pusat Vulkanologi dan Mitigasi Bencana Geologi* (PVMBG): The Centre for Volcanology and Geological Hazard Mitigation

The production of PVMBG's disaster knowledge falls under two arms: monitoring and issuing volcanic warnings and producing up-to-date hazard maps for all of Indonesia's active volcanoes. The Dieng Volcanic Observatory (*Pos Pengamatan Dieng*) located in Karang Tengah monitors activity within the Dieng Plateau as well as activity on the nearby Mount Slamet, to the west, and Mount Sumbing and Sindoro to the east. PVMBG's hazard maps are, however, produced by scientists situated in their central office in Bandung, West Java. While the scientific knowledge they create and disseminate is readily incorporated into local interpretations of volcanic hazard, like all risk

assessments it contains uncertainties and biases that complicate its seamless integration into local policy decisions, as will be discussed below.

Volcanic hazard mapping

The production of volcanic hazard maps is a key component to PVMBG's work towards volcanic risk reduction. As probabilistic volcanic hazard assessment is still in its infancy (Zoback et al., 2013), the production of volcanic hazard maps in Indonesia relies on the identification of past volcanic deposits (i.e. lava, ash fall, pyroclastic flow) combined with geomorphic features such as river depressions that can amplify hazards (i.e. a lahar) (Interview 86, senior volcanologist, PVMBG, Bandung, 16/09/15). As no strictly standard methodology can apply, the resulting map is an interpretation of the hazard based on a combination of the authors' professional opinion and the geological data available (see also Donovan and Oppenheimer, 2014; Donovan and Oppenheimer, 2015). In comparison to other hazard types, mapping volcanic hazard is also complicated by the fact that volcanic eruptions may expose a population to a range of different hazard types and intensities, resulting for example in a town being both at high risk of ash fall but low risk of pyroclastic flow (Haynes et al., 2007). Putting these uncertainties aside, hazard maps are still viewed by geological and meteorological organisations as a crucial tool used to protect the safety of the community. As quoted by an official of the Dieng Volcanic Observatory:

> Actually we protect the community using maps. The red area is the area where activities are not allowed. The map serves as a reference for the community, when there is an eruption it reminds them of the areas they must avoid, that is the areas at risk of impact from volcanic materials (Interview 80, Dieng Volcanic Observatory, Karang Tengah, 05/10/15).

Dieng's volcanic hazard map, as with all PVMBG maps, contains 3 distinct hazard zones (*kawasan rawan bencana zona 1, 2, 3*) (Kartadinata et al. 2011, see Figure 5 in Chapter 4). However, unlike other volcanoes of Indonesia, the highest hazard zone (zone 3) depicted on the Dieng map predominately

includes the area at risk of poisonous gas. This includes the spatial footprint of all active craters (Timbang, Sileri and Candradimuka) as well as the majority of Sumberejo Village. Medium hazard (zone 2) includes the area surrounding and between the craters, and low hazard (zone 1) is delineated as the downslope valleys and streams that may be used as a conduit to transport lahars or poisonous gas. PVMBG's current map was updated following the 2011 gas event to raise the hazard level surrounding the main Timbang Crater. The 2006 map by contrast, reduced the spatial extent of high hazard around the Timbang Crater Complex and placed greater emphasis on Sileri Crater.

In Dusun Simbar the expertly defined dangerous area is known locally as '*tanah merah'* (red land) marked by a boundary called the '*garis merah'* (red line). The '*tanah merah'* extends for a 1 km radius around the main Timbang Crater and is often projected over the more detailed volcanic hazard map described above (Figure 5, Chapter 4). This delineation of a single hazardous zone is better understood than the multiple hazard zones, possibly because it is an easier boundary to communicate and define. The boundary is not a physical one, yet farmers have a general idea of which fields fall within and outside of this zone. As with Montserrat however (Donovan et al. 2012c), this boundary is contested. During an eruption farmers will still enter fields within the '*tanah merah*' if they believe it safe to do so. In contrast to other areas of the globe where it is illegal to defy evacuation orders (see Bird et al., 2009; Donovan et al., 2012c), Indonesian authorities do not forcibly evacuate residents and farmers. They do, however, pressure farmers to remain away from fields by guarding the road and stationing a team of volunteers to monitor movements.

Despite the time and effort underpinning PVMBG's volcanic hazard maps, the maps are not integrated with spatial planning or policy decisions made at the district level. In 2015 a new water park was opened in close proximity to Sileri Crater (situated less than 200 m from the crater perimeter). The PVMBG firmly advocated that the park not be built in the hazard zone; however, planning permissions were still granted by the district government

and the park was built. Currently, there is no legal requirement that hazard maps are considered in local planning processes and the policy of decentralisation gives the district government greater autonomy over their decision making processes, even if this leads to the construction of infrastructure in hazardous areas.

While a thorough analysis of the accuracy of PVMBG's volcanic hazard maps is beyond the scope of this thesis, I posit that the Dieng volcanic hazard map and the knowledge it conveys are complicated by various factors. Firstly, the nature of the volcanic hazard differs to that found in other parts of Indonesia. Dieng is not a single volcano from which various hazards concentrically originate. Instead it is a series of craters, vents and lakes that periodically erupt and/or effuse poisonous gas and there is not a single zone of highest hazard. Secondly, gas eruptions do not leave a geological deposit in their path as would be expected from a lahar or pyroclastic flow. Without these deposits it is difficult to ascertain which areas may effuse gas again and at what time intervals. As gas effusions are less understood scientifically (D'Alessandro, 2006), the spatial extent of the danger they pose is more difficult to predict (Interview 86, senior volcanologist, PVMBG, Bandung, 16/09/15). As a result, the high hazard zone associated with the Timbang Crater Complex takes what can be viewed as a precautionary path and extends beyond the area that has been affected by gas in the past to encompass the majority of Sumberejo Village.

The mapping and territorialisation of hazardous zones is not an objective task and depends on the level of risk the organisation producing the map is willing to accept, alongside underlying political agendas (for example, recruiting for Indonesia's historic transmigration program, see Chapter 5). Kitchin and Dodge (2007) argue that cartography is a contextual rather than an objective science, while Harley (1989) argues that maps are influenced by the value and judgements of those who constructed them. Within the volcanic hazards knowledge literature, Donovan et al. (2012c) describe the contestation of the Montserrat hazard zones during alerts and evacuations from the period of 2006 to 2008. Here, the complexities of volcanic hazard

mapping are raised, specifically the need to draw discrete lines on a map irrespective of whether the hazard gradually or suddenly diminishes at this point, and the different margins of error carried over from input models and data sources. Donovan et al. (2012e) and Donovan and Oppenheimer (2015) also argue that individual experience and personalities within scientific organisations can influence map production. For example, Haynes et al. (2008b) describe the 'risk-averse' actions of scientists on Montserrat compared to communities who are often willing to take greater risks. This is likewise reflected in the Dusun Simbar example, where the community define the hazardous zone as the actual path taken by the gas during previous events, while the PVMBG extend this zone considerably to also incorporate the majority of Sumberejo Village (see Figure 5 in Chapter 4 versus Figure 25 in this chapter).

Jasanoff (1987) describes the complexities of drawing the boundary between science and policy. This is especially complicated in the field of risk assessment, which she argues is the point at which 'consensus among scientists is most fragile' (p. 197). To protect against harm, agencies are tasked to undertake ever more complex predictive analyses of risk (Jasanoff, 1990; 2007). As the eruption of Mount Sinabung, North Sumatra in 2011 revealed, these predictions are uncertain at best (Iguchi et al., 2011). In the Mount Sinabung case, the hazard was significantly underestimated and villagers were allowed to return to the slopes too early causing the loss of up to 16 lives (The Guardian, 2014). However, as the construction of Dieng's water park demonstrated, even in situations where more detailed hazard assessments are available, they are often still not integrated into the policy arena. Jasanoff (1987, 1990) points to the uncertainty of these assessments as the main contributor to their absence in policy decisions. This situation can worsen and lead to distrust of scientists if predictions do not eventuate, as occurred during the prolonged evacuation of Montserrat during 2002 and 2003 (Donovan et al., 2012c). The findings of the Dieng example alongside the studies of Jasanoff (1987, 1990) reveal that it is unclear how hazard assessments can be best integrated into policy decisions in Indonesia. This is

especially true when the different actors involved (developers, scientists, policy makers and farmers) all possess a different tolerance to the risks posed.

Hazard communication and warning

Alongside producing hazard maps, PVMBG is responsible for monitoring and disseminating disaster knowledge concerning volcanic activity or dangerous gas levels. These activities are undertaken primarily at the Dieng Volcanic Observatory, which operates 13 seismic stations across the plateau and two permanent gas monitoring stations installed at Timbang and Sileri Craters. This post also operates a series of portable gas monitoring units that are used to take periodic measurements at various craters and fissures (Figure 26). When volcanic activity or high gas concentrations are detected, this information is passed directly to BPBD Banjarnegara who take over emergency response activities. PVMBG also conduct their own '*sosialisasi*' exercises (with or without collaboration with BPBD), playing a substantial role in the dissemination of volcanic knowledge at the community level in doing so. This occurs through two mechanisms, the formal and informal activities of the Dieng Volcanic Observatory and the actions of the now semi-retired popular volcanologist, Pak Surono. This expert engagement with the community, particularly residents of Dusun Simbar, has led to the incorporation of scientific data into local interpretations of disaster knowledge as already discussed above.

Figure 26. Staff at the Dieng Volcanic Observatory displaying the gas masks and bottles used to monitor gas concentrations during periods of CO_2 gas effusions (source: author).

The Dieng Volcanic Observatory, situated in the village of Karang Tengah, has a well-known and respected presence across the plateau. During discussions with local farmers people spoke respectfully of the posts head scientist, and it became clear that the knowledge produced by this post is trusted and incorporated into local representations of volcanic hazard. During interviews, however, we encountered two concerns locals hold with the Dieng Volcanic Observatory. Firstly, the absence of monitoring equipment installed at the Timbang Observation Tower and, secondly, the multiple seismometers scattered throughout the plateau in need of repair. The desire of the community to have more and better-maintained equipment suggests

they respect scientific information and the operations undertaken by PVMBG. Yet, this respect is also counteracted by economic realities. While equipment is requested, in many cases the equipment installed alongside the seismometers (solar panels and the technology needed to relay recordings to the Dieng Volcanic Observatory) goes missing in the field, presumably stolen by farmers (Interview 80, Dieng Volcanic Observatory, Karang Tengah, 05/10/15). Timbang Observation Tower is also in a state of disrepair with little apparent ownership or motivation to upkeep the tower locally. This is unsurprising given the lack of community participation in the tower's construction and use.

While the Dieng Volcanic Observatory is mandated to observe and monitor the Timbang Crater Complex, during my period of fieldwork I learnt that it is sometimes the farmers who live and work in close proximity to the crater who inform the post when unusual activity occurs. In this event, farmers informally tell the village council who then pass the message on to the observation post. During my fieldwork, the staff at this post recalled that they willingly receive and respond to the observations made by local farmers. This process is made possible through the continual observations made by farmers, and their depth of knowledge acquired both through these observations and the scientific information previously shared by the PVMBG. This scientific knowledge includes explanations of the characteristics of CO_2 gas, many of which have been provided by Pak Surono.

Pak Surono, PVMBG's former head and now semi-retired popular geophysicist and volcanologist, has been an influential vessel in the dissemination of volcanic related disaster knowledge in the Dieng Plateau. During conversations with farmers it was common to hear them speak of Pak Surono, or Mbah Rono (a respectful Javanese term for grandfather followed by a shortened version of Surono). Pak Surono was once in charge of issuing PVMBG's warnings and was a frequent visitor to volcanoes in the immediate aftermath of eruptions. During these visits, information concerning volcanic behaviour was either directly or indirectly shared with the community. His name was often mentioned when residents spoke of the Timbang Crater

Complex and explanations frequently began with 'Pak Surono said...'. These conversations, conducted as if Pak Surono was indeed a close acquaintance, reflect how scientific knowledge has been usefully incorporated into local interpretations of volcanic gas.

Despite now being in semi-retirement, Pak Surono is still an active public figure. He is frequently quoted in newspapers explaining the status of active volcanoes and has a public Facebook profile where he disseminates volcanic warnings. The respect bestowed upon Pak Surono is also reflected in the title handed to him by the Yogyakarta Kraton, '*Juru Kunci Merapi*', meaning 'the gatekeeper of Merapi' (Widjaya, 2010). This occurred following the death of the traditional gatekeeper Mbah Maridjan and many of his followers in a pyroclastic flow in 2010. Pak Surono has been a positive advocate for the dissemination of volcanic disaster knowledge and I posit that the local uptake of scientific explanations found in the Dieng Plateau are in part due to his strong public presence.

While the appointment of Pak Surono, or Mbah Rono, may reflect the hybridisation of traditional Javanese with scientific knowledge, a detailed analysis of this process falls largely beyond the scope of this study. However, I will still raise some points for future consideration. Schlehe (2008) argues that 'in Java, the mandate for political authority is connected with the role of the rulers as divine mediators with the whole living universe' (p. 279). Following the 2006 Bantul earthquake she found that the event was interpreted within Yogyakarta as a warning sign to the 'modern' Sri Sultan Hamengku Buwono X, for failing to uphold his traditional role in maintaining harmony between the sea, the volcano Merapi and his Kraton[48] (Schlehe, 2010). While appointment of Pak Surono as the new '*Si Juru Kunci Merapi*' may reflect the sultan's preference for modern ways, by recognising and maintaining this traditional title, it is also likely that the appointment reflects

[48] In particular, this Sultan was criticised for overlooking the annual *labuhan* ceremony during which offerings are presented to Ratu Kidul, the Queen of the South Sea, in a bid to maintain harmony between people and nature (for a more in-depth explanation see Schlehe, 2010).

an amalgamation of Javanese cosmological and scientific explanations of natural hazards.

The discussion above has demonstrated the various avenues through which PVMBG create and disseminate volcanic related disaster knowledge. This knowledge informs both local farmers and the BPBD's interpretation of, and response to, volcanic hazards. However, it still faces some resistance at local decision-making levels as witnessed through the construction of Dieng's water park and local dismissal of evacuation orders. Part of this resistance lies in the inherent uncertainties associated with volcanic hazard assessments and the different perspectives of risk tolerance held by different actors (scientists, policy makers, developers, and local farmers). Yet, some of the expert knowledge created by the PVMBG, particularly that related to the geophysical characteristics of the crater and its gas effusions, has been incorporated into local knowledge and practice. This supports my argument presented earlier in this chapter's discussion of local disaster knowledge, that within the Dieng Plateau local and expert disaster knowledge are not binary opposites but rather inform one another.

7.3. Chapter conclusion: Competing or overlapping knowledge systems?

This chapter has described the processes governing the construction and implementation of local and expert disaster knowledge from the viewpoint of local farmers, the BPBD and PVMBG. The chapter has highlighted the subtleties that differentiate expert and locally produced perspectives, while also arguing that disaster knowledge does not evolve independently nor do local and expert knowledge systems inherently contradict one another. Despite the plethora of studies that have drawn attention to the divide between expert and local disaster knowledge (Bankoff, 2004; Dake, 1991; Donovan et al., 2012a; Hoffman, 2002; Kasperson et al, 1988; Laksono, 1988; Paine, 2002; Slovic, 1999; Wisner and Luce, 1995), others, particularly within the local ecological knowledge field of literature argue that these sources of knowledge interact, both converging and diverging from one another

(Agrawal, 1995; Berkes et al., 2000; Nygren, 1999; Shannon et al., 2011). Local and expert knowledge of volcanic hazard in the Dieng Plateau falls within this latter stream of thought. Rather than representing two distinct ways of knowing, local knowledge incorporates scientific wisdom from the PVMBG, and expert knowledge is also informed by local observation of the main Timbang Crater.

While local and expert disaster knowledge systems are not binary opposites, they can still be differentiated on various fronts. Local disaster knowledge is a hybrid space combining scientific and religious interpretation. It views volcanic hazard as one of many daily risks and weighs livelihood vulnerability heavily in decisions to evacuate or return to fields following eruptions. Many of the risks taken by Dieng's potato farmers are thus educated and rational decisions. Expert disaster knowledge on the other hand is more risk-averse, reactionary and technocratic, focusing largely on the technicalities of detection, warning and evacuation. This technocratic style of governance is further enabled through the BPBD's institutional environment, primarily its capacity and budgetary constraints. While this approach of the BPBD enables effective emergency response, it falls short of addressing underlying conditions of vulnerability or facilitating ongoing community participation. Furthermore, PVMBG's scientific knowledge is constrained by the political push to predict complex volcanic processes despite the high levels of uncertainty involved. However, PVMBG volcanologists, particularly Pak Surono, still positively inform local understandings of volcanic eruptions.

A current theme within the DRR field of literature is the need to create more opportunities for knowledge sharing between the different actors involved in DRR (Gaillard and Mercer, 2012; Spiekermann et al., 2010; Weichselgartner and Pigeon, 2015). The findings of this chapter suggest that to facilitate this dialogue, greater recognition of the locally embedded and contextualised nature of disaster knowledge from the perspective of local and expert actors is needed. This argument is elaborated on in the following chapter, wherein

the main conceptual and policy implications of this thesis aimed at reducing conditions of vulnerability to volcanic hazard, are presented.

8. Conclusions and implications

This thesis has described how access to land, livelihoods and disaster knowledge impact local conditions of vulnerability to natural hazards in the Dieng Plateau, Central Java. Situated within the field of social volcanology, the findings address the need for more contextualised studies of everyday risk in Indonesia's volcanic landscapes. They also respond to calls for greater studies of vulnerability (Briceno, 2015; Djalante et al., 2012), focusing specifically on the benefits accrued by partaking in livelihoods in hazardous areas (Bachri et al., 2015; Rigg and Vandergeest, 2012), and the way political and expert representations of risk influence local vulnerability (Collins, 2009; Donovan et al., 2012c; Mustafa, 2005; Rebotier, 2012). In the forthcoming chapter I present the main conclusions of the three empirical chapters and describe how these findings contribute to new perspectives for the theorisation of vulnerability. I discuss the conceptual and policy implications of this research; specifically its significance for helping to guide the alleviation of vulnerabilities in other upland agriculturally dominated landscapes throughout Indonesia. The chapter closes with a discussion of future research directions for disaster scholarship, followed by some final concluding reflections and a final thesis statement.

8.1. Revisiting the research problem and questions: Uncovering the multiple pathways to vulnerability and capacity in volcanic landscapes

The overarching objective underpinning this thesis was to better understand, and provide new conceptual and policy insights, into the varied pathways vulnerability is produced, and overcome, in one of Indonesia's many understudied volcanic landscapes. To realise this research objective, I employed a multi-methods approach involving semi-structured and unstructured interviews with potato farmers, labourers and small business owners; interviews with government officials involved in the management of volcanic hazards; participant observation of farming activities and

government training or *sosialisasi* exercises; a participatory workshop; and a household survey. The forthcoming section revisits the underlying research problems and questions and outlines the contribution I have made within three fields of knowledge. I then discuss how these thematic areas interrelate to present an integrated and nuanced picture of vulnerability.

8.1.1. The Dieng hazardscape: Access to, and political representations of, hazardous land

My first research question, which was answered in Chapter 5, asked:

1. What socio-economic and political processes have determined access to hazardous land, and through this, influenced past and present conditions of vulnerability to natural hazards (or the making of the 'hazardscape') in Central Java's highlands?

This question leads to my first main argument: that vulnerability to natural hazards in the Dieng Plateau is a product of the historic socio-economic and political drivers that encouraged upland development, alongside the Indonesian state's attempts to territorialise hazardous land. These historic processes include Dutch colonial and New Order Regime policies that promoted the production of export oriented commodity crops, which intensified lowland land pressures and encouraged the upland migration of farmers in the process (Boomgaard, 1999; Hefner, 1990; Li, 1999a). However, the development of a small-scale agricultural industry and its vulnerability to natural hazards has also been influenced by past attempts to define and then manage hazardous land through the process of territorialisation. I argue that government led representations of land as 'hazardous' in Dusun Simbar following the 1979 volcanic gas eruption facilitated government intervention over this land, ultimately serving to recruit participants into the then politically significant transmigration program. However, this relocation also altered the local land market, and as it was locally contested, previously land poor or landless farmers were ultimately drawn back into occupying the most hazardous zones.

In Chapter 5, I have argued that this process of territorialisation has had mixed outcomes for vulnerability. As it was locally contested, it initially lowered local land prices and encouraged resettlement of hazardous areas by land poor or landless labourers. This group were then more likely to experience crop failures as a result of volcanic gas or landslide events. However, the transmigration also provided an easier entry point to the local land market through which entrepreneurial farmers could acquire more land. The acquisition of land as a result of this historic process placed many of Dusun Simbar's farmers in an advantageous position to benefit from the coming potato boom, which would see a dramatic increase in land values. Contemporary approaches to the territorialisation of hazardous land have focused on evacuation and controlling access to fields following the 2011 and 2013 gas effusions. I argue that the technocratic style of this management, while necessary in part, is also locally contested and has distanced the community from more genuine forms of participation in state-led DRR programs.

My conceptualisation of the 'Dieng hazardscape' demonstrates how the consideration of state-led territorialisation strategies can contribute to a politically informed and spatial understanding of vulnerability in volcanic environments. While territoriality is an established framework within political ecology (Peluso, 2005; Vandergeest and Peluso, 1995, Wadley, 2003), excluding the work of Rebotier (2012), the concept is currently under-represented in disaster scholarship. However, I argue that these territorialisation strategies, which in the Dusun Simbar example were built through political agendas to manage hazardous land and develop the outer islands, can influence local conditions of vulnerability to natural hazards, often through unintentional flow-on processes. By incorporating the concept of territoriality within a broader analysis of the socio-economic processes governing access to hazardous land, I have expanded on the access model of Wisner et al. (2004). My approach responds to the absence of politics from studies of access (see Middleton and O'Keefe, 1998; Watts, 1997), and supports the argument that political representations of risk should also be

integrated with vulnerability analyses (see also Collins, 2009; Gould et al., 2016; Mustafa, 2005; Rebotier, 2012).

8.1.2. Livelihoods and agrarian transformations

My second research question, which was answered in Chapter 6, asked:

2. How have the livelihood transformations witnessed in the Dieng Plateau over the past decades influenced present conditions of vulnerability and capacity to manage the impact of natural hazards?

This question leads to my second main argument, which contends that vulnerabilities to volcanic hazards in the Dieng Plateau were not only produced, but also alleviated, by the rapid agrarian transformation of the past few decades. Overall, I argue that the potato boom in Dieng, while by no means a livelihood panacea, has provided significant economic opportunity, and through this, a means to reduce conditions of vulnerability to volcanic hazard. The relative success of this agrarian change is related to Dieng's history of tobacco farming, the material properties of the potato, the favourable biophysical characteristics of the plateau, and the adaptability shown by local farmers. Yet, this rapid agrarian shift, from a landscape of tobacco to one dominated by potatoes, also introduced new vulnerabilities.

While most landowners and labourers have broadly benefitted from the potato boom, some have been left behind. This group predominantly includes female-headed households, the elderly and those who, through a series of back luck, have experienced progressive crop failures. While ongoing concerns about the rising value of land, soil fertility and land fragmentation may impact the future sustainability of potato farming, I have argued that such predictions should be countered against the adaptability shown by local potato farmers that allows many to thrive through sometimes difficult socio-economic and environmental conditions. This finding challenges dominant assumptions that rural livelihoods in volcanic areas are inherently 'unsustainable' (see Wisner et al., 2004) and provides a more holistic picture, considering capacity alongside vulnerability.

Despite livelihoods perspectives being commonly applied in disaster research (Alexander et al., 2006; Gaillard et al., 2009; Kelman and Mather, 2008; Sanderson, 2000), the benefits of agriculture in hazardous localities are rarely given adequate attention and agrarian studies are infrequently drawn upon. By applying concepts from the literature on Southeast Asian agrarian transformations (see Hall, 2011a; Li, 2014; Mahanty and Milne, 2016; Vandergeest, 2008) I have contributed to a more detailed study of livelihood outcomes within the current disaster scholarship. I argue that this analytical lens provides a framework to capture the benefits of agriculture in hazardous environments, and overcome biases of 'unsustainability' and dominant views that people are 'pushed' into hazardous localities through lack of alternative choices (see Wisner et al, 2004). In particular, I posit that the conjunctures, or the culmination of elements that facilitated the boom, bear important insights for the creation of vulnerability in other agrarian societies living in close proximity to volcanic hazard throughout Indonesia.

8.1.3. Contextualised disaster knowledge

My third and final research question, which was answered in Chapter 7, asked:

3. How is local and expert disaster knowledge constructed, interpreted and acted on in the Dieng Plateau? How do these forms of knowledge interact and contribute to volcanic risk reduction strategies that either reduce or increase conditions of vulnerability?

This question leads to my third main argument of this thesis, which states that vulnerability to natural hazards is produced, yet also overcome, through the processes governing the construction, and implementation, of local and expert disaster knowledge. While local disaster knowledge alleviates vulnerabilities, I argue that expert disaster knowledge can at times compound vulnerabilities if important livelihood processes are not considered. In contrast to the dominant view held within disaster scholarship, which positions local and expert knowledge as opposites, I argue that this knowledge is hybridised and interrelated. For example, local

communities possess a comprehensive system of disaster knowledge that allows them to mitigate the impact of natural hazards. This knowledge is informed by expert scientific knowledge, livelihood realties, lessons gained through daily observation, oral histories and worldview; allowing farmers to mitigate risk on a daily basis, while also coping with the uncertainty posed through the irregularity of volcanic eruptions.

However, while not the binary opposite of local knowledge, I argue that expert knowledge is still heavily driven by technocratic approaches and interventions. BPBD's disaster knowledge is largely reactive and technocratic, yet also an unsurprising product of its current institutional, capacity and budgetary environment. This shortcoming inhibits the realisation of DRR at the local level, and stems from issues associated with Indonesia's decentralisation of government (Djalante et al., 2012; Grady et al., 2016; Hening, 2014), and the immensity of work required to integrate DRR with development planning in the current political climate that does not prioritise its advancement. I have argued that while PVMBG's hazard assessments are imperfect, carrying institutional and personal biases and uncertainties, they also positively inform local interpretations of volcanic eruptions. However, as the recent construction of Dieng's water park reveals, this expert scientific knowledge is yet to be systematically integrated with local planning decisions.

My contribution to the disaster knowledge field argues that both local and expert knowledge are hybrid and locally contextualised systems. As the dominant disaster knowledge literature has a tendency to set local and expert knowledge in opposition with one another (see Cronin et al., 2004; Dake, 1991; Donovan et al., 2012a; Hoffman, 2002; Kasperson et al, 1988; Laksono, 1988; Paine, 2002; Shannon et al., 2011; Slovic, 1999; Wisner and Luce, 1995), I have expanded on these approaches by drawing on local ecological knowledge studies. This field argues that knowledge is locally contextualised, unequally produced and circulated (Goldman, 2007; Turnbull, 2000). Furthermore, local and expert knowledge systems are not isolated or binary opposites that contradict one another (Agrawal, 1995;

Berkes et al., 2000; Nygren, 1999). My findings demonstrate that the local ecological knowledge theorisation of knowledge as a hybrid system more adequately represents local disaster knowledge (see also Rigg et al., 2005; Schlehe, 2010; Shannon et al., 2011) and avoids over-simplifying these complex, diverse and ever-changing knowledge systems as purely subjective or fatalistic. By studying knowledge from this contextualised perspective I was also able to address the understudied construction of expert disaster knowledge and the way this interacts with local knowledge, moving beyond assumptions that scientific knowledge is objective and unbiased (for additional examples see Donovan, 2017; Donovan and Oppenheimer, 2015a; Donovan et al., 2012c). These findings expand current understandings of knowledge within disaster scholarship, and as I will discuss below can contribute to the more contextualised facilitation of dialogue between local and expert DRR actors.

8.1.4. A detailed picture of vulnerability: The interaction between land, livelihoods and disaster knowledge

The fourth main argument of this thesis is that vulnerability can be theorised as an integrated process, involving access to land, political representations of risk enacted through territoriality, livelihood transformations, and the practice or implementation of local and expert disaster knowledge. The interaction between these processes provides a more contextualised and nuanced picture of vulnerability to natural hazards in the Dieng Plateau and in doing so, bears insights for the implementation of policies that could better alleviate local vulnerabilities. Adgar (2006) argues that scholars need to focus on conceptually refining theories of vulnerability in the face of significant global environmental and political changes; and my integration of the three thematic areas outlined above responds to this call.

Rather than standing in isolation, the three thematic areas of this thesis – access to land, livelihood transformations and disaster knowledge – all interact and have jointly contributed to the creation, or mitigation, of vulnerability to volcanic hazards in Dieng Plateau. In Figure 27, I have

summarised the arguments outlined above as processes that interact to produce vulnerability. The first component of this diagram represents the historic economic and political processes that encouraged upland migration and agricultural development of the highlands, alongside the state-led territorial processes that have re-organised local land ownership arrangements (see Chapter 5). These processes have had mixed outcomes on conditions of vulnerability; while land-poor or landless labourers were drawn into occupying the most hazardous parcels of land, some were also placed in a position to capitalise on the coming potato boom.

However, the vulnerability depicted in the centre of Figure 27 isn't only the result of issues of access to land and as Chapter 6 has argued, it is also generated through the rapid agrarian shift that transformed the Dieng landscape from the mid-1980s. While the economic rewards of potato farming have actively encouraged farmers to take greater risks farming near active craters (see also Bachri et al., 2015; Haynes et al., 2008a; Lavigne et al., 2008), participation in this livelihood activity has also increased the financial assets many farmers can draw on to overcome the impact of eruptions. This finding draws on the analysis of Chapter 5; as those who were most able to reduce their conditions of vulnerability during the potato boom, were also those who began to acquire land prior to, and in the early days of, this agricultural transformation.

The final component of the diagram (Figure 27) represents the role played by local and expert disaster knowledge. Local knowledge can both increase and reduce vulnerability by encouraging farmers to take risks near active craters whilst also equipping them with the foresight to self-evacuate and a sense of psychological resiliency in times of uncertainty. Expert knowledge likewise influences vulnerability to volcanic hazard, primarily by driving evacuation orders and providing the resources, or at times lack thereof, needed for residents of Dusun Simbar to manage the threat posed by the volcanic hazard. As I elaborate in the forthcoming section, this theorisation of vulnerability as the intersection of processes that govern access to land, livelihood outcomes and disaster knowledge, bears important conceptual and

policy implications for DRR in volcanic landscapes (these implications are also later summarised in Table 10).

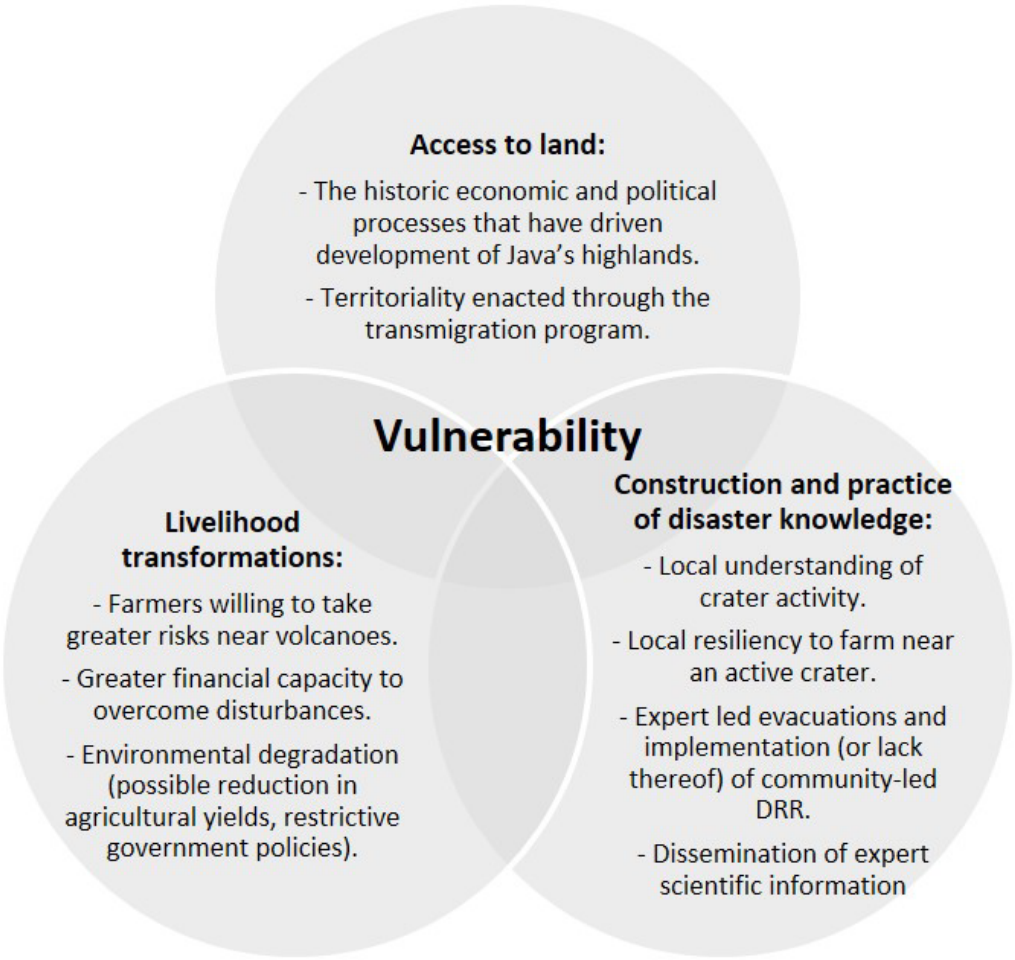

Figure 27. The intersection of, and relationship between, the main themes discussed in this thesis that jointly contribute to vulnerability to natural hazards in the Dieng Plateau.

8.2. The conceptual and policy implications of an integrated approach to understanding vulnerability

The field of political ecology has long been concerned with the advancement of policies that promote social justice through policy reform (Blaikie, 1985; Blaikie, 2008; Forsyth, 2008; Rocheleau, 2008). Through studying the construction and management of vulnerability to volcanic hazard in the

Dieng Plateau, I have drawn three conceptual and policy implications from my study. These relate to: i) issues of holistic volcanic risk reduction, ii) the limitations of the district level BPBD model, and iii) the need to facilitate dialogue between local, expert and policy actors. These implications concur with past assertions that good DRR policy requires a combination of top down (expert-led) and bottom up (local-led) approaches (Gaillard and Mercer, 2012; Weichselgartner and Obersteiner, 2002). Gaillard (2010) argues that good policy should focus on 'enhancing capacities, reducing vulnerability and building resilience' through the increased participation of local communities (p. 22). While the case presented in this thesis supports this concept in theory, I demonstrate that its actual practice is complicated by various institutional, bureaucratic, and local socioeconomic factors. The forthcoming section discusses some of the complexities of DRR in the Dieng Plateau, before concluding with a list of suggested governance strategies.

8.2.1. Holistic volcanic risk reduction

Chapters 5, 6 and 7 of this thesis all demonstrate how livelihood priorities take precedence over DRR activities in the Dieng Plateau. This isn't to say that farmers don't participate in disaster mitigation activities at all, but rather that they prioritise other life issues above potential volcanic hazards. Accordingly, the holistic management of natural hazards, including volcanic disasters, argues for the better integration of disaster management with livelihood processes and outcomes (Cardona, 2004; Kelman and Mather, 2008). As development programs fail if they don't account for the lived realities of the people with which they work (Chambers, 1995), the forthcoming discussion focuses on how future disaster programs in the Dieng Plateau, or other agrarian societies in areas of moderate volcanic hazard, need to facilitate rather than impede potatoes and other profitable agricultural based livelihoods.

Chapter 5 of this thesis has demonstrated the often unintended and ongoing consequences of certain government actions to mitigate risk, many of which have overlooked the significance of local livelihoods. In my discussion of

territorialisation, I argue that relocation was not considered from a 'holistic' angle, but was predominantly an attempt to coercively recruit volunteers for the state driven transmigration program. While it is hard to infer whether the relocation of Dusun Simbar succeeded or failed, the very act of shifting a large community without regard of their livelihood preferences, meant many returned and continued to occupy potentially dangerous land. Many of Dusun Simbar's local residents possessed a counter definition of risk, and were more concerned by the hardships of life faced in South Sumatra's forests than the risk of farming land near the Timbang Crater Complex (see also Schlehe 1996 for Mount Merapi). Kelman and Mather (2008) argue that relocation is an unfeasible solution in the majority of volcanically active environments throughout the globe and as an alternative they contend that communities should be better supported to live with, and respond to, risks; a statement that is supported throughout this thesis.

While the significance of livelihoods for vulnerability reduction is already well established (Bebbington, 1999; Chambers, 1995; Gaillard et al., 2009; Kelman and Mather, 2008; Scoones, 2009; Twigg, 2001), in Chapter 6 I have demonstrated that developing and implementing holistic programs remains problematic. A major inhibitor pertains to the contested views of sustainability that are held by district government officials and local farmers. This has led the government to promote the growth of less economically viable crops such as *carica*, which local farmers continue to largely resist. As an alternative, I posit that holistic volcanic risk reduction could support rather than constrain agricultural activities through policies that focus on improving the sustainability of the already economically rewarding cool climate vegetable industry. As I have discussed in Chapter 6, many of Indonesia's potato farmers struggle to access disease free seed potato stock (Fugile et al., 2006; Fugile, 2007) and rely on excessive quantities of pesticides to guarantee yields. Rather than impede this industry, state-led DRR programs could support this agricultural venture, for example through facilitating better access to disease free seed stock, a recommendation that

was also frequently requested by farmers in the field. After all, the potato has brought prosperity, and through this, resilience, to many of Dieng's farmers.

I have demonstrated that community-based DRR programs (CBDRR), often spruiked as the answer to holistic disaster management, also carry significant limitations that hinder their effectiveness. This style of disaster management has developed in part from a neo-liberal climate of reduced state responsibility (Jones et al., 2014), and encourages villagers to construct and enact their own disaster management plans under the initial guidance of the BPBD or local NGO actors. While the emphasis of these programs towards supporting local capacity and addressing local priorities is admirable, there are problems with how they are enacted, particularly through the BPBD's *Desa Tangguh* (Resilient Villages) program (see Chapter 7). This program is built on the assumption that DRR forms enough of a priority for the recipient villages that they will continue the program once state or NGO support is withdrawn. The fieldwork we conducted, however, revealed that after the BPBD leave the recipient village, the plan is abandoned and the local disaster management team become regarded as '*tidak aktif*' (inactive). This situation is likely compounded by the fact that ongoing community level ownership of CBDRR is harder to realise in areas of moderate hazard such as the Dieng Plateau. Unless the BPBD maintain their involvement, or the community are more frequently confronted with the direct impact of disasters, in my view it is unlikely that any ongoing formal local preparedness activities will occur at all. This finding reaffirms the argument that the state should maintain a significant and ongoing role in matters of disaster management (see Christopolos et al., 2001).

However, we should also be wary of overlooking the 'ordinary' risk reduction practices that farmers undertake on a daily basis. These more subtle forms of risk mitigation are less likely to be captured in CBDRR workshops. They include quotidian decisions about whether to approach Timbang Crater, and when to leave the fields for home. These risk-handling styles are difficult to observe and categorise, as they are so deeply ingrained with daily activities. Yet as Gaillard et al. (2009), Hellman (2015), Hilhorst et al. (2015) and van

Voorst (2015) all observe, these daily measures form the first line of local hazard defence. These measures can only be officially strengthened by empowering trust in local knowledge, a process that could occur indirectly by funnelling more responsibilities, such as the ownership and upkeep of monitoring equipment for example, directly to the community.

While the concepts of holistic volcanic risk reduction discussed above have the potential to assist in reducing vulnerability to volcanic hazard in the Dieng Plateau, they are unlikely to be effective and long lasting without significant contribution from the district government. The proceeding section will now describe the policy implications associated with DRR governance at the district government level in Indonesia.

8.2.2. District level DRR governance

My analysis of vulnerability to natural hazards in the Dieng Plateau provides important insights and lessons for disaster governance at the district government level. The country of Indonesia is widely upheld as a champion for DRR across the region (Wahlstrom, 2015); praised in particular for its development of national and regional legal frameworks[49] and the recent exponential uptake of BPBDs at the district government level (Djalante et al., 2012; Hening, 2014; Siagian et al., 2014). However, despite this observable progress, many signatory countries of the Hyogo Framework for Action claimed that the achievement of such indicators did not necessarily translate to actual effective disaster management at the local level (Jones et al., 2014; UNISDR, 2013). Furthermore, DRR is not a priority for many national and regional level governments (Jones et al., 2014; Lavell and Maskrey, 2014), including Indonesia (Djalante et al., 2012; Grady et al., 2016), and so ongoing investments are constrained. This calls for greater DRR efforts at the district government level with greater resources provided by the central government, a finding that is supported, yet also proved immensely difficult based on my analysis of the Dieng Plateau case example.

[49] For some examples see *UU 24/2007* on the National Disaster Management Law, *Peraturan 8/2008* on the regulation of BNPB and BPBD, and *Peraturan 1/2012* on the regulation of disaster resilient villages/districts.

As demonstrated in Chapter 7, district level DRR governance in Indonesia treats disasters as unusual occurrences rather than the product of the processes that generate vulnerabilities, often borne through unequal development practices (see also Lavell and Maskrey, 2014; Wisner and Walker, 2005). To redress this limitation, various authors have argued that disaster vulnerability reduction should be integrated within broader development plans (Gaillard, 2010; Heijmans, 2001; Lavell and Maskrey, 2014; Pearce, 2003; Scoones, 1998). As articulated by Lavell and Maskrey (2014), this re-focus aims to move away from 'corrective and compulsory risk management, which attempts to reduce or operate in the context of already existing risk' (p. 269). However, I argue that integrating vulnerability reduction within broader development programs is a substantial task to undertake, particularly in the context of decentralised Indonesia. While decentralisation is now seen as a requirement for the realisation of DRR activities that represent local needs (UNISDR, 2015; Williams, 2011), in reality its implementation is also accompanied by significant capacity and funding limitations and a lack of political will (Bang, 2013; Djalante et al., 2012; Grady et al., 2016; Marks and Lebel, 2016; Scott and Tarazona, 2011).

Within this current political climate, I argue that the BPBD have been charged with an immense, at times bordering on impossible, task. Not only are they to prepare communities before, and respond adequately to, disasters but they should also contribute to the integration of DRR into broader development plans (Article 6a, *UU 24/2007*), which in theory should involve the alleviation of the social vulnerabilities that worsen the impacts of natural hazards (see Lavell and Maskrey, 2014; Wisner et al., 2004). Significantly, they are to achieve all this with their limited bureaucratic capacity, financial and material resources and political power. Williams (2011) cautioned that Indonesia's establishment of stand-alone DRR mandated institutions could reduce the sense of responsibility towards DRR held by other institutions. This is particularly concerning when it is the other institutions that possess the greater power, financial resources and capacity to implement vulnerability reduction programs (see also Grady et al., 2016). I argue that

redressing this problem in Indonesia would require strengthening the political significance of the BPBD at the district government through greater resources and capacity development, or integrating some of their tasks, particularly those related to vulnerability reduction, into the mandates of the more established and capable agencies. Without such integration, I caution that their task is liable to failure at the outset.

In particular, the BPBD's *Desa Tangguh* (Resilient Villages) program, which has been geared to address local vulnerabilities, is hindered by resource limitations and an underlying conflict with local priorities. In all three empirical chapters of this thesis, I have described how the priorities of local farmers vary from those of the government organisations responsible for DRR. The very premise underpinning *Desa Tangguh,* wherein local communities will maintain and contribute to DRR, despite it not being viewed locally as a priority is thereby flawed. Furthermore, as various authors have already argued (Gaillard and Mercer, 2012; Lavell and Maskrey, 2014), there is a lack of political commitment to go beyond the rhetoric of CBDRR. While this finding is demonstrated in Chapter 7 of this thesis, here I argue that this commitment is also needed from the higher, more resourced government departments (for example the Regional Body for Planning and Development, *Bappeda*). In my experience officials of the Banjarnegara BPBD are in fact very committed; however, they are held back by budgetary and capacity constraints. Furthermore, the regulations and frameworks they work with fall short of providing ways to ensure the longevity of CBDRR, especially in areas where DRR is not perceived as a top priority.

Despite my critique of BPBD's technocratic style of disaster management provided in Chapter 7, it is important in this discussion of DRR governance to recognise what this approach does enable. The Banjarnegara BPBD officers are highly skilled in the technical components of disaster response such as search and rescue. This task is not insignificant and should not be completely overlooked in the pursuit of vulnerability reduction. While this mandate partly overlaps with the role of *Basarnas* (the National Search and Rescue Agency), BPBD are positioned in closer proximity to respond to disasters

occurring within the Banjarnegara District. I derive two policy directions from this finding: either the BPBD could redirect its resources towards tasks of preparedness and vulnerability reduction with greater collaboration from other district government units, or they could focus on what they do best. Both options are useful, yet the second is likely most achievable given BPBD's current political standing, capacity and budgetary situation.

8.2.3. Facilitating dialogue between local, expert and policy actors

The need to create a platform for dialogue between the local and expert actors involved in DRR has recently become a focus of current disaster scholarship (Gaillard and Mercer, 2012; Gall et al., 2015; Spiekerman et al. 2015; Weichselgartner and Obersteiner, 2002; Weichselgartner and Kasperson, 2010; White et al., 2001). Rather than a deficiency in the production of knowledge alone, these authors argue that limited avenues for knowledge sharing between different actors are inhibiting the progress of global DRR aims. Drawing on my analysis of disaster knowledge as presented in Chapter 7, I posit that greater recognition of the hybridised and contextualised nature of both local and expert disaster knowledge is firstly required to provide a more nuanced platform for this dialogue to take place.

While it is now widely acknowledged that DRR efforts benefit from the incorporation of local disaster knowledge (Becker et al., 2008; Mercer et al., 2007), as argued above, too often this knowledge is treated as separate from official or expert led knowledge constructs. However, I posit that unnecessarily widening the gulf between local and expert views overlooks the complexities that shape local knowledge and the often-practical DRR efforts that this knowledge informs. In Chapter 7, I have demonstrated that hybrid local knowledge exists for a very practical reason: it allows one to partake in feasible mitigation measures (see also Dekens, 2007; Schmuck, 2000), and provides the psychological resiliency to continue farming despite the reality that one's safety can never be entirely guaranteed (see also Cashman and Cronin, 2008; Chester et al., 2012; Gaillard and Texier, 2010; Kwilecki, 2004; Mitchell, 2003; Taylor, 2001; Wisner, 2010). In the Dieng

Plateau, this knowledge is not solely 'traditional' or culturally fixed; it has also evolved in response to the daily observation of crater activity, livelihood necessities, and the provision of scientific information from the PVMBG. This finding provides a counter example to the many studies that situate local communities in a long history of interpreting and overcoming disasters (see Cashman and Cronin, 2008; Donovan et al., 2012a; Gaillard et al., 2008; King et al., 2007; McAdoo et al., 2005; Skertchly and Skertchly, 1999). Recognising the contextualised and hybrid nature of local knowledge, and the way it changes with time, could help move beyond statements that local knowledge should merely 'complement' expert knowledge (see UNISDR, 2015), towards a view that considers local perspectives and priorities in the initial design of DRR programs.

With respect to expert disaster knowledge, I support the argument that experts could look inwards and reflect on their own disciplinary limitations as they derive policy recommendations (see Jasanoff, 2003, 2007). Despite the perceived superiority associated with expert disaster knowledge (Mercer, 2012; Schwarz, 2014), I have demonstrated that within the Dieng Plateau this knowledge is also contextualised and biased by disciplinary backgrounds, institutional arrangements and the positionality of volcanologists involved in risk assessments (see also Donovan, 2017; Donovan and Oppenheimer, 2015a). For example, the technocratic style of knowledge favoured by the BPBD has evolved in response to BPBD's legacy organisation (*Satlak*), its capacity and budgetary restrictions and Indonesia's program of decentralisation. Furthermore, the knowledge produced by the PVMBG is not purely objective, but is influenced by the limitations of underlying datasets, the individual opinion of scientists, and the political push to predict what are inherently uncertain phenomena. To counter these limitations, Jasanoff (2003, 2007) argues that policy makers need ways to accommodate the uncertainty that scientific knowledge holds. Here, she advocates for 'technologies of humility' or disciplined measures to act under the limits of scientific knowledge. Greater recognition of the limitations to expert knowledge could aid in the facilitation of contextualised dialogue, and

avoid the development of overly restrictive, or locally irrelevant DRR programs in the process. Furthermore, such an approach would move beyond assumptions that local knowledge is irrational and expert knowledge is objective.

In Chapter 7, I demonstrate how participatory approaches revealed a new perspective on natural hazards; specifically that the strong wind events that frequently impact crops are feared more than the less frequent, though more life threatening, volcanic gas effusions. The participatory mapping exercise we held uncovered this important and unforeseen local perspective, while also demonstrating the scope, depth and quality of local understanding of volcanic hazards. These findings validate the usefulness of participatory approaches to bridge the so-called local/expert knowledge divide (see also Cadag and Gaillard, 2012; Cronin et al., 2004; Gaillard et al., 2013; Gaillard and Pangilinan, 2010; Kelman et al., 2012; Mercer et al., 2009; Peters-Guarin et al., 2012; Riechel and Fromming, 2014). For example, if conducted with the BPBD they could initiate programs that focus on preparation for strong winds, involving local farmers in the actual design of DRR programs. The concern with participatory approaches, however, is that by not involving participants in the design and assumptions that underpin the project they can still impose outside structures, and they still require the use of expert facilitators (Le De et al., 2015; Pelling, 2007). While it is certainly a useful tool to create dialogue between expert and local disaster knowledge, I posit that it is not the sole means on which this task can depend.

The discussion above concurs with findings from the global disaster literature, which argue for greater knowledge sharing between local, expert and policy actors to reduce disaster losses (Gaillard and Mercer, 2012; Gall et al., 2015; Spiekerman et al. 2015; Weichselgartner and Kasperson, 2010; Weichselgartner and Obersteiner, 2002; White et al., 2001). However, drawing largely on my empirical data presented and discussed in Chapter 7, I argue that effective dialogue requires greater understanding of the contextualised nature and limits to both local and expert disaster knowledge, and greater awareness of the tasks district level BPBDs can realistically

perform within their operating environment. Participatory approaches that take a holistic perspective of volcanic risk are shown to be useful, yet they should not discount the important and ongoing role that should be played by local government.

8.2.4. Suggested governance strategies for vulnerability reduction in Indonesia's volcanic landscapes

The discussion above leads to a series of suggested governance strategies that have the potential to guide the better management of volcanic hazards in the Dieng Plateau. To summarise, these include:

i. Volcanic risk management should focus on holistic approaches that consider livelihood needs alongside exposure to volcanic hazard. While this is not a new finding, this thesis has identified new pathways through which this can be achieved. These include re-examining notions of 'sustainability' and supporting, rather than impeding, the local agricultural developments that contribute to local capacity and resilience.

ii. As volcanic mitigation is not a local priority in areas like the Dieng Plateau, the state has an important role in supporting the longevity of CBDRR programs. Running a workshop and installing a disaster management team is not enough to reduce vulnerabilities. Additionally, there should be greater scope to capture and support the 'ordinary' risk mitigation activities undertaken daily by farmers. These form the front line of defence and can be more effective than state-led DRR efforts.

iii. The limitations to what district level BPBDs can reasonably implement should be reflected in national disaster management frameworks. Without major operational and resource allocation changes, some of the more challenging tasks of DRR, such as vulnerability reduction, should not depend solely on the efforts of the BPBD but draw on the resources from the larger agencies (for

example, a more significant role could be played by *Bappeda* and/or the central government). The realisation of vulnerability reduction at the district government level requires greater strategic involvement from other key areas of government, alongside necessary resources and capacity development.

iv. Facilitating dialogue between local and expert DRR actors also requires understanding the contextual nature of disaster knowledge and recognition that local and expert knowledge are not binary 'irrational' versus 'objective' systems. A more appropriate pathway for knowledge integration could recognise the contribution that can be made from each perspective, alongside their underlying social, political and economic influences. Expert actors could recognise their own limitations by adopting Jasanoff's (2003, 2007) 'technologies of humility' framework, while local actors should be more meaningfully involved in the programming and design of DRR objectives.

Overall, the conceptual and governance implications of this study bear significance for a holistic and contextualised approach to the management of agriculturally dominated, volcanic landscapes. The main empirical and conceptual conclusions that have informed these policy implications are summarised below in Table 10. However, despite the ideas presented throughout this thesis, there is still much room for future work. As will be discussed below, this includes further grounded analyses of how risk is constructed and responded to, from a local and expert viewpoint, particularly in other agrarian volcanic landscapes throughout Indonesia.

Table 10. A summary of the empirical findings, conceptual and policy implications that respond to this study's three research questions.

Research question	Empirical findings	Conceptual implications	Policy implications
1.	Vulnerability is a product of the historic socio-economic and political drivers that encouraged upland development, alongside the state's attempts to territorialise hazardous land. The process of territorialisation has had mixed outcomes on vulnerability: a) it increased as people re-settled the hazardous area and became isolated from participation in state-led DRR, and b) it decreased as land-poor or landless labourers acquired land and then capitalised on the coming potato boom or accessed productive livelihoods in South Sumatra.	Theories of internal territorialisation reveal how political representations of risk also impact local vulnerabilities (Rebotier, 2012). When combined with the theory of access (Wisner et al., 2004), this approach presents a politically informed and nuanced understanding of vulnerability.	As relocation often fails, volcanic risk management should focus on holistic approaches that consider important livelihood processes. State-led DRR and environment programs in highland volcanic areas should aim to support rather than impede local agricultural development.
2.	Vulnerability to volcanic hazard has been alleviated by the rapid agrarian transformation of the past few decades. While the potato provided significant economic opportunity for many, some farmers have experienced new vulnerabilities associated with this labour intensive crop.	Agrarian studies provide a lens to capture the understudied benefits acquired through agriculture in hazardous areas and a means to re-examine state-led notions of 'sustainability' that can impede locally important agricultural development.	CBDRR needs to genuinely reflect the needs and priorities of the community and requires ongoing local government support, particularly in areas of moderate rather than extreme hazard.
3.	Vulnerability is produced, yet also overcome, through the processes governing the construction and implementation of local and expert disaster knowledge: a) it is reduced through the application of local knowledge and scientific information, and b) it is enhanced when local livelihood priorities are overlooked in state-led DRR programs.	The field of disaster knowledge can learn from local ecological knowledge studies. As opposed to pre-conceived 'opposites', local and expert knowledge are both hybrid and contextualised systems, that interact and inform one another. Facilitating dialogue between local and expert DRR actors involves recognising the contextual nature of disaster knowledge and that local and expert views are not binary 'irrational' versus 'objective' systems.	The 'ordinary' risk mitigation activities undertaken by farmers, including how these are positively informed by PVMBG's volcanologists, should be better supported. Rectifying BPBD's technocratic approach to DRR requires greater resources, political will and/or collaboration with more resourced arms of government.

8.3. Future research directions

This thesis has contributed to current understandings of how and why volcanically hazardous land is persistently occupied, and often profitably utilised, despite the known threats. Furthermore, it presents new knowledge of how governments attempt to manage or reduce this risk and the often-unintended impacts these programs can have on local communities. However, there is still much to understand concerning the processes that build vulnerability in volcanic areas, which can be guided by the findings of this thesis. One significant outcome of this thesis is a greater appreciation of concepts and frameworks from related political ecology fields of inquiry that can reveal the complex and varied processes that create vulnerability and capacity. Future disaster research therefore, needs not to feel constrained by dominant frameworks and approaches, as borrowing from related disciplines may open up invaluable new perspectives.

For example, a focus on the agrarian transformations occurring on other volcanoes may provide new, and possibly divergent, insights into the construction of vulnerability in such areas. This research need is particularly pertinent as many volcanic areas are also the sites of agricultural transformation, expansion, commoditisation or intensification (for some potential sites see Dove and Hudayana 2008 on Mount Merapi, Hefner 1990 on the Tengger highlands, Platten 2007 on the Minahasa highlands, Sulawesi, and Tobin and Whiteford 2002 on Mount Tungurahua, Ecuador). While the Dieng Plateau has been presented as a relatively 'good case' scenario of the relationship between livelihoods and vulnerability to volcanic hazards, generalisation of this study should be restricted to inferences that good cases do exist, rather than that they always exist. As volcanoes are fertile, resource rich environments boasting a plethora of livelihood opportunities, the capacities associated with their occupation are easily captured. However, this is unlikely the case for all hazardous areas, and I would warn against assuming that equal benefits are obtained for riverbank dwellers in urban areas such as Jakarta for example (see Hellman, 2015; van Voorst, 2015). Furthermore, additional work is still required to better understand the class

structure of vulnerability in the Dieng Plateau and how this is likely to emerge or change over time, particularly given the trends of population growth, decreasing size of land holdings and questions of soil fertility. Detailed study into these vulnerabilities that have emerged following the introduction of the potato could better inform future disaster policy.

Further studies of the BPBD in a diverse range of settings and hazard environments would be useful to produce more contextualised policy recommendations for local disaster management. While this thesis has reiterated the importance of local context for establishing disaster management solutions (Gaillard and Mercer, 2012), the policy implications I arrive at above have been derived explicitly through my observation of one district level BPBD office situated in Banjarnegara. This analysis was supplemented with the findings of other authors (Djalante et al., 2012; Grady et al., 2016; Hening, 2014), yet it is still a particular, context specific representation of the overall functioning of the BPBD throughout Indonesia's extensive archipelago. Each BPBD is likely to maintain a unique level of capacity and impact; for example, some of the better-known hazardous regions (i.e. Mount Merapi, Central Java and Padang, West Sumatra), accordingly boast the most effective disaster management systems (Williams, 2011). While this focus on areas of known high hazard is pragmatic, the unpredictability of volcanic eruptions suggests that there are likely to be many other areas throughout Indonesia possessing a similar, or even a more extreme, level of hazard that are yet to receive the same level of attention.

The final future research direction arising from this study relates back to the understudied nature of the majority of Indonesia's volcanoes. While the aim of this thesis was to enhance our understanding of vulnerability in one of Indonesia's volcanic environments, there are many others requiring further study. The recent eruptions from Mount Agung and Mount Sinabung emphasise that there is still much to learn about the physical and social construction of risk and vulnerability in volcanic landscapes. While this study of the Dieng Plateau has contributed to meeting this research need, this field of scholarship, particularly outside the island of Java, is far from exhausted.

8.4. Concluding reflections

With more active volcanoes than any other country on earth, the vast archipelago of Indonesia continues to exhibit signs of volcanic unrest. As I write this conclusion, Mount Agung in Bali is rumbling away causing large-scale displacements of predominantly rice farming communities. Likewise, in North Sumatra thousands remain in evacuation camps due to the ongoing eruptions of Mount Sinabung that began in August 2010 despite this volcano's prior history of inactivity. And while on a much smaller scale, Dieng's Sileri Crater continues to episodically erupt hot sulfurous mud, destroying surrounding crops as occurred most recently in July 2017. All of these events have occurred at understudied volcanoes, boasting agricultural landscapes, throughout Indonesia. They reveal the very tangible impacts volcanic eruptions have on rural livelihoods and point to the need for more policy development and research guided through the field of social volcanology.

When I first commenced this study of the Dieng Plateau I was taken aback by the high level of volcanic hazardousness that sits alongside expansive agricultural endeavours. With time, however, I came to see Dieng's extensive system of volcanic craters as a part of, rather than in juxtaposition against, this agricultural landscape. As the Indonesian phrase we commonly encountered in the field exemplifies, '*itu sudah biasa'*, volcanic hazard is 'an already normal' part of life in the Dieng Plateau. It has allowed the development of the often-lucrative agricultural ventures that have alleviated much local vulnerability. Furthermore, local farmers understand and respond to heightened activity in an informed manner, at times actively deciding to take greater risks for the achievement of livelihood outcomes. In comparison to local mitigation measures, the government takes a largely technocratic approach, alleviating vulnerabilities through the dissemination of scientific knowledge, yet also enhancing vulnerabilities through programs that disregard important local livelihood processes.

This thesis argues that local vulnerabilities to volcanic hazard in the Dieng Plateau are produced through the socio-economic and political processes that govern access to land, and the agrarian processes that influence livelihood outcomes, while also emerging through the way governments and locals alike define and respond to volcanic activity. While I did not foresee this concluding thesis statement before I entered the field, it became increasingly evident as I interacted with local farmers and government officials. I became more aware of the many socio-economic and bureaucratic reasons that drive each set of actors to a unique perspective on, and approach towards, volcanic hazard mitigation. As Indonesia's volcanoes will continue to erupt, and likely in unpredictable ways, integrated and nuanced conceptualisations of vulnerability, such as the one I have presented in this thesis, help to improve our understanding of the varied ways vulnerability is constructed and the appropriateness of policies that are developed to reduce, or overcome the creation of new, volcanic risks.

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Appendices

Appendix 1. Summary of informants

Table 11. A detailed list of the informants interviewed during this study.

Interview No.	Date	Age	Sex	Village/ Location	Livelihood/Employment Status
1	23/10/15	39	F	Dusun Simbar, Sumberejo.	Farm labourer.
2	23/10/15	60	F	Dusun Simbar, Sumberejo.	Farmer running a kiosk from her home.
3	9/10/15	35	M	Dusun Simbar, Sumberejo.	Farmer managing leased land.
4	8/10/15	32	F	Dusun Simbar, Sumberejo.	Farmer managing leased land.
5	16/10/15	41	F	Dusun Simbar, Sumberejo.	Farmer managing leased land.
6	16/10/15	70	F	Dusun Simbar, Sumberejo.	Retired farmer.
7	18/12/15	38	F	Dusun Simbar, Sumberejo.	Farmer and landowner (land in Dusun Simbar and Sumatra).
8	19/10/15 26/10/15	50	M	Dusun Simbar, Sumberejo.	Leader of the hamlet (Kepala Dusun) and landowner.
9	23/10/15	71	M	Dusun Simbar, Sumberejo.	Retired farmer and landowner (land in Dusun Simbar and Sumatra).
10	8/10/15	50	M	Dusun Simbar, Sumberejo.	Farmer and small landowner.
11	8/10/15	55	F	Dusun Simbar, Sumberejo.	Farm labourer.
12	6/11/15	56	F	Dusun Simbar, Sumberejo.	Farmer and small landowner.
13	9/11/15	38	M	Dusun Simbar, Sumberejo.	Village neighbourhood leader (Pak RT1), and farm labourer.
14	5/10/15	35, 46	M	Dusun Simbar, Sumberejo.	Village council official and small landowner.
15	16/11/15	41	M	Dusun Simbar, Sumberejo.	Farmer and small land owner.
16	25/11/15	57	M	Dusun Simbar, Sumberejo.	Landowner.
17	27/11/15	50	M	Dusun Simbar, Sumberejo.	Farmer and landowner.
18	1/12/15	41	M	Dusun Simbar, Sumberejo.	Landowner and farmer (land in Dusun Simbar and Sumatra).
19	8/12/15	59	M	Dusun Simbar, Sumberejo.	Landowner and fertiliser trader.
20	26/10/15	22	F	Dusun Simbar, Sumberejo.	Housewife and daughter of large landowner.

21	26/10/15	48	F	Dusun Simbar, Sumberejo.	Farmer and small landowner.
22	26/10/15	24	M	Dusun Simbar, Sumberejo.	Farm labourer (working in Sumatra and Dusun Simbar).
23	6/11/15	75, 72	F	Dusun Simbar, Sumberejo.	Elderly farm labourers (one retired and one nearing retirement).
24	9/11/15	67	F	Dusun Simbar, Sumberejo.	Retired farmer (recently sold land to complete the Hajj).
25	9/11/15	50	M	Dusun Simbar, Sumberejo.	Village neighbourhood leader (Pak RT2), farmer and small store owner.
26	16/11/15	28	F	Dusun Simbar, Sumberejo.	Farm labourer.
27	16/11/15	42	M	Dusun Simbar, Sumberejo.	Farmer and large landowner
28	27/11/15	40	F	Dusun Simbar, Sumberejo.	Small business owner, runs school canteen and trades vegetables.
29	27/11/15	54	M	Dusun Simbar, Sumberejo.	Farmer and small landowner.
30	27/11/15	70	F	Dusun Simbar, Sumberejo.	Farmer and small landowner.
31	4/12/15	60, 26	F, M	Dusun Simbar, Sumberejo.	Farmers who lease Forestry owned land.
32	8/12/15	31, 28	M, F	Dusun Simbar, Sumberejo.	Small landowners, own 8 sheep.
33	8/12/15	45	M	Dusun Simbar, Sumberejo.	Farm labourer and construction labourer.
34	8/12/15	36	F	Dusun Simbar, Sumberejo.	Owner of a small kiosk in her home.
35	9/12/15	50	M	Dusun Simbar, Sumberejo.	SD (Primary School) teacher.
36	9/12/15	54	M	Dusun Simbar, Sumberejo.	Farmer and large landowner.
37	9/12/15	42	M	Dusun Simbar, Sumberejo.	Farmer and landowner.
38	7/12/15	35	F	Dusun Simbar, Sumberejo.	Housewife and small landowner.
39	5/12/15	55	F	Dusun Simbar, Sumberejo.	Farmer and small landowner.
40	5/12/15	28	M	Dusun Simbar, Sumberejo.	Farmer and small landowner.
41	10/12/15	20	F	Dusun Simbar, Sumberejo.	Housewife and daughter of small landowner.
42	6/11/15	48	F	Dusun Simbar, Sumberejo.	Farm labourer.
43	10/12/15	60	M	Dusun Serang, Sumberejo.	Farmer, large landowner and trader.
44	16/10/15	55	M	Gembol.	Potato trader.
45	12/10/15	40	M	Sumberejo.	Village official.

46	24/10/15 9/12/15	41	M	Sumberejo.	Seed potato propagator and seller.
47	9/12/15	50	M	Batur.	Farmer and small landowner originally from Bandung.
48	2/10/15	35	M	Kepakisan.	Village Leader (Kepala Desa) and landowner.
49	30/10/15	40	M	Kepakisan.	Farm labourer and trader.
50	12/10/15	33	F	Kepakisan.	Farmer and small landowner.
51	12/10/15	55	M	Kepakisan.	Farmer and small landowner.
52	12/11/15	29, 50	F	Kepakisan.	SD (Primary School) teacher and her mother-in-law.
53	30/10/15	40	F	Kepakisan.	Small landowner with fried food kiosk.
54	12/11/15	50	F	Kepakisan.	Farmer and small landowner.
55	12/11/15	28	M	Kepakisan.	Farmer and small landowner.
56	12/11/15	40, 32	M, F	Dusun Serangan, Kepakisan.	Vegetable trader and small kiosk owner with her friend, a farmer and driver.
57	30/10/15	60	F	Kepakisan	Farmer and small landowner.
58	3/11/15	60	F	Dusun Serangan, Kepakisan.	Farmer and small landowner (currently leasing her fields under a sharecropping arrangement).
59	12/11/15	102	M	Dusun Serangan, Kepakisan.	Retired farmer and Kecamatan official from Batur.
60	13/11/15	40	F	Dusun Serangan, Kepakisan.	Farmer and small landowner.
61	13/11/15	45	F	Dusun Serangan, Kepakisan.	Farmer and landowner.
62	3/11/15	40	F	Dusun Serangan, Kepakisan.	Farmer and small landowner.
63	3/11/15	103	M	Dusun Serangan, Kepakisan.	Retired farmer and landowner.
64	3/11/15	55	M	Dusun Serangan, Kepakisan.	Farmer and landowner.
65	3/11/15	75	M	Dusun Serangan, Kepakisan.	Farmer and landowner.
66	12/11/15 13/11/15	104	M	Dusun Serangan, Kepakisan.	Retired farmer and landowner.
67	12/10/15 12/11/15	50	M	Kepakisan.	Village council official (Perangkat Desa) and farmer.
68	3/10/15	47	M	Pekasiran.	Village leader (Kepala Desa) and landowner.
69	4/11/15	23	F	Pekasiran.	Unemployed, daughter of a small landowner.
70	4/11/15 27/11/15	26	F	Pekasiran.	Farm labourer.
71	4/11/15	30	F	Pekasiran.	Farm labourer.
72	3/10/15	39	M	Pekasiran.	Farm labourer.
73	3/10/15	40	M	Pekasiran.	Farm labourer.

74	3/10/15	63	M	Pekasiran.	Farmer and small landowner.
75	19/10/15	55	M	Bakal.	Head of Islamic Emergency Volunteer Organisation (Pos Bagana) and farmer.
76	27/10/15	55	M	BPN (National Land Agency), Banjarnegara.	Administration officer.
77	30/10/15 14/12/15 16/12/15	45, 50	M	BPBD (District Disaster Management Agency), Banjarnegara.	The first and second in command at BPBD.
78	27/10/15	35, 30	M	Spatial Planning Unit of *Bappeda* and Forestry Body, Banjarnegara.	Spatial Planning Officer and Forestry Officer.
79	14/12/15	43	F	Agricultural Body, Banjarnegara.	Agriculture Officer.
80	5/10/15	30	M	Dieng Volcanic Observatory, Karang Tengah.	Geologist.
81	21/12/15	43	M	Indonesian Red Cross, Banjarnegara.	Head of the Red Cross in Banjarnegara.
82	2/12/15	60	M	Duren, Banjarnegara.	Farmer and member of the village level community police (*Linmas*).
83	16/12/15	45	M	Banjarnegara.	Farmer, village council official and member of the village level community police (*Linmas*).
84	24/10/15	40	M	Dieng Go Green NGO in Wonosobo.	NGO employee.
85	24/09/15	45	M	Spatial Planning Unit (*Tata Ruang*) of Bappeda, Wonosobo.	Spatial planning officer.
86	16/09/15	35, 55	M	PVMBG (Centre for Volcanology and Geological Hazard Mitigation) Bandung.	Landslide geologist and senior volcanologist.

Appendix 2: Sample interview questions

The forthcoming questions were raised during interviews with local informants and government officials involved in the management of volcanic hazards in the Dieng Plateau. While these served a guide only, they reveal the direction that many of our fieldwork conversations proceeded in.

Local informants

The leading questions below were asked during the semi-structured interviews we held with residents in the Dieng Plateau:

Access to land:

1. How do you access land? Is it owned, leased or do you labour for others? How much land do you own/lease? How did you acquire this land?
2. Is this land situated in close proximity to a volcanic crater or a steep slope? If so, how much was this land, and how and why do you continue faming it?
3. Were you born in this village? If not, why did you move here? Where are your ancestors from and what brought them to the Dieng Plateau?
4. Can you recall the events of the 1979 gas eruption from the Timbang Crater Complex or the 1944 eruption from Sileri Crater?
5. Were you involved in the government transmigration program? What are your experiences of this program and why did you return to Dusun Simbar?
6. Do the government enforce any land use regulations in the Dieng Plateau?

Livelihood transformations:

7. What is your main livelihood activity, why have you chosen it, and how long have you partaken in this activity?
8. Can you explain your farming practices, for example labour arrangements, crop patterns, how you access seeds and agrochemicals, markets, and forms of credit?
9. Is your land ever affected by natural hazards, eruptions or landslides, and if so what is the impact on crop yields and how do you respond?

10. If you could diversify into another livelihood activity what would this be? Are there other opportunities in Dieng? What did your parents do and what do you think, or desire, your children to do for a living?
11. What are the biggest issues facing potato farming in the Dieng Plateau?
12. What do you think of government programs to overcome land degradation in the Dieng Plateau? Why do you choose to participate in, or resist, these programs?

Disaster knowledge:

13. What do you think causes volcanic eruptions, specifically toxic gas emissions, landslides and soil erosion?
14. Do you think there is anything that can be done to minimise the occurrence of these hazards? If so what activities can be done and whose responsibility should these activities fall under?
15. Before volcanic activity occurs, do you receive any warning? If so, what does this warning look like? Where does it come from (e.g. the government, friends or nature)? Do you share the warning with others? If so, who?
16. What kind of information does the government provide concerning natural hazards? Do you think this information is sufficient? Do you trust this information? Are there other local sources of information about natural hazards besides the government?
17. Do you worry about the impact of hazards such as poisonous volcanic gas events, earthquakes and landslides? How do you rate this risk compared to other life issues?

State informants: BPBD and PVMBG

The leading questions below were raised during discussions with the BPBD Banjarnegara staff:

1. How does BPBD respond when a natural hazard occurs in the Dieng Plateau or Banjarnegara district?
2. Which hazards are you most concerned about and how do you prioritise where to work?

3. What type of preparedness activities have you conducted to reduce the impact of these hazards?
4. How do you respond when a volcanic gas eruption occurs in the Dieng Plateau?
5. What programs have you implemented to reduce the impact of gas eruptions?
6. How are funds and resources allocated to the BPBD? What type of programs do you prioritise?
7. What kind of financial and capacity support do you receive from BNPB?
8. What extra resources do you think the Banjarnegara BPBD require to manage disasters more effectively?
9. Why do you think you were selected to work in the BPBD?
10. What do you think of the local capacity in the villages you've worked in throughout Banjarnegara to respond to disasters?

The leading questions below were asked during discussions with senior volcanologists at PVMBG and staff at the Dieng Volcanic Observatory:

1. What sources of information were used to develop the Dieng volcanic hazard map? How accurate is this map? Is it integrated into local planning decisions?
2. How do you respond when an eruptions occurs in the Dieng Plateau?
3. What equipment do you rely on to monitor seismic and volcanic activity and how do you relay warnings?
4. How do you interact, and share volcanic hazard information, with the local community?

Appendix 3: Survey conducted with 124 households, Dusun Simbar

Basic information:

1. Name: _____
2. Age: _____
3. Sex: Male Female
4. Livelihood: _____
5. How many people live in this home? _____
6. What is the highest level of education completed by a member of this household?

   Not yet finished primary school Primary school Middle School
   High School Diploma University
7. Do you have another income aside from farming? _____
8. Are there any other family members who also earn money for this household? If so, who and how? _____
9. Where are you originally from? _____
10. If you are originally from another village why did you move to Simbar?

    Work To buy land Follow my husband/wife
    Other _____

Information about poisonous gas:

11. Do you often worry about poisonous gas?

    Yes, very often (weekly) Often enough (monthly)
    Rarely, only if there is an eruption/earthquake Not at all
12. Has your land ever been affected by poisonous gas?
    a. If so, how did you meet your daily needs?

       Reduced family shopping expenditure Borrowed from family
       Borrowed from the bank Used savings Other _____

b. If so, how did you find the capital to plant again?

Borrowed from an organisation Borrowed from family

Borrowed from the bank Used savings Other _____

13. After a volcanic gas event how many days do you wait until entering the fields again? _____
14. Do you feel safe living here? _____
15. Do you feel comfortable living here? _____
16. Have you ever attended an information session about poisonous gas?

_____

a. If not, why?

Too afraid Too busy Too lazy

Not afraid of poisonous gas Other _____

17. Have your family members attended an information session?
    a. If not, why?

Too afraid Too busy Too lazy

Not afraid of poisonous gas Other _____

18. According to you, what distance is considered safe from Timbang Crater?

<50 m 50 – 100 m 100 – 500 m 500 m – 1 km

1 -2 km > 2 km

Financial information:

19. Does anyone in your household own a motor bike? _____
20. Does anyone in your household own a car/truck? _____
21. Has a member of your household already completed the Haj?

_____

22. If you already have children, have you already helped them buy/build a home? _____
23. How many parcels of land do you manage? _____
24. Do you give money to the Mosque? _____
    a. If so, when?

Often (every week) At harvest time

Building/renovating the Mosque

25. Has any member of your household borrowed money? _____

a. If so, where do you/they borrow it from?

The bank Family Neighbours

An organisation

b. How often do you/they borrow it per year?

Rarely (less than once) Once Twice

> than 3 times

Information about land ownership:

26. Do you own farm land yourself? _____

a. If so, how many parcels of land do you/they own?

1 2 – 3 4 – 6 > 6

b. How many hectares do you/they own?

0.1 – 0.5 0.5 – 1 1 – 3 > 3

c. Do you/they have a certificate of land ownership (issued by BPN)?

_____

d. Where did you/they get the land from?

Bought it Inherited from family Other _____

27. Do you manage rented land? _____

a. If so, how many hectares?

0.1 – 0.5 0.5 – 1 1 – 3 > 3

28. Have you, or someone in your household, ever experienced crop failure?

_____

a. If so, how did you meet your daily needs?

Reduced family shopping expenditure Borrowed from family Borrowed from the bank Used savings Other

_____

b. If so, how did you find the capital to plant again?

Borrowed from an organisation

Borrowed from family Borrowed from the bank Used savings

Other _____

29. Do you or someone in your household own land outside the area of Dieng?
    a. If so, where? _____
    b. Who manages the land? _____
    c. What is grown on the land? _____
    d. How many hectares is the land? _____

Appendix 4. Summary of survey results

The data below is a summary of the information obtained during the household survey of all Dusun Simbar's 124 households.

Table 12. Total hectares of land owned by households in Dusun Simbar (note that this data excludes farmers who partake in sharecropping arrangements, lease land or manage their parents land and such arrangements may fall within the 'no land' category).

Hectares of land owned	No. of households	% of total households
No Land	45	36
0.1-0.5	37	30
0.5-1	31	25
1-3	11	9
>3	6	5

Table 13. The type and frequency of ownership or leasing arrangements undertaken in Dusun Simbar (note that a single household may fall in various categories).

Land ownership status	No. of households	% of total households
Own land directly.	79	64
Lease and own land directly.	14	18
Landless:	45	36
Access land through rental or sharecropping arrangements.	32	26
Rent land or manage parents land.	46	37
Neither own nor lease land.	13	10
Identify primarily as a 'farm labourer'.	10	8

Table 14. The type and frequency of credit arrangements used by households in Dusun Simbar (note that a household may rely on multiple sources of credit during a single year).

Credit arrangements	No. of households	% of total households
Have ever borrowed money.	110	89
Borrow from bank at least once per year.	36	29
Borrow from family at least once per year.	34	27
Borrow from local organisation at least once per year.	26	21
Borrow from neighbours at least once per year.	24	20

Table 15. The number of households that have had their crops directly impacted by gas eruptions in Dusun Simbar.

Crops damage by volcanic gas in the past	No. of households	% of total households
Yes	45	36
No	79	64

Table 16. The level of concern informants from Dusun Simbar reported to feel due to the threat of poisonous gas eruptions.

Level of concern with volcanic gas (each household chose one response)	No. of households	% of total households
I never worry about volcanic gas.	11	9
I rarely worry about volcanic gas, only when there is a big event.	90	73
I worry about volcanic gas sometimes (monthly).	12	10
I worry about volcanic gas on a weekly basis.	11	9