THESIS

ECONOMIC RESILIENCE OF AGRIBUSINESS HOUSEHOLDS IN PUTIH RIVER REGION FOLLOWING THE 2010 MERAPI VOLCANISM EVENTS

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DISCLAIMER

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ABSTRACT

Motivated by preliminary field visit findings about the presence of ability to minimise loss resulting from impacts of the 2010 Merapi volcanism events on economic activity performed by agribusiness households in Putih River region, this research aimed at constructing economic resilience theory to explain the process in which this ability developed, measuring economic resilience of agribusiness households in Putih River region, as well as developing economic resilience model.

Construction of economic resilience theory adopting grounded-theory methodology explains that economic resilience emerges as a consequence from the implementation of strategies in dealing with impacts of disastrous events on business activity. These strategies, ranging from simply absorbing loss to taking variety of active measures, are shaped through the interaction of internal feature of business (contextual setting) and external situations (intervening conditions), as well as the length of business interruption. The presence of causal conditions, being physical damage, intensity of disastrous events, and disruption on utility service, also contributes influence to economic resilience.

Measurement of economic resilience finds the average aggregated economic resilience in a year period of time after disaster reached 0.33, denoting maintaining of one-third normal business functioning. Level of functioning that exceeds the normal functioning level (one value) as well as that reflects the absolute cessation of economic functioning (zero value) was also found. Over three timespans disaggregated economic resilience value shows tendency of inclination with time moving away from disasters. With robust statistical model (exceeding 0.9 R^2 value), the number of active measures implemented to deal with disaster impact was disclosed as the most influential factor to the development of economic resilience. Seen from the variability of time, type of measures being continuously influential was the one that involves change in business practice.

Those research findings and results present the existence of immanent feature of element at risk to soften severity resulting from disasters impact. This supports the possibility of living with disaster risk and can be an underlying reason to the necessity of promoting resilience nurture as complementary to mitigation and preparedness in disaster risk management practice. Another implication of this research includes inclusion of economic resilience value or index into disaster economic loss assessment practice to gain closer proxy to truly unavoidable economic loss.

This research acknowledges its weaknesses, particularly in relation to its simplistic performance of grounded-theory method. Some methodological difficulties within the work of measuring and modelling empirical economic resilience at micro-economic level are also noticed, particularly in determining appropriate parameters in both works without causing excessive burden to data collection process. Despite of these flaws, this research performs its capability in explaining economic resilience development process and conducting empirical measurement on resilience using economic purview at micro-economic level, as well as opens niches for future researches in topics of disasters' economic impact.

Key words: economic resilience, theory, measurement, modeling

INTISARI

Terdorong oleh survei pendahuluan yang menemukan adanya indikasi terdapatnya suatu kemampuan rumah tangga agribisnis di area Kali Putih untuk meminimalisasi kerugian ekonomi pada bisnis mereka akibat aktivitas vulkanisme Gunungapi Merapi di akhir tahun 2010, penelitian ini diarahkan untuk membangun suatu konstruksi teori kelentingan ekonomi (*economic resilience theory*) yang menerangkan bagaimana kemampuan meminimalisasi kerugian yang disebut sebagai *economic resilience* ini terbentuk, mengukur derajat dari *economic resilience* ini, serta memodelkan *economic resilience*.

Konstruksi teori *economic resilience* yang mengadopsi metode penelitian grounded-theory menjelaskan bahwa economic resilience merupakan konsekuensi dari penerapan strategi-strategi dalam menghadapi dampak kejadian alam pada aktivitas ekonomi. Strategi-strategi ini, berkisar dari sekedar menerima kerugian hingga melakukan berbagai macam reaksi aktif, terbentuk melalui interaksi-interaksi berbagai keadaan yang mendukung maupun menghambat, serta durasi dari gangguan pada aktivitas ekonomi. Penyebab pokok dari gangguan pada aktivitas ekonomi, yakni kerusakan pada lahan pertanian, derajat kejadian alam, serta kerusakan pada infrastruktur pendukung pertanian juga memengaruhi pembentukan *economic resilience*.

Pengukuran derajat *economic resilience* mengungkapkan bahwa rataan derajat *economic resilience* dalam jangka waktu setahun pasca vulkanisme mencapai 0,33, menunjukkan kemampuan untuk mengembalikan fungsi ekonomi hingga sepertiga keadaan normal. Dari rumahtangga agribisnis tersurvei, derajat kemampuan ekonomi yang melebihi keadaan normal (nilai *economic resilience* >1,00) serta yang menunjukkan ketidakberfungsian total (nilai *economic resilience* = 0,00) juga ditemukan. Tinjauan dinamika economic resilience menunjukkan bahwa derajat *economic resilience* cenderung meningkat seiring bertambahnya waktu menjauhi saat kejadian vulkanisme. Dengan model statistik yang kuat (nilai R^2 melebihi 0,9), jumlah tindakan aktif yang dilakukan untuk menghadapi dampak vulkanisme pada aktivitas ekonomi ditemukan sebagai faktor yang paling berpengaruh pada derajat *economic resilience*. Ditinjau dari segi dinamikanya, jenis tindakan aktif yang terbukti paling berpengaruh adalah yang melibatkan perubahan pada praktik kegiatan ekonomi.

Temuan-temuan tersebut menunjukkan bahwa elemen beresiko sejatinya memiliki kemampuan dari dalam dirinya sendiri untuk mengurangi bencana akibat kejadian alam. Hal ini dapat mendukung konsep "hidup berdampingan dengan alam" serta mendorong perlunya ditumbuhkannya kemampuan menghadapi dampak kejadian alam sebagai pelengkap dari upaya mitigasi dan kesiapsiagaan dalam manajemen bencana. Implikasi lainnya, derajat empiris *economic resilience* dapat dilibatkan dalam penghitungan kerusakan dan kerugian sehingga akan menghasilkan perkiraan yang lebih akurat terhadap kerugian yang benar-benar tidak dapat ditangani.

Penelitian ini mengakui kelemahannya pada penerapan metode *grounded-theory* secara relatif sederhana. Kesulitan metode terdapat pada penentuan indikator dan parameter pada pengukuran derajat dan pemodelan *economic resilience* tanpa membebani proses pengumpulan data tentang ekonomi yang dihadapkan dengan isu kerahasiaan. Meskipun begitu, penelitian ini terbukti berhasil menerangkan bagaimana *economic resilience* terbentuk, mengukur derajatnya secara empiris, dan membuka peluang bagi penelitian lanjutan yang mengkaji dampak kejadian alam pada ekonomi.

Kata kunci: economic resilience, teori, pengukuran, pemodelan

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Abbreviations and Glossary

Bappenas	:	Badan Perencanaan Pembangunan Nasional (Indonesia's National Bureau for Development Planning)
BNPB	:	Badan Nasional Penanggulangan Bencana (Indonesia's National Bureau for Disaster Countermeasure)
BPPTK	;	Balai Penyelidikan dan Pengembangan Teknologi Kegunungapian (Indonesian Agency for Investigation and Technological Development on Volcanism)
BPS	:	Badan Pusat Statistik (Statistics Bureau)
DSER	:	Direct Static Economic Resilience
PVMBG	:	Pusat Vulkanologi dan Mitigasi Bencana Geologi (Indonesia's Center for Vulcanology and Geological Hazard Mitigation)
RBI	:	Rupa Bumi Indonesia (map containing Indonesia's land use information and administrative boundary)
VAAC	:	Volcanic Ash Advisory Centre (one of divisions within Australia's metrological bureau for volcanic ash observation)
VEI	:	Volcanic Explosivity Index
District	:	an administrative region comprises of several villages administrative areas with authority level below a regency
Hamlet	:	an administrative region smaller than a village, hamlets constitute a village
Regency	:	an administrative region comprises of several districts with authority level below a province
Sengon	:	a perennial timber plant, species *Enterolobium cyclocarpum*
Teak	:	a perennial timber plant, local name: *jati*, species *Tectona grandis*
Zalacca	:	name of a fruit, species *Salacca zalacca*, also known as snake fruit

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1 INTRODUCTION

1.1 BACKGROUND

The 2010 eruption of Merapi Volcano, commencing in late October 2010 and culminating on 5 November 2010, was pronounced as the volcano's biggest eruption event since the last century (BNPB, 2010b). This 4-VEI explosive eruption has brought about the most intense volcanic material ejection and has led to high uncertainty in emergency response, particularly in terms of evacuation activity (PVMBG, 2010; BNPB & Bappenas, 2011; BNPB, 2010a; BNPB, 2011; VAAC, 2010). Series of eruption took place until the end of November, and finally on 3 December 2010 the volcano's caution status was lowered (BNPB, 2010c). In addition to high temperature pyroclastic and intensive tephra fallout, threat of lahar from the volcanic materials deposit shadowed area close to rivers which upstream lies in the vicinity of volcano's summit (see **Figure 1.1**). Amongst the total volume of material, 60% of deposit was present in west flank, heading to Pabelan and Putih River, while the rest 40% was in south flank, heading to Gendol and Opak River (BNPB, 2011). The first lahar to flow was seen on 4 November 2010 and series of lahar flood events continued until months later. Per April 2011, only about 25% from total volume of volcanic material deposit has cascaded while the rest 70% was predicted to still be flowing until the next three rain seasons, or approximately within three years period (KOMPAS, 2010; BNPB, 2011).

Impact of 2010 Merapi Volcano eruption involved (but not limited to) casualties, property destruction, mental and health problems, and economic loss. Over 350,000 people were evacuated during the eruption period in October-December 2010, as many 353 people as were reported killed, and the economic loss were priced as much as 3.62 trillion Rupiah (The Jakarta Globe, 2010; BNPB & Bappenas, 2011). Lahar flood events also led to detrimental impact on the affected regions, with type of impacts ranging from the destruction of lifeline system utilities (particularly irrigation), physical damages to farm land, settlements, and transportation infrastructures, as well as evacuation and casualties (BNPB, 2011).

Amongst regions receiving impact from the complexity of Merapi's volcanism, region along Putih River became the focus of interest. The 5 November 2010 explosive eruption resulted in intense tephra-fallout ground-deposits as the wind drove volcanic properties southwestward. In addition to this, the area was severely affected by lahar. Lahar even made the popularity of the region since it led to total devastation of Gempol Hamlet, which lies in the downstream area of Putih River (see **Figure 1.2** for the illustration of 2010 Merapi volcanism impact on the region). Threat of lahar to this area continues as heavy rainfall in the summit area can trigger volcanic deposit flowing. The remaining volume of volcanic deposits possibly to flow was predicted to be lots higher than the volcanic materials that have currently flowed (BNPB, 2011).

The above-mentioned environmental events brought impact on households inhabiting area in the proximity of Putih River whose livelihood is predominantly sourced from selling agriculture products. Official statistics mention that in 10 villages along Putih River, as much 73.65% as land is allocated for farming (BPS, 2008a). Interview with the leader of hamlet that situated along Putih River also revealed that at average, around 80% of households work in agriculture.

Figure 1.1 Rivers with Upstream Lies on Merapi Volcano Summit

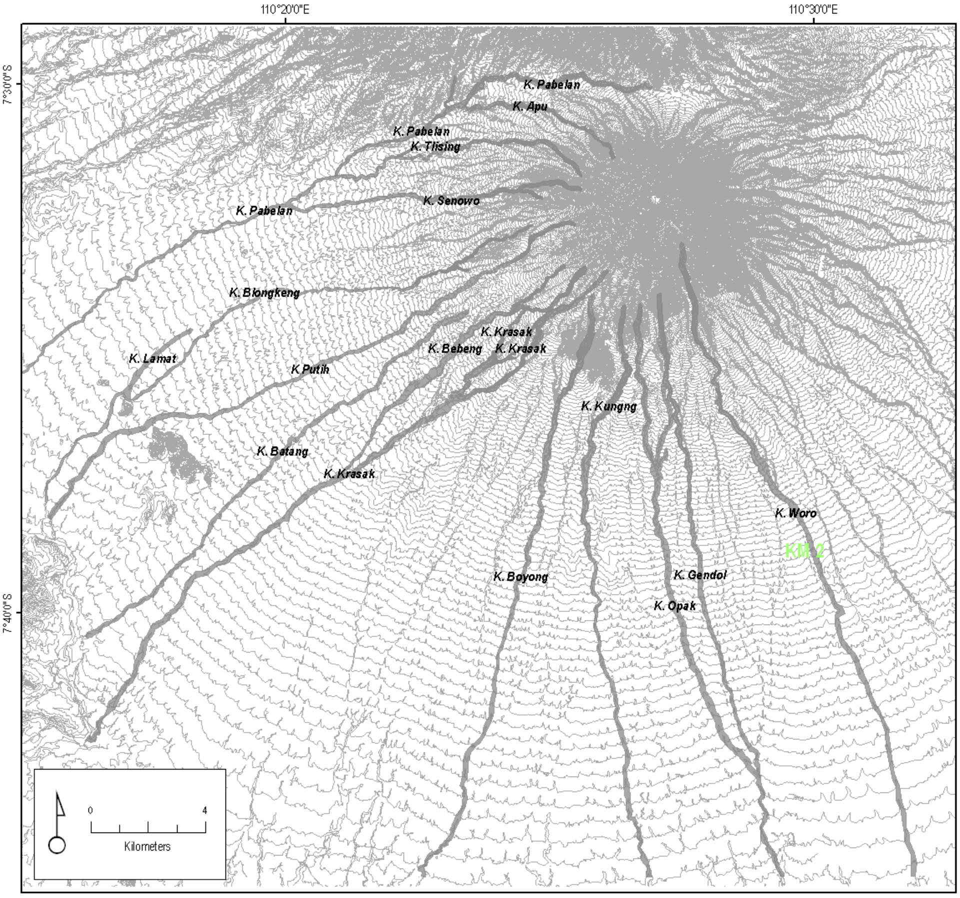


Figure 1.2 The Complexity of Volcanism Impact in Region along Putih River

			
Tephra load on *zalacca* trees, seen in Srumbung Village, November 2010 Source: (Nugroho, 2010)	Lahar from Putih River in Jumoyo Village disrupted transportation network of Yogyakarta-Magelang, January 2011 Source: (BNPB, 2011)	Lahar from Putih River devastated Gempol Hamlet, January 2011 Source: (KOMPAS, 2010)	Lahar in Putih River seen in Cabe Kidul Hamlet, October 2011 Source: author's documentation, 2011

Preliminary field visit witnessed that following 2010 Merapi volcanism events, farmers struggled to deal with the economic impacts of volcanism and to maintain their economic productivity. A farmer in Cabe Kidul Hamlet (Srumbung Village) mentioned that right after the eruption event on 5 November 2010, he got his entire *zalacca* farm covered by hot ash and he had to spend a month to clear his farm up. The heavy load of up to 30cm thick volcanic ash caused half of his *zalacca* plants to collapse and the fruits were rotten due to tephra's hot temperature, leaving him with no financial output from the farm production.

He recalled that the first eruption on 26 October 2010 did not lead to the worst consequence, but the 5 November 2010 eruption did. He was in evacuation during this eruption period, doing his duty as the head of hamlet, organising his community member. With this duty and having assumption that the road was blocked, he did not come home to visit his farm. Unfortunate for him, he could not do an early harvest, making him get nothing when evacuation was over. With his farm damaged, production outcome was far lower than it should have been if eruption never happened. In a normal condition, he could harvest *zalacca* once a week yielding around 50kgs fruits. After getting hit by the ash, farm was damaged and he could not yield anything. The plants were productive no more since ash load damaged the leaves. It took more than a year before these plants could restore producing fruits. To keep economically productive, he planted chili, corns, and beans while also restoring the rest of *zalacca* plants that could still be saved. Compared to his original commodity, he regarded these later commodities as less profitable. Cultivating *zalacca*, he did not have to renew the plants, as they are long-lived plants (can live and produce for about 20 years); while with these short-lived plants he had to renew the plants within short period. Corns, for example, after yielding crops at the age of about three months, have to be renewed. As the restoration of land from the detrimental consequence of volcanic ash took time and the growth of new commodities needed some time as well, the farm did not produce during two months period after the eruption. This farmer could then enjoy crops from his chili plants on February 2011. Since the farm is 50m away from the river body, his suffering was lessened since lahar did not contribute to worse consequence.

Another farmer, whose farm lies in Cabe Lor Hamlet (about 1km away from Cabe Kidul Hamlet), told different story. His farm was completely destroyed by lahar. Nevertheless, during the evacuation period before lahar occurring, he could send his wife and kids home to do an early harvest. They got 700kgs of *zalacca* fruits and could sell them. Following the disaster event, he jumped into mining activity and sold sand that was present in his farm to remain economically productive.

The above-mentioned narrations highlighted the presence of such process containing different circumstances with relation to 2010 Merapi volcanism's impact on agribusiness households' economic activity. Hot ash load in case of farmer in Cabe Kidul Hamlet and lahar flood in case of farmer in Cabe Lor Hamlet implied a background situation, *zalacca* plants collapse in case of farmer in Cabe Kidul Hamlet and devastation of farm land in case of farmer in Cabe Lor Hamlet implied the impact of 2010 Merapi volcanism events, while cultivating chili and corns as complementary and substitution to *zalacca* and jumping into sand-mining activity implied response to the impacts. Result of this process was also implicitly present. While the farmer in Cabe Kidul Hamlet enjoyed his chili crops in post-disastrous event period, the farmer in Cabe Lor Hamlet received money from his sand-mining activity.

What then interesting was how the entire process in relation to the impact of 2010 Merapi volcanism events on agriculture economy, as well as result of this process, can be pictured at larger-scale agribusiness households situated within Putih River region.

1.2 PROBLEM STATEMENT

Households with agriculture-based livelihood residing area along Putih River as business entity performed different response in dealing with impacts of the 2010 Merapi volcanism events on their economic activity. As preliminary field visit provided indication, situations surrounding this response were present and along with the response itself shaped a process from which such result was subsequently generated. However, big picture of this process as well as its result was still missing since the amount of information obtained during preliminary field visit was considerably little and more thorough analysis has not been conducted.

Rose (2004, 2007, 2009), Rose & Lim (2002), and Rose, Oladosu, & Liao (2007) term the ability of business to cushion itself against loss due to impact of disastrous events and to maintain functioning after these disasters as *economic resilience*. This ability is measurable through conceptual and operational calculation technique that focuses on the deviation of actual economic loss from the maximum possible economic loss. As a resultant of behavioral conditions in the post-disaster period, this ability is fluctuating through the variability of time since the performance of business at certain period close to the happening of disasters might be different from it at a further-away period, and thus the dynamics of economic resilience will then be present. (Rose, 2007; 2009)

This research was interested in observing the process related to agribusiness households' performance in dealing with economic impact of 2010 Merapi volcanism events as well as result generated from this process. With reference to the works of Rose and his fellows previously mentioned, the result of process resembled the ability to deal with and minimise the economic loss (i.e. the level of economic resilience), while the process in which this result was generated resembled the economic resilience theory that explained interrelations amongst situations which led to the achievement of this ability. Having the explanations and the level of economic resilience known, further investigation could be performed to establish a model that showed what situations would possibly contribute the most influence to economic resilience level. This latter analysis would draw more general findings about economic resilience.

Initial researches in topic of or that closely resemble economic resilience do exist (see Webb, Tierney, & Dahlhamer, 2002; Rose & Liao, 2005; Rose, Oladosu, & Liao, 2007; Leiter, Oberhofer, & Raschky, 2009; Zhou, Wang, Wan, & Jia, 2010; and Sun, Zhou, Wang, & Yuan, 2011; among others) and they can possibly give insight and answer to the process in which economic resilience achieved and what situations contribute the most influence to it. However, with intent of providing empirical comparison to the current references, this research sought for its own explanation by constructing an economic resilience theory 'from the ground' through the capture of empirical and local experience, which would then be capable of providing input to establish economic resilience model to give answer on what factor being the most influential to the achievement of economic resilience. Other underlying reasons, being either that: the previous literature or research was aimed towards business in urban setting, was conducted in macro-economy level, was carried out based on hypothetical simulation rather than empirical observation, did not employ the similar conceptual basis of economic resilience, did not specifically concern agricultural activity, was carried out based on totally different character of disastrous events, also encouraged the quest for its own explanation.

1.3 RESEARCH OBJECTIVES AND RESEARCH QUESTIONS

Objectives of this research were:

1. To construct economic resilience theory explaining the process in which economic resilience of agribusiness households in Putih River region in the aftermath of 2010 Merapi volcanism event was developed;
2. To measure agribusiness households' economic resilience in a time-path manner; and
3. To develop economic resilience model.

The following **Table 1.1** provides detailed research objectives and research questions that served as guidance in the attainment of research objectives:

Table 1.1 Research Objectives and Research Questions

RESEARCH OBJECTIVES AND QUESTIONS
To construct economic resilience theory
1. What conditions/circumstances relate to the impact of 2010 Merapi volcanism events on agribusiness business?
2. How do those situations interrelate to each other?
To measure agribusiness households' economic resilience level in a time-path manner
3. What indicators and parameters can be used to measure economic resilience level?
4. How much loss could be minimised at a time point in the aftermath of 2010 Merapi volcanism events?
5. How does economic resilience fluctuate during a period of time in the aftermath of 2010 Merapi volcanism events?
To develop economic resilience model
6. What variables can be used as predictors for economic resilience level?
7. How much does a variable contribute influence to economic resilience level?
8. What variable contributes the most influence to economic resilience level?
9. Is the model good enough to explain the economic resilience?

1.4 LIMITATIONS

The concept of economic resilience applies to business behaviour or flow, without evaluating physical stocks (e.g. damage to business property) which instead is the domain of engineering-based resilience observations (Rose & Lim, 2002; Rose, Oladosu, & Liao, 2007; Rose, 2004; 2007; 2009; Bruneau, et al., 2003). Even though business flow measure has advantages over stock measure in disasters economic loss assessment (see discussion in section **2.1 Economic Resilience** sub section **2.1.1 Definition and Concept**), it should be clarified that economic resilience assessment will address only the level of business economic functioning, not the state of its stock.

Another limitation relates to livelihood analysis. Although business activity being observed in this research is a source of livelihood, no specific (sustainable) livelihood assessment was performed. As suggested by DFID (1999), adequate livelihood analysis should engage comprehensive well-being factors that are sometimes apart from economic output and are unquantifiable, such as belief and cultural welfare. This research concerned only economic face of livelihood and treated households as business entity, therefore it engaged economic purview in observing and analysing livelihood in the aftermath of disasters.

This research observed business at micro-economic level. Due to this, major type of economic loss being observed as proxy to economic resilience was direct loss, with no inclusion of indirect loss (see description about direct and indirect loss in section **2.1 Economic Resilience** sub section **2.1.1 Definition and Concept**).

Issue of temporal dimensions seems to be a point of debate in disasters' economic impact assessment (Xiao, Wan, & Hewings, 2011). Temporal dimension used in this research was limited to a year period after the occurrence of 2010 Merapi volcanism events. Longer period of observation might provide holistic picture of economic resilience, but shorter period of observation made detail and longitudinal investigation possible, thus satisfied the concept of resilience as a behavioral process while contrasting with time and financial resource limitation. This would also be complementary to initial business recovery observation that was conducted in cross-sectional manner and conducted in a long-period after disasters occurrence (Webb, Tierney, & Dahlhamer, 1999, 2002). While some economic-loss estimation method suggests the use of length of physical asset reconstruction to limit the time period in assessing disasters' economic impact (Bappenas; the Provincial and Local Governments of D.I. Yogyakarta and Central Java;

International Partners, 2006), the fact that reconstruction works has not finished during this reseaarch being undertaken made this limitation criteria not applicable.

1.5 RESEARCH BENEFIT

This research serves benefits as follows:

1. Improving accuracy in modelling disasters' economic impact.
   The concept of economic resilience implies that economic entities as recipients of disasters impact do not passively react to the disruption brought about by disasters; therefore the actual economic loss is likely to be different from estimation that does not involve the influence of this active measure to minimise loss. Involving economic resilience to the economic loss modelling will lead to the amount of economic loss truly unavoidable.
2. Precautionary measures of poverty level.
   Revealing the ability of households in maintaining their economic functioning after such disruption provides insight to the dynamics of economic prosperity. They who fail maintaining economic functioning in a long-time period may add the number of poor.
3. Contribution to vulnerability analysis.
   With its concern on business functioning level in the aftermath of disastrous events, economic resilience provides input for vulnerability analysis for subsequent disastrous event with economic activity and productivity as element at risk. Economic entity with low degree of economic resilience would possibly belong to vulnerable groups.
4. Methodological contribution.
   The construction of economic resilience theory that initialised the establishment of economic resilience measurement and modelling provides a way to understanding the economic resilience in a specific way with respect to the character of natural hazard and affected agents. Attainment of variables for measuring and modelling of economic resilience from this own-developed theory contributes methodological value for further research.

2 LITERATURE REVIEW

2.1 ECONOMIC RESILIENCE

2.1.1 Definition and Concept

Lexical source defines *resilience* as:

> *"the ability of people/things to feel better quickly after something unpleasant such as shock, injury, etc.; the ability of a substance to return to its original shape after it has been bent, stretched, or pressed"* (Oxford University Press, 2011e)

While *economic* is defined as:

> *"connected with the trade, industry and development of wealth of a country, an area or a society; producing enough profit to continue"* (Oxford University Press, 2011b; Oxford University Press, 2011c)

With reference to lexical definitions above, *economic resilience* can be perceived as *the ability of economy/wealth to return quickly to its original condition after enduring such shocks or pressures.*

Definition and conceptualisation of resilience in the context of economy are prevalent in works of Adam Rose and associates (Rose & Lim, 2002; Rose, 2004; 2007; 2009; Rose, Oladosu, & Liao, 2007). The earlier works (Rose & Lim, 2002, p. 4; Rose, 2004, p. 308) define resilience as "the ability of a/an entity/system/community to absorb and cushion itself against damages and losses" (more clear mentioning of *economic* resilience emerges in the latter work). The more recent works, with adding the word *static* before the term economic resilience (so that it becomes *static economic resilience*), give "the ability of an entity or system to maintain function (e.g., continue producing) when shocked" as definition (Rose, Oladosu, & Liao, 2007, p. 516; Rose, 2007, p. 384; 2009, p. 8). As to encompass the dynamic consideration of this capability, the term *dynamic economic resilience* is then introduced with definition being: "the speed at which an entity or system recovers from a severe shock to achieve a desired state" (Rose, 2007, p. 384; 2009, p. 8). Thus, the dynamic viewpoint of economic resilience will involve temporal dimension and integrate the presence of fluctuation and stability.

Economic resilience comprises: 1) *inherent resilience*, which is the ability to deal with crisis under ordinary condition or in other words, ability that is already built up within the system, e.g. availability of inventories, ability to substitute other input materials for those being cut due to external shocks; and 2) *adaptive resilience*, which is the ability to deal with crisis on the basis of extra effort, e.g. ability to increase the possibilities of input substitution, change in production technique (Rose, 2004; 2007; 2009; 2011; Rose, Oladosu, & Liao, 2007).

Economic resilience is present at three level of economic entities, being: microeconomic level, e.g. individual firm, individual household, or individual organisation; mesoeconomic level, e.g. collective group of firms, households, economic sector, individual market; and macro-economic level, e.g. all individual sectors and markets combined, a nation as a whole (Rose, 2004; 2007; 2009; Rose, Oladosu, & Liao, 2007).

The definition of (static) economic resilience positions itself to be in similar view to definition of resilience from ecological perspective (Holling, 1973), in a manner that resilience expresses the ability of a system to absorb external influence and driving factors and to continue its existence, or in other words, *buffer capacity*. However, difference is stressed. While in ecological version resilience shows the amount of disturbance an ecosystem can absorb without causing change, in economic version resilience shows the amount of losses due to such shocks that can be minimised in order to continue functioning. Reasons being that while changes can be a useful proxy to identify resilient ecosystem, it has little advantage in assessing economic system because only catastrophe is likely to trigger changes in economic system (Rose, 2007).

In comparison with the conceptualisation present in engineering-based academic work (Bruneau, et al., 2003), definition and concept of economic resilience differs in some ways. While the engineering-based perspective includes “reduced probability of failure” as the aspect of resilience, the economic-based perspective does not concur, with reason being that this aspect is more the domain of mitigation rather than resilience. Mitigation is perceived as the pre-event action with concerns mainly on technological or technical improvement to reduce losses in the aftermath of disasters (e.g. the use of special structure resistant to ground shaking). On the other hand, even though some actions can be taken in the pre-event of disaster to enhance resilience, resilience is a post-disaster response and mainly is behavioral (e.g. the inventories of water) rather than being fixed conditions like mitigation is (Rose & Lim, 2002; Rose, 2004; 2007; 2009).

Another dissimilarity emanates from the aspect of “reduced time to recovery”. While this concept seems to be in agreement with dynamic economic resilience, economic perspective does not follow the notion of “returning to pre-event functioning level” as indication of recovery. Instead, it uses the notion “desired state” to allow for growth, changes, and new equilibrium state, as opposite to the concept of *stability*. Underlying reason is that while an engineering work can be assumed to be able to snap back to its initial condition, an economic system may experience change to adapt to new condition in the aftermath of disasters and the use of term “desired state” is intended to reflect the behavioral nature of resilience (Rose, 2007; 2009). This presence of adaptive measure shows compliance with the conceptualisation of resilience originated from social-organisational viewpoint (Paton & Johnston, 2001; Paton, 2007). Since “return to the previous state” is considered to be untenable due to the physical, social, and psychological changes of societal reality after experiencing the disasters, the definition of resilience within their work is referred to the wellness of people and society to adapt to a changed reality.

Albeit having these discrepancies, the conceptualisation of resilience from engineering and economic viewpoint shares similar point about the aspect of “reduced consequences from failure”. The notion of “ability to cushion against loss and maintain functioning” being present in economic resilience concept serves this similarity.

The concept of resilience is often interrelated with other concepts within disaster management practice. Two terms likely being most frequently interrelated to it are *vulnerability* and *sustainability*. Rose (2007; 2009) emphasise the difference between vulnerability and resilience from its temporal dimension. Vulnerability reflects pre-disaster condition whereas resilience reflects post-disaster condition. This idea is in consistence with the definition of resilience being served by lexical definition. Despite of this difference, resilience and vulnerability does have relationship, being that resilience and vulnerability share reciprocal influence, of which the improvement of resilience can reduce vulnerability to future events, along with the presence of mitigation (Rose, 2007; 2009; Zhou, Wang, Wan, & Jia, 2010). In regard with the term *sustainability*, resilience is said to correspond with short-run survival and recovery mechanism that contributes to long-run survival, and when this long-run survival is integrated with the concept of life and environmental quality improvement, becomes the core concept of sustainability (Rose, 2007; 2009; 2011). However, it is also acknowledged that these two concepts can sometimes be less distinct especially when addressing long-term disasters, like climate change, of which reference to a specific shock/hazardous event in order to maintain the idea of resilience as short-run response and recovery is difficult to make.

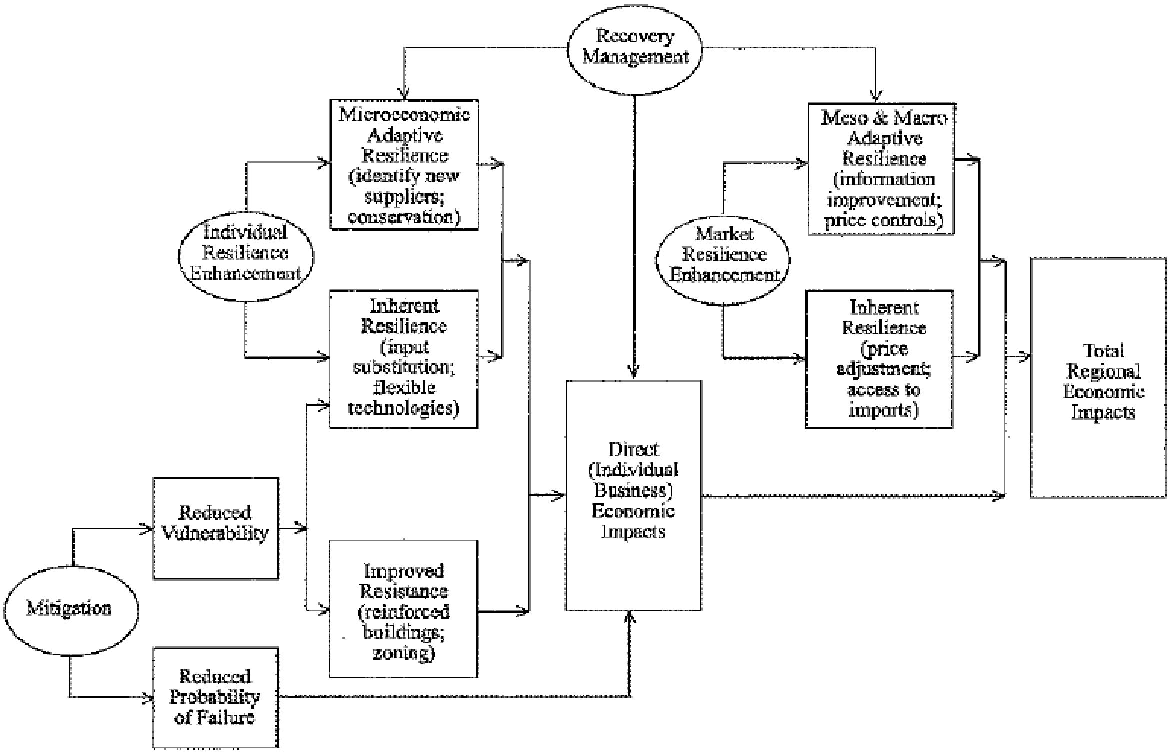
The concept of economic resilience is to be incorporated to the measure of flow (operation/functioning of business/economy) in the aftermath of disasters, as opposite to the stock damage measure (Rose & Lim, 2002; Rose, 2004; 2007; 2009). The measure of stock addresses the quantity of capital at a single time point while the measure of flow corresponds to the service or output that stocks can give over time. Superiority of flow measure in the aftermath of disaster over stock damage measure is as follows (Rose & Lim, 2002):

1. Flow measure can cover broader range of loss possibility, as economic loss due to business interruption is still be possible to happen even without stock damage.
2. Flow measure reflects welfare better than stock measure does as it involves the variability of time.
3. Flow measure is more readily linked to the assessment of indirect impacts of disasters on business. (Direct and indirect impact is differentiated by their sequence. In the aftermath of earthquake, for example, the damaged electricity infrastructure that forces a factory to shut down its operation can be referred as direct impact. While the shutdown of this factory gives impact to other factories, e.g. the factory that uses products from it as input materials, can be referred as indirect impact.)
4. Flow measure supports the idea that disaster losses are dependent not only on the severity of hazardous events, but also on human integrity, will, and resources.

The involvement of economic resilience in disaster economic loss modelling and assessment is said to serve more accurate estimates because it strongly supports the idea that given a shock, businesses will not be just passive and they will perform their best to get their functioning. With this incorporation to the assessment and modelling of economic loss in the aftermath of disaster, overestimation can be avoided. In addition to this, recovery decision and vulnerability analysis can also be improved (Rose & Lim, 2002).

The following **Figure 2.1** presents the role of economic resilience in disaster economic losses with also its interrelationship with other close concepts (mitigation and vulnerability):

Figure 2.1 The Role of Economic Resilience in Disaster Economic Losses



(Image is property of Rose, 2004)

2.1.2 Quantifying and Measuring Economic Resilience

Originated from its concept, operational formula for quantification of static economic resilience is presented as the deviation of actual losses experienced by an individual business or economic entity or individual market from the maximum losses possibly be endured given that such amount of input for business production is curtailed by such shocks/disasters. This quantification concept is formulated in mathematical formula as appears in **Equation 2.1** (Rose, 2007; 2009):

Equation 2.1 Direct Static Economic Resilience

$$DSER = \frac{\%\Delta DY^{m} - \%\Delta DY}{\%\Delta DY^{m}}$$

DSER stands for Direct Static Economic Resilience, refers to the amount of which estimated actual direct economic output reduction (ΔDY) deviates from the maximum possible output loss (ΔDY^{m}) that is experienced by individual business firm/household/organisation/market. The term "direct" here is used to indicate that DSER corresponds to "partial equilibrium" that expresses the operation of economic entity itself (with disasters/shocks as the only source of influence, i.e. without influence from other economic entities). DSER is presented as a percentage number, as a reflection that the concept of economic resilience is not aimed to a level of output, but a level of functioning instead.

The key point of this mathematical formulation lies on how to define the possible maximum loss as a baseline. The application of linear input-output model, which examines the direct/linier consequence of input supply shortage to the operation of an economic entity (i.e. with X% of input reduction, X% of economic output reduction will happen). As this linear consequence model could implicitly omit the presence of resilience, it could be used as the defined standard to examine resilience itself.

In order to observe the whole economy (i.e. macro level), both direct and indirect impact (i.e. price and quantity interactions) should be incorporated into quantification and measurement of economic resilience. The "total" static economic resilience will then correspond to "general equilibrium". To serve this objective, the utilisation of Computable General Equilibrium (CGE) model or macroeconometric model is then chosen, as these techniques are capable of explicitly including market forces into the computation. Total static economic resilience will then operationally mean the gap between linear input-output multiplier and Computable General Equilibrium (CGE) model. This is presented as the following **Equation 2.2**:

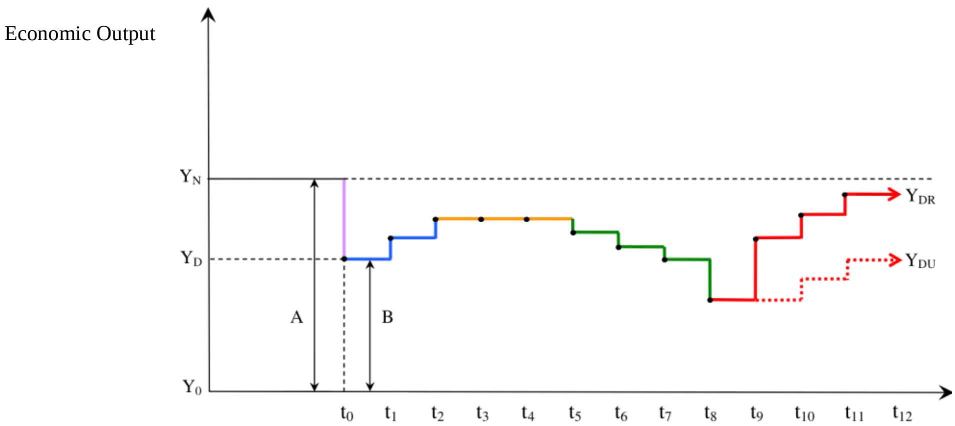
Equation 2.2 Total Static Economic Resilience

$$TSER = \frac{\%\Delta TY^m - \%\Delta TY}{\%\Delta TY^m} = \frac{M\%\Delta DY^m - \%\Delta TY}{M\%\Delta DY^m}$$

TSER, standing for Total Static Economic Resilience, represents the resilience of the whole economic system being observed. Whereas M is the economy-wide input-output multiplier. Similar to DSER, TSER is presented as percentage number.

Over a period of time, one of the interesting points in observing economic resilience is the variability of the achieved loss reduction, i.e. the variability of static economic resilience. This variability indicates fluctuation on the effectiveness of such resilience action over time. The time-path of static economic resilience constitutes what so-called dynamic economic resilience that can be represented over a diagram, as appears through the following **Figure 2.2**:

Figure 2.2 Static Economic Resilience over a Period of Time



(Image is property of Rose, 2007; 2009)

Y-axis denotes the level of business activity output, while the X-axis expresses time. The normal level of economic output is indicated by Y_N, proceeding until the occurrence of external shocks (denoted at t_0). The disruption causes modification to the level of economic activity and, as opposed to absolute cease of the economy (baseline losses) as denoted by Y_0, the presence of economic resilience promotes the post-shock achievement until the level Y_D. As Y_D is a result of resilience influence, the resilience value could be measured as the following **Equation 2.3**:

Equation 2.3 DSER Quantification from Graph

$$\frac{Y_D - Y_0}{Y_N - Y_0}$$

The initial level of resilience right after the shock occurs is most probably representing the presence of *inherent resilience*. Through time, the level of resilience could rise (see between t_0 to t_2) likely due to the presence of *adaptive resilience*, then reach an equilibrium state (see between t_2 to t_5), or adversely, could also sustain a downturn (see between t_5 to t_9) possibly because some disaster-coping strategy is no longer effective. This variability of resilience makes up the *dynamic economic resilience*. The sense of 'dynamic' is often referred to the matter of stability or the speed of achieving a particular level of resilience. The focal point of this concept is the resilience pattern, being what level exists at a particular point of time and why it exists.

In the diagram, the line of Y_{DR} denotes the effects of reconstruction works or also external assistance on the level of achieved loss-reduction (e.g. in the case of electricity blackout, water service disruption, or other lifeline system disruption, Y_{DR} represents the amount of economic output being achieved after the repair of electricity generator and restoration of electricity distribution), Y_{DU} reflects the scenario if no reconstruction or external support was available (i.e. the level of economic output if electricity distribution is still disrupted).

Operationally, the dynamic economic resilience could express the total reduction in loss triangle (the loss triangle is the area between Y_N and Y_D), which is computed through dividing the area under the recovery path by the area of the rectangle (Y_N - Y_0) (t_i - t_0). Given the presence of Y_{DR} and Y_{DU} scenario, it will be possible to infer how effective the reconstruction or external support is to enhance the degree of loss reduction.

2.1.3 Initial Works in Relation with Economic Resilience Topic

Tierney (1995) performed a large mail-survey to individual firms in Des Moines and Los Angeles in the aftermath of Midwest flood and Northridge earthquake to disclose the impacts of disasters on business activity. Important findings include: 1) physical damage to business properties was not the major reason for business interruption, rather, disruption of lifeline service (water for the case of Des Moines and electricity for the case of Los Angeles) was the major reason for business closure in a period of time after the disaster events (median of closing time: 4 days for Des Moines, 2 days for Los Angeles) and dollar losses; 2) other reasons for business closure included loss of customers and inability of workers to reach the workplace; 3) the popular mechanism of overcoming the impacts of disasters was by using personal savings, loans and insurance, and mainly, simply absorb the losses; 4) major reason being said to support business recovery was the overall improvement in economy, and some of information sources also cited the occurrence of disasters as the stimulus for growth; 5) in Los Angeles, small businesses which experienced severe physical damage in the aftermath of Northridge earthquake were more likely to being worse off.

Webb, Tierney, & Dahlhamer (1999) conducted a large-scale mail survey to private-sector firms across the United States aimed at disclosing factors that influence firms preparedness towards disasters, disaster-related source of business disruption and financial loss, and factors affecting the business ability to recover in the aftermath of disasters. Among extensive findings, it was disclosed that: 1) the degree of preparedness was dissatisfactory, denoted by the small number of preparedness action being conducted; 2) the disaster preparedness was predominantly taken to enhance life safety rather than to ensure business continuity; 2) apart from direct damage emerged in the aftermath of disasters, disruption in lifeline service and damage to the nearby area that affected the traffic of demand also contributed to business disruption; and 3) size of firms, health of business prior to disasters, and initial disaster experience influenced the extent of business recovery. It is stressed within the research that confidentiality matter causes the proxy of recovery to be rather qualitative and general (being: the firms condition after disaster is about the same, better-off, or worse-off) than detail quantitative measure of business performance. Besides, as the survey is conducted cross-sectionally, no behavioral process of recovery could be captured.

Webb, Tierney, & Dahlhamer (2002) develop indicators and predictors to predict the long-term business recovery following the occurrence of disasters. The dependent variables being used are: the owner's perception on the current state of business; recent number of employees; recent number of clients; and recent profitability level of business, of which four of them are measured as ordinal scale. The predictors used to develop the model of recovery are:

1. Business and owner characteristics, consist of: the economy sector in which business operates (boolean); number of full-time employees (ordinal scale); business age (ordinal scale); financial condition (ordinal scale); business ownership (boolean); legal status (boolean); business location (boolean); primary market (boolean); woman-owned (boolean).
2. Previous disaster experience (boolean).
3. Direct and indirect disaster impact, consist of: degree of physical damage; duration of business closure; lifeline lost; degree of disruption on business operation, of which all of them are measured in ordinal scale.
4. Loss containment measure, consist of: number of aid used and number of preparedness actions participated; both are measured in ratio scale.
5. Business environment, being the owner-perceived business climate (ordinal scale).

Amongst those predictors, only business age, financial condition, primary market area, degree of physical damage, duration of business closure, degree of disruption on business operation, and owner-perceived business climate contribute to the model at confidence level of 95% or more. Although the R^2 of the overall model is about 25%, the performance of the whole model is good with confidence level of higher than 99%.

Rose & Lim (2002) performed deterministic simulation to estimate economic loss on the regional economy of Los Angeles as the impacts of electricity outage due to the occurrence of Northridge earthquake (1994). This deterministic simulation employed input-output linear model on the Los Angeles regional economy to produce baseline of economic losses, given the scenario of blackout being the same as the length of blackout in 1994 (the service could be restrored to the entire of Los Angeles area within approximately 24-hour period). The upper-bound of losses as baseline was 8.3% of total gross output disruption. Then, with the inclusion of the (deterministic) effects of some resiliency actions/situations, being: 1) the importance of electricity to business operation (in %); 2) level of production can be recaptured at later date (in %); and 3) time-of-day use of electricity (in %), the losses was estimated to be far lower than 8.3%, being 0.5%. The accuration of this loss deterministic simulation was then to be compared with the loss data based on large-scale mail survey conducted in the previous study (the subsequent work of (Tierney, 1995)). The survey, which covered 23.6% of the total business firms in Los Angeles, resulted in loss estimation to be 1.9% for business that reported electricity outage as their top reason of business interruption. The difference between those two studies were said to be likely because: 1) the difference in sample size, of which deterministic simulation utilised regional economic data thus probably covered wider economic entities than the survey did; 2) the difference in the coverage of blackout, the deterministic simulation implied curtailment to the entire business entities while the survey performed information only about limited sample of business entities that reported electricity outage as the top reason of business interruption. It is also mentioned, that since the curtailment of lifeline service lasted only in very short period, indirect impact was assumed to be very minimal thus the simulation of impacts on the macro economy did not involve such economic modelling technique that allows for the inclusion of disequilibrium due to the influence of behavioral pattern of economic entity in observing the general equilibrium state (e.g. the Computable General Equilibrium model).

In the latter work (Rose, 2007), the gap between actual loss that reported in the survey and the upper-bound loss which was resulted from the linear input-output model was translated as the economic resilience, being as great as 77.1% ([8.3%-1.9%]/[8.3%]).

Precedents on the modelling of economic impact of disasters/other external events (such as terrorism) at macro economy level that involve the inclusion of indirect impacts (i.e. the interaction of price and quantity across economic entities) can be found in Rose (2004); Rose & Liao (2005); and Rose, Oladosu, & Liao (2007).

Rose (2009) provides options of resilience actions/conditions for households, business firms, and government sectors, along with their probability of effectiveness. These options are mainly grouped into categories of: conservation, input substitution, import substitution, excess capacity, input unimportance, relocation, production recapture, technological change, and management.

Zhou, Wang, Wan, & Jia (2010) employ the degree of diversification in the source of income and dependency to agricultural activity as the measure of resilience to drought in northern China. Higher degree of diversification and less dependency to agricultural activity are said to be the main contributor to resilience. The prominent use of income as resilience indicator leads to perception that the attribute of resilience being measured is economy, albeit the research explicitly presents the intent to incorporate various attributes of resilience (social, environmental, economic, institutional) into the formulation of single-major resilience, being geographic resilience. Within this research, resilience is perceived as "the capacity ..... to resist loss during disaster and to regenerate and reorganise after [the occurrence of] disaster ....." (p.28).

On the other hand, Sun, Zhou, Wang, & Yuan (2011) use another approach in assessing resilience to drought in southern China. They distinguish resilience into three stages of resilence, being resilience before the occurrence of disaster, resilience in (during) disaster - reflecting the emergency response, and resilience after the occurrence of disaster. However, only mesurement to resilience during and after disaster is performed. Resilience during disaster is structured from the multiplication of ordinal score of three indicators, being size of paddy field, the amount of income generated from agricultural activity. The ordinal scale ranges from 1 to 5, with 1 denotes the lowest class of each indicator. Resilience after the occurrence of disaster is measured through multiplying ordinal scale of agricultural drought (represented by the frequency of drought event being experienced) by ordinal scale of reduction in agricultural production.

2.2 DEFINITION OF AGRIBUSINESS

Lexical definition of agribusiness is

> *"an industry concerned with the production and sale of farm products"* (Oxford University Press, 2011a)

While farm is defined as:

> *"an area of land and the buildings on it, used for growing crops and/or keeping animals; the main house on a farm, where the farmer lives; (especially in compounds) a place where particular fish or animals are breed"*. (Oxford University Press, 2011c)

According to Statistic Bureau of Magelang Regency, the activity of agriculture encompasses the area of: staple food farming, fishery, estate plantation, livestock farming, and forestry (BPS, 2009).

2.3 LIVELIHOOD

2.3.1 Definitions of Livelihood

Lexical source provides the definition of livelihood as:

> "*a means of earning money in order to live"* (Oxford University Press, 2011d).

On the other hand, the Department for International Development within their *Sustainable Livelihood Guidance Sheet* states:

> *"A livelihood comprises the capabilities, assets and activities required for a means of living"* (DFID, 1999).

2.3.2 DFID's Sustainable Livelihood Framework

Within the DFID Sustainable livelihood Guidance Sheet (DFID, 1999), it is said that:

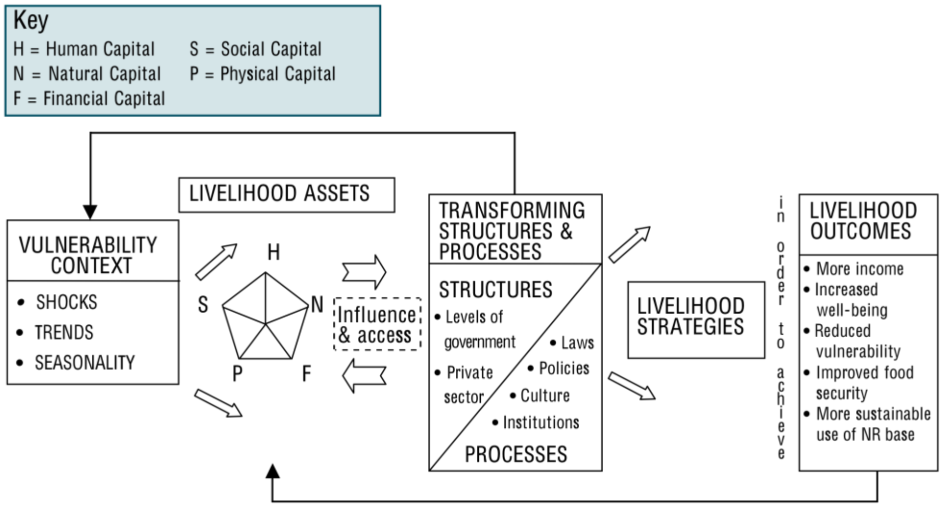
> *"A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base"* (sect. 1.1).

DFID provides elements to analyse the sustainable livelihood, being:

1. The vulnerability context;
2. The livelihood assets;
3. The transforming structures and processes;
4. The livelihood strategy; and
5. The livelihood outcome.

The general framework is pictured as appears in **Figure 2.3**.

Figure 2.3 DFID Sustainable Livelihood Framework



(Image is property of DFID, 1999)

The vulnerability context represents external environment in which people live. This could be in form of trends (e.g. economic trend, population trend, technological trend), shocks (e.g. human health shocks, natural shocks, conflict), or seasonality (e.g. seasonality of price, health, production).

Livelihood asset is made of five kinds of assets (the asset pentagon), being: human capital, social capital, natural capital, physical capital, and financial capital. These assets are detailed as follows:

1. Human capital refers to labours' amount and quality (i.e. skills, knowledge, leadership potential, health).
2. Social capital refers to the networks and connectedness, membership of more formalised groups, relationship of trust, reciprocity, and changes.
3. Natural capital refers to natural resource stocks from which resources useful for livelihoods are derived, could be intangible public goods (e.g.: atmosphere) or divisible assets directly used for production (trees, land).
4. Physical capital refers to the basic infrastructure and producer goods (tools, equipment) needed to support livelihood.
5. Financial capital refers to financial resources being used to achieve the livelihood objectives, such as available stocks (savings, bank deposits, liquid assets: jewellery, livestock), and regular inflows of money (pensions, remittance).

The transforming structures and processes are the institutions, organisations, policies and legislation that shape livelihoods. The term 'structures' refers to the body/organisation that set and implement policy and legislation, deliver services, purchase, trade and perform all manner of other functions that affect livelihoods. On the other hand, the term 'process' is used to refer the way in which structures and individuals operate and interact.

The livelihood strategy denotes the range and combination of activities and choices that people make/undertake in order to achieve their livelihood goals (including productive activities, investment strategies, reproductive choices, etc.).

The livelihood outcome is the result of livelihood strategy. It is stressed within the framework guidance that the important idea associated with this component of the framework is that investigation should aim to investigate, observe, and listen, rather than judge the nature of outcomes being pursued by people. Another particular notion is that assumption that people devote their entire resource to maximise their income should not be made. Instead, understanding on the variability of livelihood goals is more important. This understanding leads to further apprehension to what priorities are set by people, why they do what they do, and where the constrains are present.

2.3.3 Livelihood Assessment

A question with increasing popularity in regard with sustainable livelihood conceptualisation is *who is sustainable and who is not?* This notion particularly important in the necessity of assessing impacts on livelihood due to implementation of programs aimed at increasing people's quality of life or the ability of livelihood to sustain when faced with such external shocks or change. Assessment of livelihood then sometimes is used as proxy to community resilience (see for example, Elasha, 2005).

One amongst other methods commonly used in livelihood assessment is Livelihood Asset Status Tracking (LAST). This method employs 'word picture' as tools to assess livelihood condition. Parameters of livelihood status were developed based on the productivity, equity (similarity of access), and sustainability (managerial aspect) of five nature of livelihood asset as described within the DFID Sustainable Livelihood Framework. These parameters were then translated into a 'word picture', being ranges of qualitative description of livelihood asset, depicting worst to best condition. Incremental scores ranging from 0-100 were then assigned into the description, with principle being the better the condition the higher the score. Quality of livelihood was computed as the aggregation of scores from the entire parameters. Comparison of livelihood before and after a program being implemented was then used to describe the impact of program being aimed to the society to enhance their resilience to drought.

It is suggested that Livelihood Asset Status Tracking (LAST) should be incorporated with other technique of investigation, such as in-depth interview, as the technique applies score aggregation in order to illustrate big picture of livelihood asset condition, therefore some deficits may not be well reflected in the total score although they are actually visible (Bond & Mukerjee, 2002).

2.4 IMPACT OF VOLCANIC ACTIVITIES ON AGRICULTURE

2.4.1 Impacts on Soils

Long-term effects of volcanic eruptions bring beneficial impacts on soils. Soils with volcanic ash deposition could accumulate large amount of organic carbon and nitrogen. Besides, ash deposition forms high porosity soils that enhance the soil ability to preserve water, which is essential for plant growth as well as in reducing overland flow possibilities (Shoji & Takahashi, 2002). These advantages make Andisol, soil that is formed from volcanic activity, an attractive factor for people to settle around volcanoes (Shoji & Takahashi, 2002; Wilson, Kaye, Stewart, & Cole, 2007; Lebon, 2009). Apart from this huge benefit, studies witness that the benefit takes time to appear and in short term following eruption event, soil fertility may be negatively affected as the mineral components of the ash may not be available for plant uptake (Rees, 1979; Wilson, Kaye, Stewart, & Cole, 2007; Lebon, 2009).

In long-term perspective, the chemical properties of volcanic ash can contribute effects to soil characteristic. Study conducted on Chaîne des Puys soil (Prévosto, Dambrine, Moares, & Curt, 2004) witnesses the influence of volcanic ash chemistry to soil properties. Area with Andisol soils formed by trachytic ash has lower pH value and shows accumulation of Fe-Al organic complexes while Andisol soils formed by basaltic ash has higher pH value, less organic matter, and more allophane. Weathering of trachytic ash causes acidification that enhances the formation of Fe-Al humus complex and nurtures accumulation of organic matter. On the other hand, weathering process towards basaltic ash encourages faster release of Al, Fe, and Si, resulting continuation of high pH containment and benefiting the formation of allophane. This structure of properties, along with bigger influence from former land use, is disclosed to reveal the present land fertility, vegetation composition, and stand development.

2.4.2 Impacts on Vegetation

Impact of volcanic activity on vegetation can be sourced either from tephra fallout or acid gas emission.

The impact of tephra fallout on vegetation could vary depending on the thickness of tephra deposit on plants; plants physical characteristics; and possibly on the maturity level of plants (Rees, 1979; Neumann, 1997; Wilson, Kaye, Stewart, & Cole, 2007). Tephra fallout with its loading forces and abrasive nature leads to: plants burial (especially short plants with lush leaves in heavy tephra ground-deposit zone); stems and leaves breaking; hindrance to photosynthesis if not removed immediately; tissue bruising; and hindrance to pollination (Rees, 1979; Wilson, Kaye, Stewart, & Cole, 2007; Nelson & Sewake, 2008). Volcanic tephra in the form of ash, when exposed to atmospheric moisture, can form acidic substance that can result in foliar and flower damage. Besides, ash can also lead to cosmetic damage on plants, causing fruits no longer edible. Thus, treatment to plants exposed to volcanic ash should involve washing ash away from foliage and fruits (Nelson & Sewake, 2008).

Gases emitted from volcanism, such as SO_2 and HCl, can be acid precursors that give detrimental impact on plants. This has been documented by Nelson & Sewake (2008) through their work in Kīlauea Volcano (Hawaii). Emission of poisonous gases from volcanic activity can bring about air pollutant injury; vog (volcanic smog); sulfur dioxide injury; also trigger the occurrence of acid rain. In general, SO_2 will not cause damage to plant until the threshold of SO_2 impact on human is met or exceeded (unpolluted air for human is considered to contain less than 0.05ppm SO_2). SO_2 injury emerges when the gas successfully enters the foliage through stomata. The degree of injury will depend on sensitivity of plants. Sensitive plants, which could suffer injury due to exposure to 0.05-0.5ppm SO_2 in 8 hours or 1-4ppm SO_2 in 30 minutes, as documented by Nelson & Sewake (2008) include bean (*Phaseolus* sp., *P. vulgaris*), clover (*Trifolium* sp.), soybean (*Glycine max*), violet, (*Viola* sp.), broccoli (*Brassica oleracea*), brussel sprouts (*Brassica oleracea*), endive (*Cichorium endivia*), sweet clover (*Melilotus* sp.), lettuce (*Lactuca sativa*), okra (*Hibiscus esculentus*), pea (*Pisum sativum*), violet (*Viola* sp.), Swiss hard (*Beta vulgaris*), zinnia (*Zinnia elegans*), and turnip (*Brassica rapa*). While resistant plants, including asparagus (*Asparagus officinalis*), cabbage (*Brassica oleracea*), celery (*Apium graveolens*), coffee (*Coffea arabica*), and corn (*Zea mays*), would suffer injury due to exposure to higher SO_2 intensity, being 2ppm (in 8 hours tenure) or 10ppm (in 30 minutes tenure). Exposure to high intensity SO_2 in short period of time can lead to acute injury, appearing as lesion on plants physiology, while exposure to low intensity of SO_2 in long term period can lead to chronic injury, such as leaf yellowing/chlorosis. With SO_2 level increase, general detrimental impact on plants can include: decrease of seed germination capability; susceptibility to other plants diseases; rupture of plants epidermis; declination of chlorophyll content; and increased membrane permeability.

The presence of rain following volcanic eruption with enormous material deposit could be problematic. While it washes ash away from plants' foliage, it can trigger lahar that is highly destructive, leading to absolute cessation to plants metabolism (Rees, 1979; Wilson, Kaye, Stewart, & Cole, 2007; Lebon, 2009).

2.4.3 Impacts on Farmers

In addition to the economic loss of crops due to direct damage resulted from volcanic activities (e.g. lahars, pyroclastic flows, heavy loading of tephra fallout), the economic loss suffered by farmers also emerges from the reduced quality of the remaining crops, which influences its market price. This amplifies the difficulties small farmers have already been experiencing, of which small plots of land they possess are sometimes insufficient to produce adequate crops to support daily living. Besides, although some mitigating actions have already taken place in current agricultural system around volcanic region, e.g. through crop rotation and diversification following the eruption event, farmers frequently consider themselves to be unable to afford losses due to damage on one crop rotation as resulted by extreme volcanic activity (Wilson, Kaye, Stewart, & Cole, 2007).

Lebon (2009) shows the variability of volcanism impacts on farmer's lives. Farmers in the Philippines heavily struggle to pursue their good level of livelihood outcome following the eruption of Mt. Mayon and Mt. Pinatubo. The absence of agriculture re-establishment after huge damage resulted from the eruption forces people to seek other livelihood strategy, such as pumice gatherer for jeans industry, which is currently unable to raise their prosperity level. On the other hand, successful agriculture re-establishment programme in Mt. Unzen area, Japan, provides farmers with opportunity to reach their prosperity.

2.5 GROUNDED-THEORY RESEARCH METHODOLOGY

Grounded-theory inquiry is one of qualitative research methodologies that pursues the establishment of a theory concerning about issue in people's life from field data. Grounded-theory approach bears message that knowledge may be improved by generating new theories rather than analysing data within the existing ones. Therefore, no preconceived truth should be presented; rather, issue is emerging from the data (Glaser & Strauss, 1967; Heath & Cowley, 2004). Grounded-theory approach is rooted from the presence of symbolic interactionism between people and people's ability to see themselves within the perspective of others (Heath & Cowley, 2004). Theory is established through coding process that conceptualises description (Charmaz, 2003). Comparison of cases is used to develop features and produce meanings related to the object being studied, as well as to refine relationship between them (Heath & Cowley, 2004). The source of data in grounded-theory inquiry is mainly from interview with open-ended questions. The transcription is where data for analysis from (Glaser & Strauss, 1967; Creswell, 2007).

Contrasted to quantitative research method that is situated within post-positivism paradigm, grounded-theory method represents the application of constructivism paradigm (Creswell, 2007). While post-positivism paradigm aims at confirming the already-established theory and data collection should then be initialised by meticulous literature review to determine the required data in this regard, constructivism paradigm aims at understanding the nature of process or experience through theory/explanation derived from field data, thus data collection will initialise the research (Heath & Cowley, 2004; Creswell, 2007; Creswell, Hanson, Plano, & Morales, 2007). When carried out well, the grounded-theory inquiry should perfectly fit at least one dataset (Creswell, 2007).

The necessity of grounded-theory inquiry emerges when the currently present models are regarded as being inadequate since it was developed or tested on different samples/populations and/or not addressing the subtle valuable variable particular to a certain population (Creswell, 2007). This research method fits purposes to answer process question, i.e. question about experience, change, or action over time or stages or phases (Creswell, 2007; Creswell, Hanson, Plano, & Morales, 2007).

The development of grounded-theory methodology is originated from a joint-work of Glaser & Strauss (1967). This earlier work drew a basic ontological view of this method, being relativism (that truth exists in relation with culture, society, or historical context, and is not absolute), and presented basis analytical pathways to establish theory, being constant comparison between data to extract codes and interactions between them. In the following time, the two scholars were no longer in perfect agreement. This leads to a split, familiarly being known as Glaserian and Straussian grounded-theory (in later development Strauss cooperated with Corbin). This is noticeable from their following work (see Glaser, 1998; Strauss & Corbin, 1998 among others), with discrepancy is primarily in regard with methodology/research design rather than ontological view (Heath & Cowley, 2004). The following **Table 2.1** describes differences between Glaserian and Straussian view on grounded theory methodology:

Table 2.1 Glaserian and Straussian Grounded-theory Method

GLASERIAN	STRAUSSIAN
The role of induction and deduction	
The theory should emerge purely from data, thus the main and only approach of formulating knowledge is through induction without involvement of any deductive measures. As a consequence, researcher should keep themselves away from any influence of literature or predefined idea about the object being studied. As the theory is established purely from data, data is performed as it is, confusion is tolerated, and selection of information to support premature idea shoukd be avoided. Theory should be emerged, relying on solely interpretation towards data.	No one could be entirely free from the influence of literature and past experience. Keeping ourselves away from such influence is more like ignoring the fact that we know something rather than acting like generating understanding as insider in the area being studied. Claiming that in the purist grounded theory induction process may be overplayed and that induction should not be overstressed, inductive measures (i.e. involving literature study and past experience) are incorporated in establishing theory as a way of verification. This verification could possibly exclude any information that fails to materialise during the generation of theory. It is acknowledged that the degree of induction may vary due to incorporation of deductive measures. Theory is then to be constructed, involving imagination rather than interpretation purely.
Theoretical sensitivity	
(ability to get insight into the area of study, ability to perceive informants' words, ability to costruct meaning. and ability to separate what is pertinent from what which is not)	
Theoretical sensitivity should be built by the emergence of data instead of from predefined ideas.	Theoretical sensitivity may be established from comparison to prior knowledge, intensive questioning (like asking 'why, how' to the emerging information), and flip-flop technique, but to be noted that these technique is not to add data, but to stimulate reflection about data.
Treatment to litarature	
Literature study is to be minimised to avoid contamination, constrain, stifle, and impediment. Data and knowledge rely on the very nature of participant. Researcher is the pure observer against the research participant, thus they are strictly separated.	Literature study is contributor to the construction of theory, improvement of theoretical sensitivity, provision of example to stimulate better examination towards data, and provision of meso and macro context which will benefit the theory.

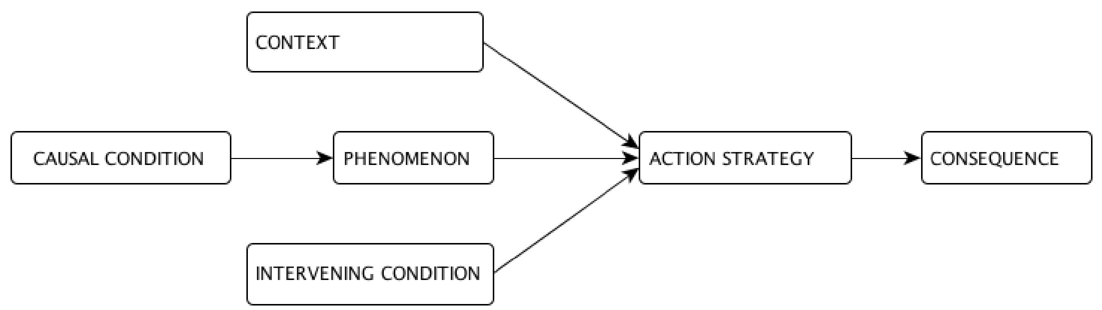
to be continued

Table 2.1 continued

GLASERIAN	STRAUSSIAN
Coding procedures: discovery of theory vs construction of theory	
Two levels of coding are employed. 1. Substantive coding: constant comparison to extract codes from data (ceased when core category that being the central hub of relation between other codes is emerged). 2. Theoretical coding: building conceptual connections between categories. The whole coding procedure is always data-relevent. Glaser developed 18 alternatives of relationship framework to connect codes, establishing a theory.	Three levels of coding are employed: 1. Open coding: the extraction of codes from data The coding is done by imposing a self questioning: like "what is this about?/what is being referenced here?" To discern which one belongs to categories and which one belongs to the properties, a practical strategy of recognising the kind of words is helpful. While categories are nouns and/or verbs of a conceptual world, properties are adjective and/or adverb. 2. Axial coding: the action of relating codes (categories and their properties) to each other via a combination of inductive and deductive thinking (involving exclusion of categories that fail to materialise due to redundant answer resulted from intensive questioning done in open coding stage). 3. Theoretical/selective coding: the identification and choosing of core category, relating all categories to this category, and developing of a storyline with this category as centre. The theory and working hypothesis are established through this final step. A diagram of generic relationship between codes originated from one of Glaser 18 alternatives framework (the "Six Cs", namely) is commonly employed, although later it is claimed not to dictate particular connection pattern, rather, to suggest possible linkage to achieve logical nature while maintaining complexity. This diagram/conditional matrix draws connection between causes, consequences, influential conditions, and strategy of action (see **Figure 2.4**).

Source: (Glaser B. , 1998; Strauss & Corbin, 1998; Heath & Cowley, 2004; Mills, Bonner, & Francis, 2006)

Figure 2.4 Generic Frame of Relationships in Straussian Grounded-theory Analysis



Phenomenon is the code that holds all other codes together.
Causal condition is a set of causes (events, variables) and their properties that leads to the development of the phenomenon.
Context is the mediating condition that becomes background of such actions.
Intervening condition is the moderating condition that becomes the background of such actions.
Action strategy is the intended activities carried out in response to the phenomenon and intervening condition.
Consequence is both unintentional and intentional result of action.

Source: (Creswell, 2007)

Quality of the theory developed through grounded-theory methodology will be seen from several aspects, being: 1) its capability to fit the substantive area; 2) its state of being general enough to be applied to many situations in the area; and 3) its capability to allow users for controlling over the theory as daily situationsare likely to change (Glaser & Strauss, 1967).

Recent development on grounded theory methodology witnesses the emergence of new approach in this method. Originated by Charmaz (2003, amongst other previous works), the new emerging method is underlined by assumption that interaction between researcher and research participants is the core tool in producing data, thus it must influence meaning that then interpreted/constructed. Priority is on the phenomena rather than on the method, thus relationship between researcher and research participants is important and data analysis should reflect researcher thinking rather than positioning researcher as external authorities and treating data as it is. It implies difference from the previously developed approach that tries to treat data as objective facts, leaving researcher in separated position with research participants (Charmaz, 2003). With importance of researcher-participant relationship being stressed, the involvement of the presence of participants as a whole (with emphasis on their views, values, beliefs, feelings, assumptions, and ideologies) as well as researcher reflection is crucial in establishing theory (Creswell, 2007; Creswell, Hanson, Plano, & Morales, 2007; Charmaz, 2003; Mills, Bonner, & Francis, 2006). The style of reporting in this newly emerging method resembles literary work rather than sticking to scientific writing presentation to better reflect the values, beliefs, and ideologies of research participants (Creswell, 2007; Creswell, Hanson, Plano, & Morales, 2007; Mills, Bonner, & Francis, 2006).

The split of methodological point of view is acknowledged to possibly confuse entry-level researchers. However, it is strongly suggested that over thinking on how to do grounded-theory inquiry rightly should not be necessary and researchers are encouraged to do their research albeit the possible imperfectness on applying the methodology. Grounded theory is a cognitive process and it is highly recognisable that people's cognition differs from one's to another's, thus the stigma to discover *the* theory should necessarily be to discover *a* theory that helps build understanding and action in the area of study (Heath & Cowley, 2004).

2.6 CONCEPTUAL FRAMEWORK

Following the literature study, this sub chapter describes basic definitions and concepts being applied in this research.

Economic resilience refers to the ability of business to maintain functioning in the aftermath of disasters given with proxy being amount of economic loss that can be minimised. This is quantified as gaps between the actual loss to the maximum possible loss likely experienced given a particular amount of input production is curtailed by the occurrence of hazardous events.

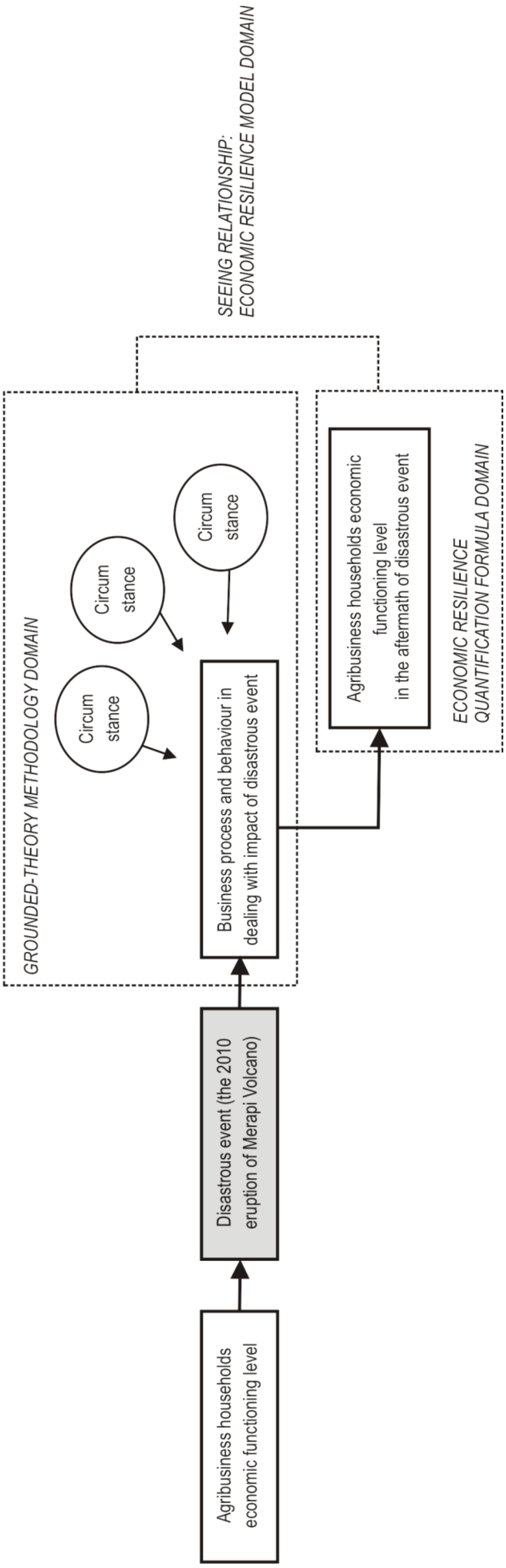
Agribusiness refers to the practice of farming, encompassing the area of staple food farming, fishery, estate plantation, livestock farming, and forestry, that is oriented for selling purposes.

Livelihood refers to any activities of generating money in order to fulfill daily needs.

Households with agriculture-based livelihood refer to households that farm to obtain money from the outcome of farming activity.

The conceptual framework of this research is described through the following **Figure 2.5**:

Figure 2.5 Research Conceptual Framework

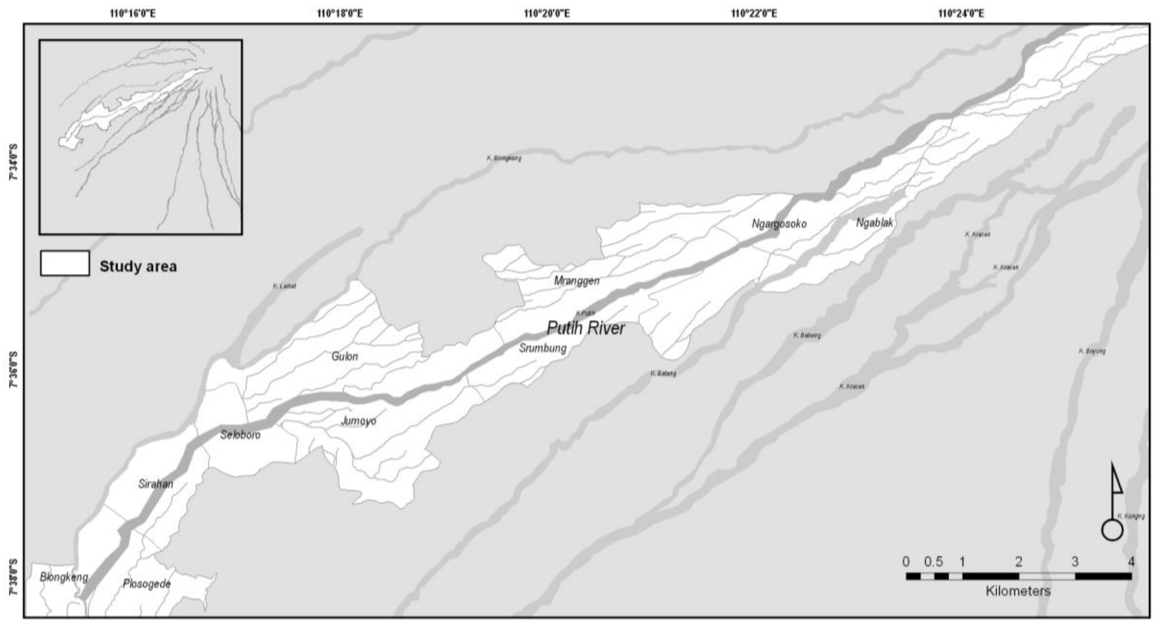


3 STUDY AREA

3.1 LOCATION

Putih River flows across the southwest flank of Merapi Volcano within Magelang Regency's administrative area. This research concerned economic resilience of agribusiness households in Putih River region. This translated into administrative areas of villages passed by Putih River. Boundary of a village was considered to be adequate in representing the variability of agricultural business as well as complexity of volcanism impacts. The following **Figure 3.1** illustrates location of villages along Putih River:

Figure 3.1 Location of Villages along Putih River



3.2 LAND USE IN VILLAGES ALONG PUTIH RIVER

The following **Table 3.1** presents categories of land use and their size based on statistics figure. On the other hand, **Figure 3.2** illustrates land use in villages along Putih River resulted from on-screen digitation based on IKONOS (2006) image visual interpretation confirmed with information from RBI Map.

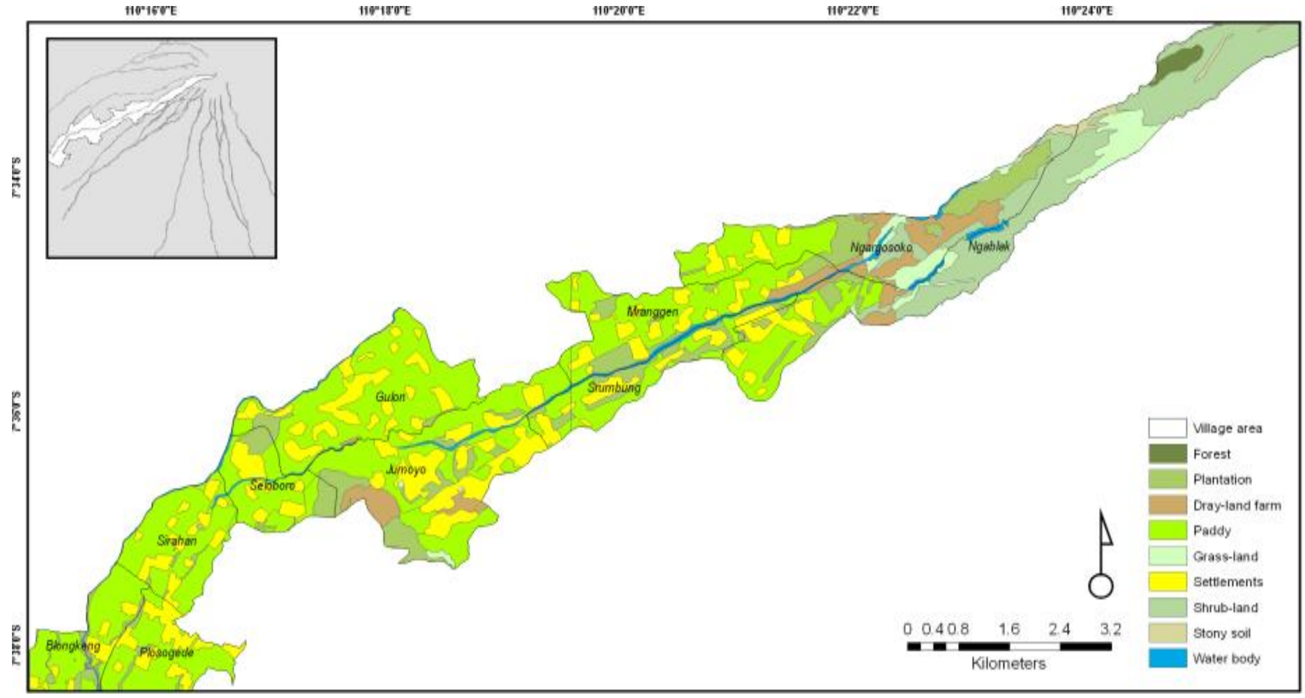
These two different data illustrate the dominance of agricultural land use over the area of villages along Putih River.

Table 3.1 Land Use of Villages along Putih River (Ha)

VILLAGE	RICEFIELD WITH TECHNICAL IRRIGATION	RICEFIELD WITH SEMI-TECHNICAL IRRIGATION	RICEFIELD WITH SIMPLE IRRIGATION	RAINFED RICEFIELD	SETTLE MENT	DRY-LAND FARM	POND	OTHERS
Ngargosoka	0.00	0.00	70.00	0.00	30.00	120.00	0.00	5.00
Ngablak	0.00	0.00	31.00	0.00	38.00	212.00	0.00	15.00
Mranggen	0.00	0.00	91.00	0.00	94.00	241.00	0.00	21.05
Srumbung	0.00	51.00	15.00	57.00	54.00	128.00	0.00	32.00
Jumoyo	0.00	0.00	197.45	0.00	111.08	58.03	0.37	13.15
Gulon	48.00	0.00	248.16	0.00	93.11	15.92	0.44	77.65
Seloboro	17.00	35.00	36.21	3.083	37.64	9.89	0.45	7.62
Sirahan	44.75	64.00	112.29	0.00	48.76	0.00	0.546	4.29
Blongkeng	141.70	(no data)	(no data)	(no data)	30.02	14.29	0.00	21.53
Plosogede	186.05	(no data)	(no data)	(no data)	56.31	0.00	0.00	22.19

Source: (BPS, 2008a; 2008b)

Figure 3.2 Land Use Map of Villages along Putih River



Source of information: IKONOS 2006; RBI Map

3.3 DEMOGRAPHY OF VILLAGES ALONG PUTIH RIVER

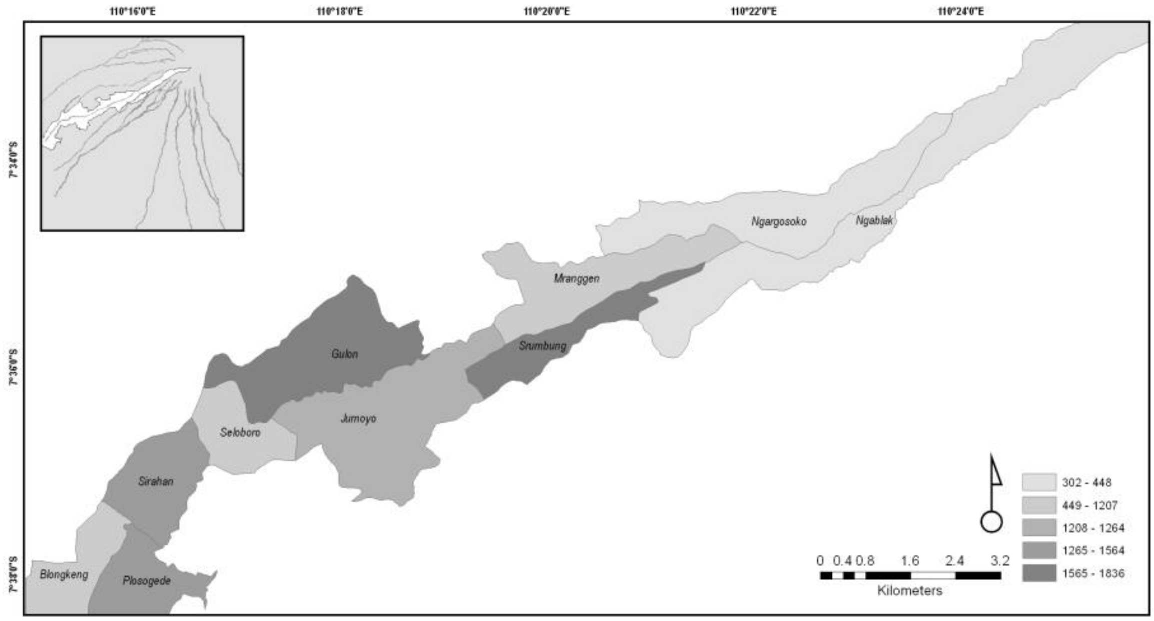
The following **Table 3.2** and **Figure 3.3** describe the population in study area:

Table 3.2 Population of Villages along Putih River

VILLAGE	AREA (KM2)	POPULATION (PEOPLE)	DENSITY (PEOPLE/ KM2)
Ngargosoka	4.74	2126	448
Ngablak	7.36	2226	302
Mranggen	3.51	4216	1202
Srumbung	2.05	3759	1836
Jumoyo	5.69	7194	1264
Gulon	4.41	7420	1684
Seloboro	1.83	2151	1176
Sirahan	2.38	3416	1434
Blongkeng	2.17	2622	1207
Plosogede	2.61	4074	1564

Source: (BPS, 2008a; 2008b; 2008c)

Figure 3.3 Map of Population Density in Villages along Putih River (People/Km2)



Data source: (BPS, 2008a; 2008b; 2008c)

From the spatial visualisation above, it can be said that the population mainly concentrates in the midstream, then spreads to downstream zone, and the most sparse distribution is present in upstream zone.

3.4 THE 2010 MERAPI VOLCANISM EVENTS

This subsection presents the considerable important event during the 2010 Merapi volcanism. The source of information was online KOMPAS newspaper (www.kompas.com). The original news is in Bahasa Indonesia. Illustration on this was expected to give insight into situations that possibly relevant to the development of economic resilience dynamics. The following **Table 3.4** describes these events:

Table 3.3 Important Events in the 2010 Eruption of Merapi Volcano

MONTH	KEY EVENT
October 2010	The first explosive volcanic eruption took place on 26 October. It involved pyroclastic flows, lava dome deformation, and lava flows, The first fatalities happened on this date.
November 2010	The 4-VEI eruption happened on 5 November 2010. Following this, the radial safety radius of 20km from the volcano summit was announced.
	On 4 November 2010 lahar began to flow Putih River and the instruction to keep distance of 300m away from body was made public. A number of big rocks and other volcanic material were seen in Putih River, observed from Srumbung Village.
	Series of tephra falls happened until the mid of November.
	On 14 November 2010 the radial safe radius from Merapi Volcano summit in the administrative region of Magelang Regency changed to be 15km.
	As volcano's threat getting lower, residents of Srumbung Village were reported to come home cleaning their environment up from tephra deposits (news on 20 November 2010).
	As many 65,898 as evacuees of Merapi Volcano eruption in the Province of Yogyakarta and Central Java were reported to leave the evacuation (news on 23 November 2010).
	In the late November lahar was reported to flow through Putih River destroying the dam (news on 22 November 2010).
December 2010	The threat status of Merapi Volcano was downgraded to Level 3 (Level 4 is the highest) on 3 December 2010 following the declining volcanism intensity (volcanic tremor, sulphur emission).
	Lahar flood struck Putih River region and overflowed the river body in downstream area causing Jumoyo Village intruded by mud, water, sand, and rocks. The main Yogya-Magelang road-network was blocked following lahar destroying Putih River bridge and overflowing the road surface. As many 1,061 as people fled (news on 8-10 December 2010).
	Series of lahar event continuously happened until the late December.
	On 30 December 2010 the threat status of Mt. Merapi was downgraded again, to Level 2.
January 2011	Lahar struck part of Jumoyo Village, causing the area swamped by sand and the blockade of Yogya-Magelang road-network (news on 3 and 9 January 2011).
	A person died being flowed by lahar in Sirahan Village (news on 10 January 2011).
	Due to lahar flood event on 9 January 93 houses in Jumoyo Village were destroyed while 49 others were carried away. Sirahan Village was swamped by sand (news on 10 January 2011)
	As many 4,187 as people fled as the result of 9 January-lahar. Evacuees were primarily from Jumoyo and Sirahan Village (news on 11 January 2011).
	Other series of lahar struck the area of Jumoyo Village in the late January, causing the road-network of Yogya-Magelang to get blocked. The width of Putih River was said to be 20m larger, from the originally 30m to be 50m wide (news on 20-23 January 2011).
	Putih River emerged as a disaster tourist-destination area (news on 21 January 2011).
February 2011	Series events of lahar flood flowing through Putih River overflowed the downstream area and caused the Yogya-Magelang main road network to be blocked. The road was inundated by 20-30cm thick volcanic materials along 100m horizontal distances (news on 1 February 2011). The area of Jumoyo and Sirahan Village was swamped by sand up to 1.5m high (news on 1 and 3 February 2011).
	BPTTK survey mentioned that Putih River was the area where the most volcanic materials flowed as lahar. As many 15-million m^3 as volcanic material flowed through Putih River (news on 3 February 2011).
March 2011	After series of lahar-flood events, 500 evacuees from SIrahan Village who fled since 11 January were reported to come home on 2 March 2011.
	Lahar was reported to destroy 44 irrigation channels along Pabelan and Putih River (news on 11 March 2011). In total, 636 houses were affected by lahar (news on 27 March 2011). The administrative zone receiving most impact was Kecamatan (District of) Salam, where 67 houses carried away, 266 houses heavily damaged, 32 houses moderately damaged, and 48 houses slightly damaged.
	Series of lahar happened and affected Jumoyo and Sirahan Village. Impacts included the blockade of Yogya-Magelang main road-network.
	Lahar was reported to raise the base of Putih River in Seloboro Village as high as 7-12m. The top surface of Putih River was 1.5-2m higher than a one-storey house (news on 28 March 2011).
April 2011	Lahar was reported to hit a bridge on Pabelan River in the main road of Yogya-Magelang (1 April news).
May 2011	Press release by Subandriyo (head of BPPTK Yogyakarta): total volcanic material having been flowed through lahar was 'just' 30% from estimated 150-million m^3 total volcanic material. It needs at least 3 period of rain season to get all material to flow.

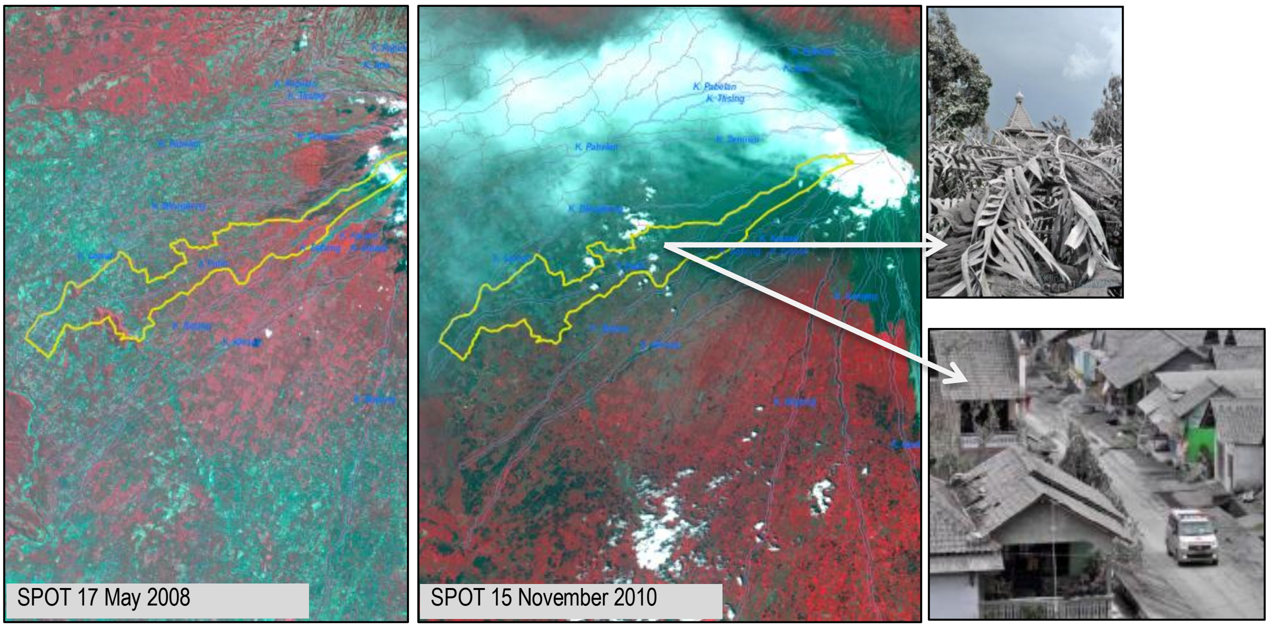
3.5 IMPACTS OF THE 2010 MERAPI VOLCANISM EVENTS

The 2010 Merapi volcanism events have led to tephra ground-deposit and lahar flood in villages within the neighbourhood of Putih River. No trace of pyroclastic flow was present.

3.5.1 Tephra Falls

Tephra fallout and deposit, particularly in the form of volcanic ash, were vastly present in study area, mainly after the 5 November 2010 eruption that was directed southwestward. The following **Figure 3.4** illustrates the presence of tephra falls-trace over study area. The prevalence of red-coloured area in SPOT - 17 May 2008 image denotes large amount of vegetation while the prevalence of whitish and greenish area in SPOT – 15 November 2010 area denotes the presence of tephra falls. The photographs represent situation in Srumbung Village. Photograph 1 pictures the *zalacca* plants loaded by ash and photograph 2 pictures ash covering settlement area.

Figure 3.4 Tephra Fall Trace Over Villages along Putih River

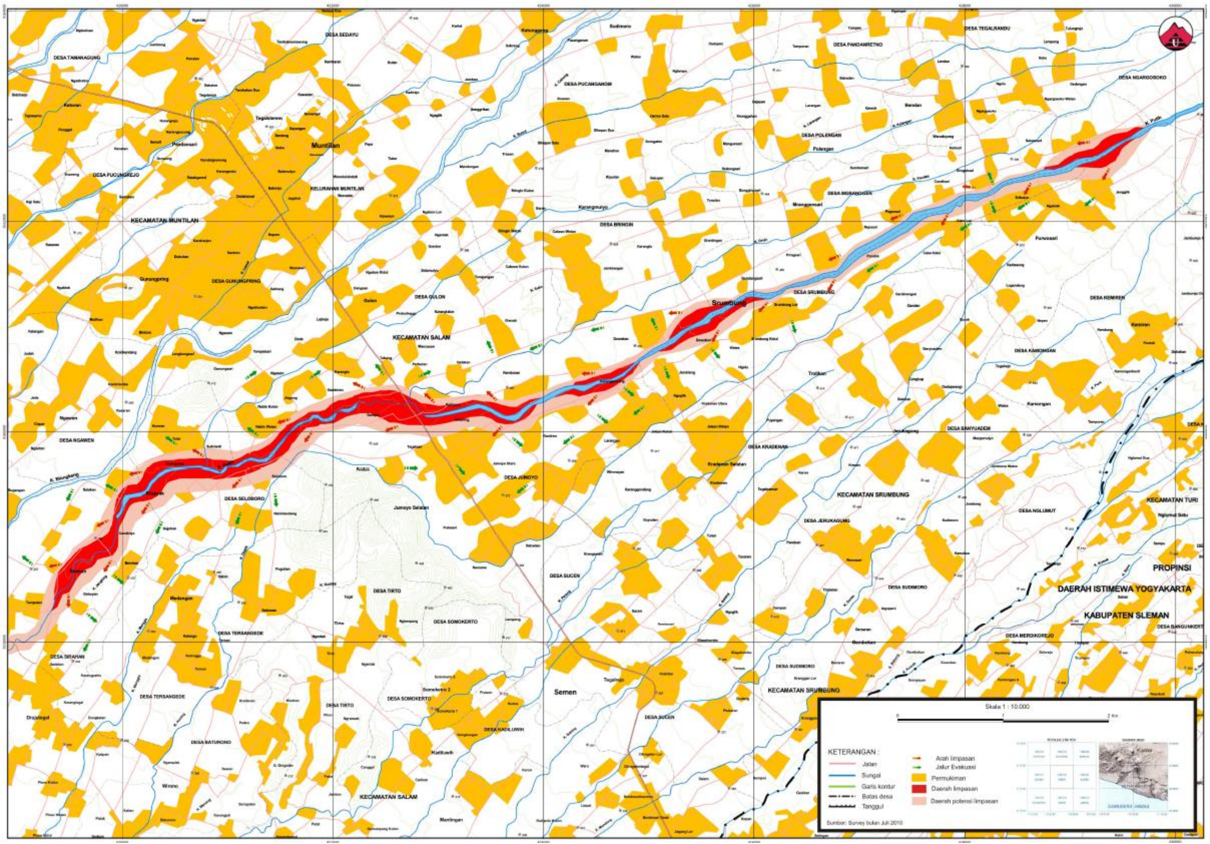


Source of photographs: (Nugroho, 2010)*; http://www.tempointeraktif.com/hg/jogja/2010/11/18/brk,20101118-292614,id.html*

3.5.2 Lahar

In November 2010, when heavy rainfall following the series of big eruption (culminated as a 4-VEI eruption on 5 November 2010), lahar began flowing the path of Putih River. The extremity reached its climax in the period of December through February when intense lahar flood struck the study area. The area receiving most consequence was the downstream area where lahar overflowed the river body intruding settlement area. Following the happening of devastating lahar flood event, evacuation was made to residents living in the proximity of river. The following **Figure 3.5** is a map produced by BPPTK describing the operational of lahar in Putih River. Information contained includes the direction of lahar flow and evacuation orientation:

Figure 3.5 Operational of Lahar along Putih River



Operational of lahar in Putih River area. Orange-coloured polygons denote settlement area, blue-coloured lines denote river body, darker-red-coloured polygons denote the area of lahar inundation, the light-red-coloured areas denote the potential extension of inundated area, red-coloured arrows denote the direction of lahar flowing, and green-coloured arrows denote the orientation of evacuation. Source of map: (BPPTK, 2011)

4 METHODOLOGY

4.1 RESEARCH PARADIGM AND METHOD

In order to satisfy the objectives, this research was carried out with combination of some paradigm. First, to satisfy objective to construct economic resilience theory, social constructivist epistemology paradigm was adopted. This means that truth or reality is constructed from the views of research participants. Second, to satisfy objective to disclose what action or situation becomes most influential to the level of economic resilience, this research applied post-positivism epistemology, which shapes the realities based on reductionist, scientific-based, deterministic, and logical thinking based on the priori theories. The post-positivism work was based on the result of social-constructivist work.

With those paradigms, the construction of knowledge was initialised by an inductive process then followed by a deductive process. Grounded-theory methodology took the role in inductive process. With the fact that literatures actually gave strong influence to the shaping researcher's sensitivity towards data and that the researcher is a novice in inductive research work (so that high-level purity of inductive work may not be present), this research inclined to Straussian-style grounded-theory work. Also, it has to be acknowledged that what present in this research may be simplistic if comparison to other more-advanced grounded theory work is to be made. The simplistic lay on considerable far less time being spent for data collection, the use of only interview as source of information, as opposed to involvement of research participant's personal journal or other extensive source of information, and the absence of subsequent meeting with research participants to let them review the result of analysis, as exampled in other grounded-theory works (see e.g. in Creswell, 2007). In performing deductive task, inferential statistics analysis was involved to make scientific-based evidence towards the theory having been developed through grounded-theory work.

4.2 UNIT OF OBSERVATION AND ANALYSIS

4.2.1 Population and Sample

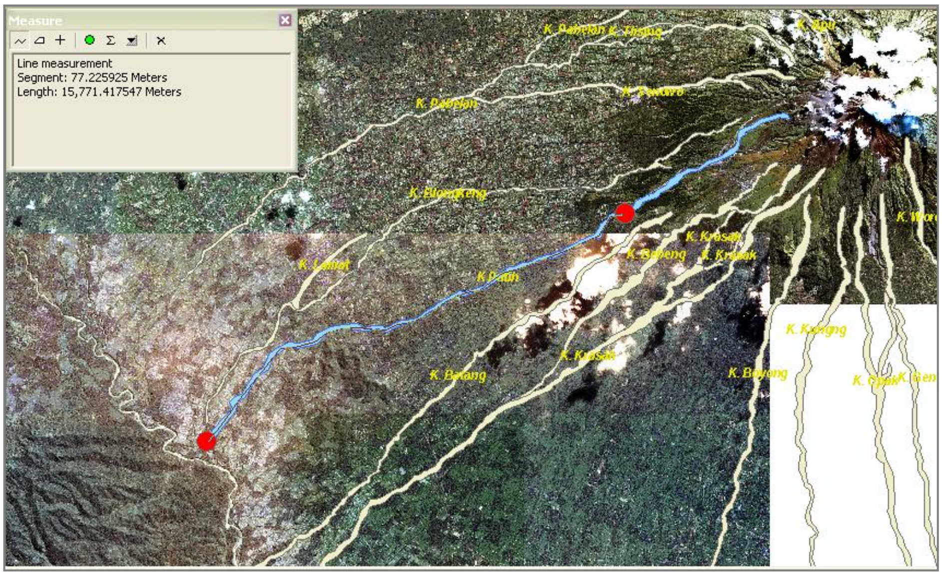
Population of this research was all households within the research locus whose farming activity (either in the form of staple food planting, fishery farming, estate planting, livestock farming, and forestry farming) is aimed to selling purposes to generate money. Exclusion of subsistence agriculture was aimed to focus the observation on households that resemble business operation. Besides, it was to avoid assessment towards too-small scale of agricultural work that is positioned merely as the additional activity and may not be oriented to money-generation activity. Observation towards subsistence agriculture does not allow for impression towards broader economy scope, as it does not relate to the market environment. As resources were limited, analysis was carried out towards sampled population members.

To construct economic resilience theory, 20 research participants as the source of information were involved in an in-depth interview. The total number 20 was regarded as being adequate (Creswell, 2007) and it was assumed that the information would be saturated (no new information emerges) with this number of information sources. The selection of individual was purposive, based on:

1. Their representativeness towards the variety of agriculture activity (staple food planting, fishery farming, estate planting, livestock farming, and forestry farming).
2. Their availability.
3. Equal distribution principle, meaning that research participants are distributed evenly within research locus.

Recommendation from the hamlet leader was used to determine who to be interviewed. This approach assured the fulfillment of selection criteria number 1 and number 2 as the leader of hamlet was the one who knows the local circumstances. The selection criteria number 3 was satisfied by considering topographical difference across research locus. Stratification divided population members into classes according to their farm location using a consistent horizontal distance-range. The distance of farm population was measured from the farm that is located in the uppermost part of Putih River to the farm that is located in the lowermost part of Putih River and a distance-range of 1.5km was used as divider. It was assumed that this stratification strategy is capable of representing the heterogeneity of the population in terms of agriculture products variety. With the resultant 15-16 segments, each segment contributed 0ne to two research participants. (See the following **Figure 4.1** about on-screen distance measurement using ArcGIS 9.2 that was utilised to stratify the research locus based on topographical variety).

Figure 4.1 Distance Measurement of the Research Locus



The research locus was divided into segments with 1.5km distance as divider. Red dots in the picture indicate the start and end-point of research locus. It measures 15.77km. In regard with this, there were about 15-16 segments in total.

Number of samples in the survey of economic resilience to obtain data for economic resilience quantification and its influential factor to establish economic resilience model was determined based on quota. The number of 100 was selected, with underlying assumption that this number is adequate for performing inferential statistical operation. Based on the above stratification, with principle of equal samples distribution, the number of samples per segment was six to seven agricultural households.

The selection of individual household as data source employed the combination of non-probabilistic and probabilistic sampling method. Applying snowball-sampling technique, the initial respondents were asked to name 5 people whose farm located in the similar pre-determined segment to be the next respondents. Based on this recommendation, probabilistic sampling method was then performed, by randomly choosing 1 among these 5 names. This method was continuously implemented until the desired number of informants obtained. Reason behind this strategy was to assure the availability of respondents.

4.2.2 Unit of Analysis in the Construction of Economic Resilience Theory

Purpose of this investigation was to disclose the process in which agribusiness households' economic resilience was developed. This process was shaped by all possible circumstances likely to have relevance with the development of economic resilience. Thus, primary focus in this investigation was to capture the lived experience of agribusiness households in dealing with impacts of 2010 Merapi volcanism events on their economic activities. This lived experience emanated from the following points of inquiry:

1. The condition of households' farming activity before the 2010 Merapi volcanism events, encompassing: 1) conditions of four factor of production, i.e. land, labour, capital, and entrepreneurship; 2) the cropping pattern being implemented; 3) the output of farm production; and 4) the crop marketing;
2. The 2010 Merapi volcanism impacts (tephra fall and lahar) on agribusiness households;
3. The measures taken to deal with impacts of 2010 Merapi volcanism events; and
4. The condition of households business in the aftermath of 2010 Merapi volcanism events.

The above-mentioned points of inquiry were asked in consecutives manner. With naturalistic and phenomenological features inherent within grounded-theory methodology principle, data for analysis was to be as much as possible sourced from the very perspective of research participants, thus minimising pre-defined researcher's knowledge within the inquiry process was prerequisite. Based on this, open-ended questions were asked in covering the points of inquiry having been mentioned before. Although encourager to answer was as much as possible to be limited, such inducement for wider-range of information was inevitably necessary to assure the attainment of wide-range information, because the level of communicability and openness across research participants varies. However, imposing a leading question (e.g. the ones with question tags) was strictly avoided. Inducements were present as following-up questions from the research participants' answer. For example, in asking point of inquiry number 3:

What did you do then, knowing that your farm was completely devastated? (main question)
→ *Why did you choose to do that? (inducement)*
→ *How was it done? (inducement)*
→ *How many times did you do that (inducement)*

Initialising the interview process, research participants were informed the objective of this interview, being for study purpose to build understanding to the economic impact of 2010 Merapi volcanism events. They were also notified that the interview would be voice-recorded.

4.2.3 Unit of Analysis in Determining the Level of Economic Resilience

Quantification of economic resilience employed Direct Static Economic Resilience (DSER) formula developed by Rose (2004, 2007, 2009), being:

$$DSER = \frac{\%\Delta DY^m - \%\Delta DY}{\%\Delta DY^m}$$

with $\%\Delta DY^m$ represents the possible maximum output reduction possibly experienced by business entity given a particular level of input curtailment due to shocks from disastrous events, and $\%\Delta DY$ represents the actual outcome reduction experienced by business.

To capture the dynamics of economic resilience, the above-mentioned formula was to be operated within a range of timespan, therefore, a set of measures that would be necessary consisted of: 1) agribusiness households' economic output in normal business state (if disastrous events had not occurred); 2) the maximum output reduction likely to be experienced; 3) the estimated actual loss following the occurrence of disastrous events; and 4) time variability (time interval).

As insight into local circumstance was necessary in defining these indicators and parameters, indicators and parameters for quantifying the level of agribusiness households' economic resilience was present as one of research results rather than being part of methodology section. Indicators and parameters of economic resilience emanated from the explanation of process generated through the construction of economic resilience theory.

4.2.4 Unit of Analysis in Establishing Economic Resilience Model

To establish an economic resilience model describing level of influence of relevant factors to the achieved level of economic resilience, some predictors were required. These predictors, which belonged to the group of possible influencing factors, were known through the generation of economic resilience theory. Therefore, instead of being positioned as pre-defined research material, the predictors belonged to one of research results.

4.3 DATA

4.3.1 Data Gathering

Data from primary source (i.e. economic resilience data) was collected through interview and survey. Other data, such as imagery and secondary-source data, was obtained from institution and library. Institution being involved included: the Faculty of Geography, Gadjah Mada University, Statistics Bureau of Magelang Regency, and office of village administration.

4.3.2 Data Validity

The main source of data within this research was *story told by people*. It is highly acknowledged that self-reporting bias might be unavoidable. Notwithstanding this flaw, the nature of grounded-theory work within this research, being: 1) organising the data in somewhat useful way to explain a process; 2) engaging sufficient number of research participants to make sure that data is saturated; 3) analysing the data with the involvement of constant comparison across data source and confirming and disconfirming examples; 4) involving deductive process in putting data back together to form a conceptual framework, could assure the probability that what data realised into a theoretical framework was the ones that successfully went through a careful examination. Moreover, the establishment of model based on theory having been developed provided an opportunity to certify the functionality of the theory, and vice versa, the presence of explanative theory could provide justification why such model existed.

4.4 RESEARCH INSTRUMENT

Research instrument refers to tools and dataset being used in this research. The following **Table 4.2** describes the type of research instrument, its function within the research, and its source.

Table 4.1 Research Instrument

INSTRUMENT	FUNCTION	SOURCE
Stationery	Making notes	Researcher's properties
Global Positioning System receiver	Mapping the sampled households' farms, tracking the lahar trace	Survey-tool rentals
True colour composite high resolution imagery of research locus pre-volcanism period	Mapping land cover (and land use) of research locus (being used to guide data collection in economic resilience survey, in terms of knowing where to find respondents)	The Faculty of Geography, Gadjah Mada University
Map of lahar distribution	Performing the area affected by lahar	Fieldwork activity (GPS tracking)
In-depth interview guide	Guidance in conducting interview	See section 4.2.2 above
NVivo 9.2 software	Tools for open coding analysis using interview record	Free trial is obtainable through http://www.qsrinternational.com
Questionnaire *	Survey tool on the level of dynamic economic resilience and influential factors	Result of grounded-theory work
Microsoft Office Tools 2008	Words and numbers processing device	Researcher's properties
SPSS for Windows 12.0	Statistic analytical tool	Researcher's properties
ArcGIS 9.2	Spatial data analysis and visualisation	Researcher's properties

*Note: * = see Appendix*

In addition to all of those instruments, it should also be stressed that researcher himself was a research instrument in the implementation of grounded-theory methodology. The researcher was data-obtaining and analysing tool through the involvement of his theoretical sensitivity, critical thinking, and creativity.

4.5 TECHNIQUE OF ANALYSIS

The technique of analysis varied depending on the purpose of analysis and data being used. **Table 4.4** provides the detail of analysing technique being used in this research.

Table 4.2 Technique of Analysis

PURPOSE	TECHNIQUE OF ANALYSIS
Constructing economic resilience theory	Open coding, axial coding, and selective coding analysis of Straussian-type grounded theory method (see section **2.5 Grounded-theory Research Methodology**)
Measuring agribusiness households' economic resilience in a time-path manner	Computation based on Direct Static Economic Resilience (DSER) formulation and graphing DSER over a period of time
Establishing economic resilience model	Statistical regression analysis

4.6 RESEARCH STAGES

4.6.1 Pre-fieldwork Activity

Activities carried out in this stage included: formulation of research problems; library research; development of research design; proposal writing; consultation; and preliminary data gathering.

4.6.2 Fieldwork Activity

This stage was when primary data collecting process was present. The range of activities included (in sequential manner): field observation; interview; and households' economic resilience survey. The activities of lahar trace tracking and taking photographs were done in field observation. Interview process was to collect data as input for generating economic resilience theory. Following this, households' survey was to provide data input for measurement and modelling economic resilience.

4.6.3 Post-fieldwork Activity

Post-fieldwork activities consisted of data analysis, research report writing, and result presentation.

The chronological illustration of research stage is given through the following **Table 4.3.**:

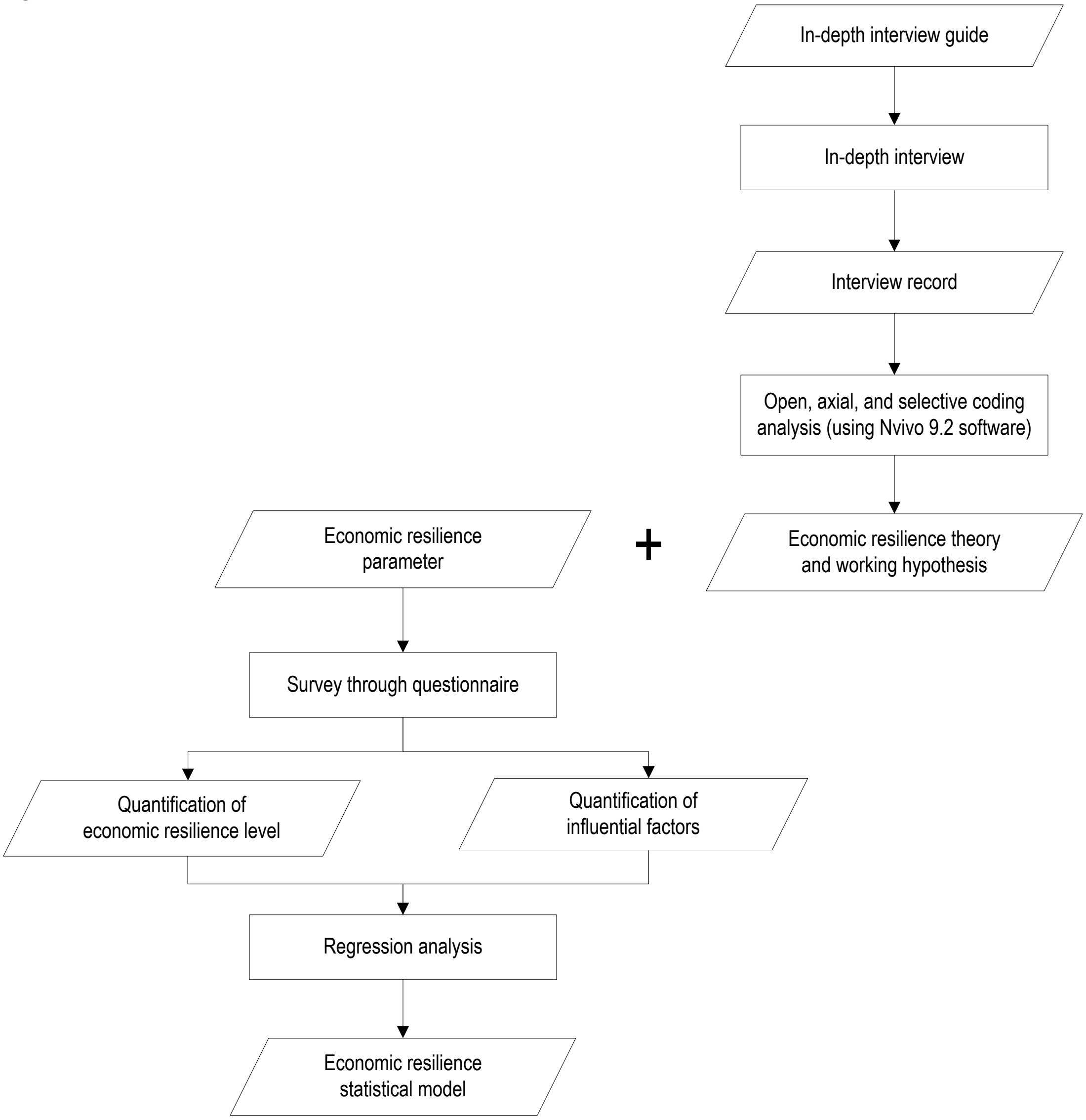
Table 4.3 Research Timetable

ACTIVITY	Jul'11	Aug'11	Sept'11	Oct'11	Nov'11	Dec'11	Jan'12
Pre-fieldwork							
Contact establishment	■						
Preliminary visit	■						
Research proposal	■						
Fieldwork							
Observation, interview, survey		■	■	■	■		
Post-fieldwork							
Data analysis					■	■	
Consultation				■	■	■	
Mid-term progress					■		
Thesis writing				■	■	■	■

4.7 RESEARCH FRAMEWORK

The following **Figure 4.2** presents framework guiding this research.

Figure 4.2 Research Framework



5 CONSTRUCTION OF ECONOMIC RESILIENCE THEORY

This section presents the result of grounded-theory work in construction of economic resilience theory to generate explanation about the process in which such economic resilience was developed. This section is organised as follows:

1. Description of research participants and data;
2. Coding analysis;
3. Economic resilience theory;
4. Discussion; and
5. Working hypotheses.

In this section, the term of "research participant" and "informant" are used interchangeably with no intent of referring to different meanings.

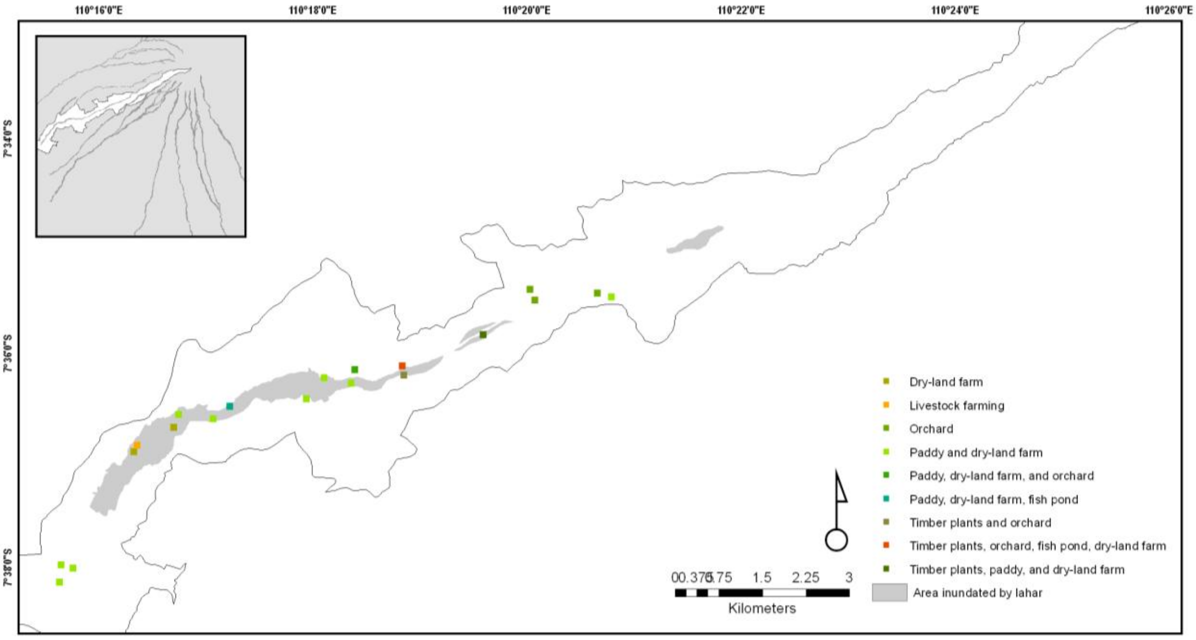
5.1 DESCRIPTION OF RESEARCH PARTICIPANTS AND DATA

Total number of participants involved in the in-depth interview process was 20 people. The following **Table 5.1** describes the research participants and **Figure 5.1** illustrates the distribution.

Table 5.1 Research Participants Characteristics

CHARACTERISTIC	N	%
Sex		
Male	13	65
Female	7	35
Age		
Younger than 30	0	0
30 – 40	4	20
40 – 50	10	50
Older than 50	6	30
Farm type		
Dry-land farm	2	10
Livestock farming	1	5
Orchard	2	10
Paddy and dry-land farm	9	45
Paddy, dry-land farm, and orchard	1	5
Paddy, dry-land farm, and fish pond	1	5
Timber plants and orchard	1	5
Timber plants, orchard, fish pond, dry-land farm	1	5
Timber plants, paddy, and dry-land farm	1	5

Figure 5.1 Research Participants Distribution



Each participant took part in 34 to 73-minute in-depth, open-ended interview. Interview started with asking research participants to describe their agriculture business activity in period before the 2010 Merapi volcanism events followed by the impact of 2010 Merapi volcanism events on their agriculture, measures taken in dealing with these impacts, and households business situation in period after the 2010 Merapi volcanism events. Following-up questions as inducement were used at each point of inquiry to develop the conversation as explained within sub-section **4.2.2 Unit of Analysis in the Construction of Economic Resilience Theory**).

Data consisted of 960-minute digital voice record that documented the interview process. Interview was conducted either in Bahasa Indonesia, Javanese, or combination of both. The digital voice record was then imported to Nvivo 9.2 software for coding analysis. Transcription of interview process was also made.

In general, research participant welcomed the interview and were approachable. Apart from this, the researcher faced challenge when research participants thought that this interview was part of data collection process for providing funding support or donation to them. Some of research participants complained the frequent data collection processes promised to provide funding support they have gone through before but ended up in no follow up. At first, this eroded the researcher's confidence, but later this challenge was overcome by explaining that the purpose of interview was for study. A thanking souvenir, in the form of small-sized shopping bag worth Rp 3,000.- (0.30 USD) was given to each research participant. This was mainly to raise researcher's confidence that at least this interview process was not done to take advantage of research participants. The considerable little monetary value of the souvenir, as well as the interview process which kept research participants unnoticed that incentive was provided until the interview finished, assured that this strategy did not spoil research participants, therefore risk that research participants gave untrue answer for researcher's convenience could be as much as possible minimised.

5.2 CODING ANALYSIS

Open coding analysis initialised the process of coding analysis. Open coding analysis was conducted by "sweeping" through the voice record data, then marking important section and putting a descriptive name on it, or "coding" it. The name or code sometimes was either words that participants used in the interview or researcher's words, with focus of importance was its capability to represent meaning being conveyed through the part of speech. A self-question of "what is this about?" was utilised to generate codes.

As for being example about the way in which codes were extracted in open coding analysis, the following passage describes the first 10-minute speech out of all 40-minute speech of a research participant during the data collection (original interview is in Bahasa Indonesia and Javanese – mixed) and the subsequent **Table 5.2** illustrates the extraction of codes (open coding process):

> Our agriculture activity is planting zalacca/But since the eruption we are cropping nothing/People here plant zalacca/There was sufficient water/The crop was good/But now there is no water/Even zalacca needs water/If only we could flow (the water) from the river/At that time we could/It (the production) was good/But now.../Currently we cannot flow the water (to the zalacca farm)/From the (occurrence of lahar) flood supply was stopped/Until recently I cannot flow the water (to the zalacca farm)
>
> In a year, we could get big amount of crops twice/The big harvest/But (the crops) actually did not stop (after big harvest)/Each month, we must be harvesting/But in big harvest we got plenty/Lots more/In the ordinary (days the crops were) fewer/But (the harvest) did not stop/In a one-day cropping in big harvest/at least/1000sqm of farm er.../250 trees/at least/approximately/in a one-time harvest/we could get 200kgs (of zalacca fruits)/That was weekly ordinary (cropping)/That is why/at that time/having a few (zalacca) plants was adequate for (daily) needs/But then (the cropping) just got (suddenly) terminated/Then nothing/Until recently we have not (got any crops)/It is starting to blossom
>
> But there is a (government) programme/The labour-intensive (public works) programme/It is good/The labour-intensive programme/PNPM is the donor/Before (it) there was er.../The Department of Transmigration programme/and the Department of Agriculture/It was cleaning works/But paid/Not a direct donation/that could make other people envy/This month/there is a 13-day labour-intensive work/from PNPM/The work from them (PNPM) has long procedure/the process is complicated/takes long process/ (the procedures of public works from) the Department of Transmigration and the Department of Agriculture are much shorter.
>
> Before eruption the (zalacca) fruits were sold Rp 3,000.- per kg/Just wait at home,/there were people to take (buy) them/There was no worries in selling/I never had to go to the market/
>
> In planting zalacca/you will need to graze (the land)/fertilise (the land)/and cultivate (the land)/People used Urea (name of fertiliser)/or organic (fertiliser)/Mine was organic/Organic (fertiliser) makes the (zalacca) fruits long-sustained/wherever you send them they would be kept dry/Using the chemical (fertiliser), the fruits decay more quickly/But if you talk about the size (of the fruits)/Urea and PSP (name of chemical fertiliser) give you bigger-size fruits/But for long-distance delivery purpose, these fertilisers are not good/And the fruits are less sweet/Using compos, or, organic fertiliser, the fruits can be sent to Jambi, or some other faraway place/that takes long delivery time/without decaying/The effect just/the fruits get dryer/The flesh of fruit get er.. kind of glued to the skin

Table 5.2 Example of Open Coding Analysis

PART OF SPEECH	WHAT IS IT ABOUT?	REFERENCE
Our agriculture activity is planting zalacca[1)]/But since the eruption we are cropping nothing[2)]/People here plant zalacca[3)]/There was sufficient water[4)]/The crop was good[5)]/But now there is no water[6)]/ Even zalacca needs water[7)]/If only we could flow (the water) from the river[8)]/At that time we could/It (the production) was good[9)]/But now.../ Currently we cannot flow the water (to the zalacca farm)[10)]/From the (occurrence of lahar) flood supply was stopped[11)]/Until recently I cannot flow the water (to the zalacca farm)[12)]	Type of plant	1, 3
	Crop amount	2
	Sufficiency (water)	4
	Crop quality	5, 9
	Insufficiency (water)	6, 10, 11, 12
	Needs for water	7
	River (source of water)	8

Following open coding analysis was axial coding analysis. This phase of coding analysis was to explore connections amongst emerging codes, to group them into category, and to assign a label on category being developed. A category must have connection with codes being its properties/sub-categories. The form of connection can be as examples, context, setting, degree, or causes. Within these stages, comparison of incidents emerged through the response across research participants was made. After finding as many codes as possible through open coding process, theoretical sensitivity and deductive thinking were involved in the comparison process until idea of categories emerged. When it emerged, a memo was taken to note the category and its possible properties. The following **Table 5.3** describes the resultant categories from emerging codes being its properties/sub-categories:

Table 5.3 Categories and Properties

CATEGORY	PROPERTIES	SUB-PROPERTIES
Water supply for farming	Sufficiency	
	Insufficiency	
Physical damage	From tephra fallout	Plants collapsed
		Crops decomposed
		Stressful environment for livestock
		Death of fish in pond
		Water channel obstructed
	From lahar	Farm damaged
		Dam damaged
		River damaged
		Irrigation channel damaged
		Death to livestock
		Settlement damaged
	Extent	Partial
		Total
Intensity of volcanism	Thickness of tephra ground-deposit	
	Height of lahar inundation	
Evacuation	In evacuation	Shorter time
		Longer time
	Not in evacuation	
Having new economic activity	Sector of activity	Sand-mining
		Manual labour
		Neighbourhood-level retail
	Function of activity	Complementary to farming
		Substitution to farming
External aid	Paid community service	
	Productive economy stimuli	
	Daily needs supply	
	Loan	
Government policy	Prohibition of using heavy equipment	
	Normalisation of Putih River	
Season	Dry season	
	Rain season	
Farm location	Closure to river	
	Elevation	
Lahar characteristics	Continuing	
	Destructive	
	Type of material	

to be continued

Table 5.3 continued

CATEGORY	PROPERTIES/CODES	SUB-PROPERTIES
Price fluctuation	Increasing production cost	Livestock feed
		Fertiliser
		Seeds
		Labour
		Water
	Crop selling price fluctuation	Massive crop
		Plant disease
		Delivery problem
Absorbing loss	Doing nothing	
	Selling asset	
	Consuming owned low-quality crops	
	Personal savings	
Households economic functioning	Farm yield	
	Economic outcome	
Commodity characteristics	Type of commodity	
	Life cycle	
	Needs for water	
Having alternatives for source of water	Flowing from river	
	Flowing from water well	
	Relying on rain	
Restarting farming activity	Time onset from disaster	Slow
		Quick
	Different cropping pattern	Commodity change
		Planting schedule change
	Similar cropping pattern	
Saving commodity	Early cropping	
	Covering cage	
Relying on old non-farming economy source	Income as teacher	
	Income as pensioner	
	Income as carpenter	
Households' business characteristics	Farm characteristics	Farm size
		Dependency to irrigation service
		Soil condition
	Business diversification	
	Business turnover	
	Entrepreneurship	
	Human resource	
Repairing farm	Cleaning remnant	
	Removing sand	
	Tilling land	
Labour addition	Adding worker	
		Perennial to seasonal plants
		Water demanding to less water demanding
		Environment-sensitive to env.-insensitive
Interruption on farm production	Type	Crop failure
		Unproductive land
		No livestock to breed
	Length	Short time
		Long time

Subsequent to axial coding analysis was selective coding analysis. Within this process, core category was selected and relations amongst categories are established. The development of relationship involved the search of confirming and disconfirming examples. The core category was the one with centrality to other categories, frequent emergence, and ease of being related to other categories. Result of this final stage is a theoretical framework that adopted the generic conceptual framework of Strauss & Corbin (see **Figure 2.4** in **Chapter 2. Literature Review**) as will be described in the following sub-section.

5.3 ECONOMIC RESILIENCE THEORY

Economic resilience theory for agricultural households is an explanation about the process of which such ability of agribusiness households to minimise loss and maintain economic functioning was generated. The theory that was developed through grounded-theory methodological process is represented through the following theoretical framework as appearing in **Figure 5.2** (in the following page)

5.3.1 Causal Conditions of Phenomena Related to the Impacts of 2010 Merapi Volcanism Events

Three types of causal conditions emerged from data, being: 1) physical damage; 2) intensity of volcanism; and 3) issues of water supply for farming.

Physical damage from tephra fallout, being plants collapsed, crops decomposed, death to fish in ponds, the emergence of stressful environment to livestock, and water channel obstructed, shaped the background of phenomena related to the impact of 2010 Merapi volcanism events on agriculture business. Informant 2 reported,

> "… half of my *zalacca* plants collapsed. They could not stand the load. Hot ash made the fruits rotten…. the ash was abundant. I could see as thick as this [gesturing a thickness measure by her thumb and index finger] ash around my house. It seemed really unbearable by my *zalacca* [plants]."

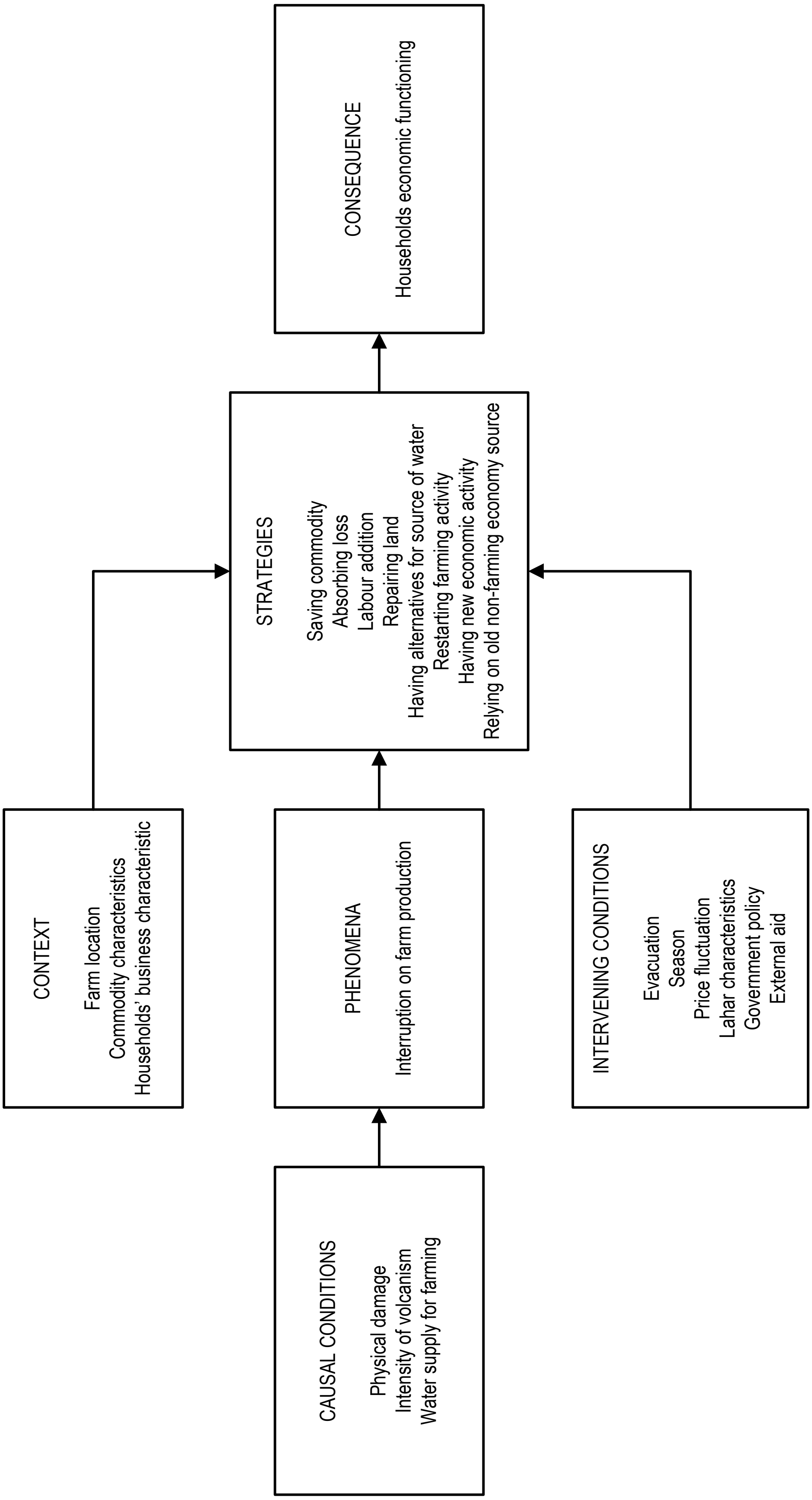
On the other hand, informant 6 said:

> "The coconut leaves and branches fell down… They [the ash] were so heavy, I guess. It was like 30cm thick".

Similar responses were also reported by other informants whose commodity was paddy, chili, beans, and cabbages. In addition to this, tephra (in form volcanic ash and sand) ground-deposit was also reported to obstruct ditch and irrigation channel (reference from informant 2, 7, and 14). To livestock commodity, tephra fallout has resulted in fatalities to fish and stressful environment to chickens (informant 5, 8, 11).

Physical damage caused by lahar included farm damaged, dam damaged, river damaged, irrigation channel damaged, death to livestock, and settlement damaged. Informant 1 reported 80% of his farm damaged by lahar flood. The other farmers (informant 6, 12, 14) reported total devastation on their farm, while to the rest portion of land destroyed by lahar varied from 0 to 90%. All informants reported devastation of dams, river body, and irrigation channel after lahar hit them. Informant 7 and 8 commented on the devastation of houses in their surroundings. Informant 11 added to these, by reporting death to his chickens of which cages were situated near the river body where lahar flowed.

Figure 5.2 Theoretical Framework for Agribusiness Households' Economic Resilience



The third background is the issues of water supply for farming. All of participants reported their difficulties and impossibility in obtaining water for farming purposes. Informant 16, for example, said

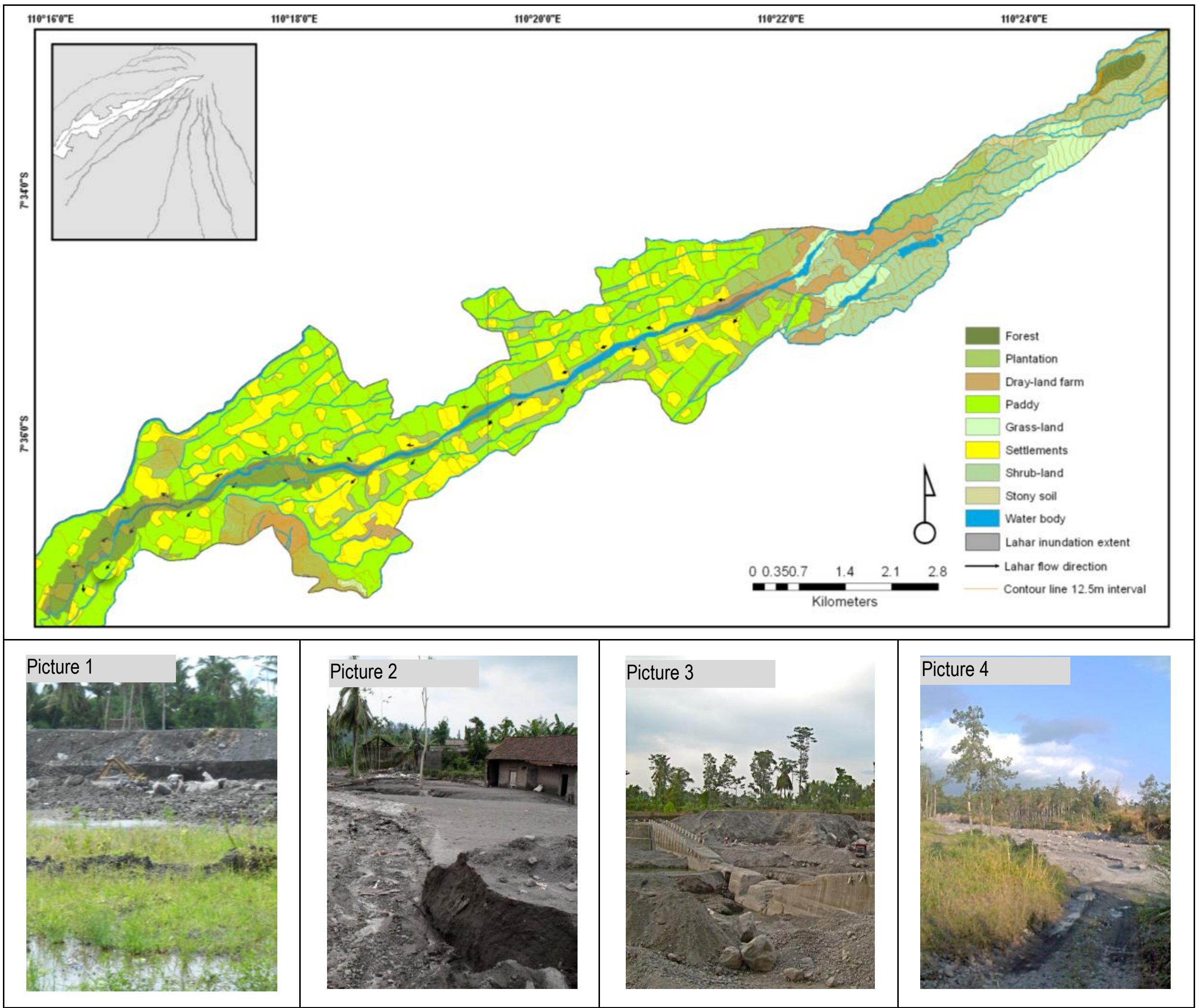
> "It is hard to water my farm. Compared to the old time, it is different. Water was abundant. From dams, river …."

Informant 19 reported:

> "There is no way to get water. No channel left. All dams were gone."

The result of lahar-trace tracking fieldwork, with addition of information from operational lahar map from BPPTK (see **Figure 3.5** in **Chapter 3. Study Area**), adds information about these causal conditions. From GPS-tracking activity, extent of lahar inundation that depicts the degree of lahar flood events can be seen. Complementary to this, 12.5m-interval contour lines pre-volcanism events are also presented. Contour lines are meant to be representation to the degree of tephra falls as it is logical to interpret that the intensity of tephra ground-deposit will decline with distance from volcano summit rises. This research did not perform special investigation to create an isopach map because: 1) fieldwork was performed months after the eruption events when rain and human effort to clean the environment up had initially occurred, thus direct information of tephra ground-deposit was blurred; and 2) although participatory mapping could provide possibility to create an isopach map, large number of data source would be needed to produce reliable isopach map because people's perception on the measure of thickness might severely vary, and since the creation of isopach map was not focus, objective, or main topic of this research, it was felt wiser not to put burden on this task. An official isopach map has not been produced by authority. The following **Figure 5.3** provides illustration on the degree of volcanism events as causal conditions:

Figure 5.3 Lahar Inundation on Villages along Putih River



Damage caused by lahar flood and inundation: 1) picture 1 represents devastation of paddy in downstream area; 2) picture 2 illustrates the encroachment of lahar into settlements area; 3) picture 3 illustrates the destructive power of lahar to bridge and dam; 4) picture 4 shows the destruction of river body and perennial plants planted along the river edge in upstream area.

Source: (IKONOS 2006; RBI Map; Field observation, 2011; Author's documentation, 2011)

Compared to the map of operational of lahar made by the authority (BPPTK, from **Figure 3.5** in **Chapter 3. Study Area**), the result of lahar trace-tracking showed an agreement. Lahar encroached downstream zone more intensely than it did upstream zone. In upstream zone, lahar hit non-settled human properties (i.e. farm) while in downstream zone it hit both non-settled and settled human properties (i.e. farm and residential area).

5.3.2 Phenomena Resulting from Physical Damage, Volcanism Intensity, and Water Supply Issues

Interruption on farm production emanated from several types of interruption, being: 1) crop failure; 2) unproductive land; and 3) the absence of livestock to breed.

All research participants reported crop failure. This category emanated from the quality and amount of yield. As said by informant 10:

> "Nothing left in my farm. Chili that was ready to crop, vegetables, all gone with ash loading them. The remaining one was only … two kilos, I think. Two kilos of chili. They were awful. Rotten. Nobody would eat."

This was echoed by the others, as what informant 14 said, for example:

> "Teak, *sengon*, all was gone swept by lahar flood, leaving me with only sand on my farm."

Unproductive land was primarily expressed by farmers experiencing farm damage from lahar flood. As in informant 1 speech:

> "…. the sand [on my farm] was 1.5m high. I could not produce ….".

Although not experiencing lahar, informant 2 expressed similar situation:

> "With too much ash [on the land], I could not plant anything".

Interruption on farm production also happened to livestock farming activity. With no fish in pond and dead or stressed chickens, production from livestock farming activity was terminated (informant 5, 12, 14).

The degree of disruption on farm production varied, indicated by the length it happened, in case of informant 1:

> "Until now [October 2011, 1 year after eruption event], I have my 80% farm land uncultivated. The sand is plentiful",

while in case of informant 2:

> "It took some time, but in February [2011] we could start planting".

5.3.3 Context in Which Strategies are Developed

Context, referring to circumstances that surround and mediate the development of strategies in facing phenomena resulting from the causal conditions, consisted of; 1) farm location; 2) commodity characteristics; and 3) households' business characteristics.

Farm location emerged primarily when reference to the degree of volcanism impact was made. Some research participants have their farm located close to river. Proximity to river became influential to the development of strategy when reference to the extent of lahar emerged. Informant 1, for example, said:

> "I have more than 1 metre [high] sand in my farm. [It will] take long time to clean it. Rather than forcing myself to plant something, taking advantage from it [the sand] is better."

Some farmers possess large area of land and the land is split in different location. This gave them opportunity to have some area undamaged while also having the other damaged. Like in the case of informant 17:

> "I have 7,600 sqm land. No, not all of them is [located] near the river. The 1,300 [sqm land] one is near the river. It has been destroyed [by lahar]. The 3,900 sqm, I have it in Salakan [name of hamlet]. It is safe, partially. And the rest I have it here [pointing on a map brought by researcher during interview]. This one is safe."

In addition to these, informant 2 expressed how having farm in higher elevation shaped the strategy in dealing with the volcanism impacts:

> "My *zalacca* farm is 50m away from river. I can still do something now, but with I live up here [in higher altitude location] I had thicker ash, probably. It was very hard to clear the land up".

Characteristics of commodity, being type of plants and livestock, life cycle, and level of demand for water, contributed to the choice of strategy. Type of plants was said to give consideration because of their economic value and easiness to cultivate. For certain types of livestock (i.e. egg-layer chickens), environmental change and noise can cause stress to them. Life cycle of commodity ranges from months (e.g. paddy, corns, vegetables, chili) to years (fruit plants, timber plants). On the other hand, level of demand for water ranges from considerably low, as what present in dry-farm products (chili, beans, vegetables), to considerably high, as for paddy. In regard with the types of plants, two groups of farming plants emerged during interview with informant 2, being the ones with short life cycle (seasonal plants) and the ones with long life cycle (perennial plants). She said:

> "Actually it is less profitable to have seasonal crops, like paddy, chili, vegetables, corns, if you compare them to the long-lasting one, like this zalacca. You must renew your corns. But zalacca can last for 20 years".

The last contextual condition that contributed influence to shaping the development of strategies is households' business characteristics. Five properties constituting the characteristics were: 1) farm characteristics (size of land, dependency to irrigation, and soil condition); 2) households' business diversification; 3) households' business turnover; 4) entrepreneurship; and 5) human resource.

Size of land under possession shaped the development of strategy, as the same proportion of physical damage on bigger size of land would lead to different absolute size of undamaged land compared to smaller size of land. This was perceived as having something to do with provision of options for strategic actions.

Some farmers heavily relied on irrigation service to water farm. This happened to farmers whose farm is in downstream zone. With the irrigation service ceased and no major reconstruction has finished, they thought that trying to recover their land from sand inundation would be useless because finally they will face problem with water. This made them think over the strategy. While in other cases, farm used to be rain-fed, thus the absence of irrigation contributed little influence to choice of strategy. Another form of watering method used to be done in pre-volcanism events period was flowing water from river.

Soil condition also shaped the consideration for strategy choice. Informant 8, whose farm lies on a location with considerable amount of sandy soil, expressed that even before the volcanism events, he could only enjoy small amount of crops and the choice for planting was already limited. This contributed to his strategy choice having the farm was then destroyed by lahar. On the other hand, informant 11 presented how soils on his farm "changed" after the occurrence of Merapi volcanism events:

> "After the eruption we planted chili again. But it seemed different. The plants, they could not grow like usual. They were shorter, their roots seemed weaker. We had to remove them from the ground. We had them planted in polybags."

Households' business diversification emanated from the presence of economy source other than farming activity. From the investigation, three types of non-farming jobs emerged, being: teacher (informant 1 and informant 11); public officer pensioner (informant 17); and carpenter (informant 5).

Business turnover shared another contextual condition to the strategy choice. Informant 9, having her big size of land and amount of yield, has large amount of savings even after the farm partially destroyed by lahar. This influenced her choice in facing the impact of 2010 Merapi volcanism events.

Entrepreneurship emanated from discussion on how cropping pattern decision being made. There was no necessity to follow particular planting guideline. Households are free to choose what they want to cultivate. Even with the presence of communal farmer group, no obligation of practicing uniform farming method is present.

The last agriculture business characteristic was denoted by human resource being available. Some households manage their farm on their own while some others entrust the land to other cultivators. Informant 12 described;

> "I am old now. No much power left. I entrust the hard work to the young."

5.3.4 Intervening Conditions Influencing the Development of Strategies

Intervening conditions, being any circumstances that moderate the development of strategies in dealing with the impacts of 2010 Merapi volcanism events included: 1) evacuation; 2) season; 3) price fluctuation; 4) characteristics of lahar; 5) local government policy; and 6) external aid.

Figure 5.4 Shelter for Sirahan and Jumoyo residents whose houses devastated during lahar flood events

Source: (Author's documentation, 2011)

Evacuation became circumstance that influences the choice for strategy for facing the resultant phenomena of tephra fallout and lahar and water supply problems. Expressed by informant 2:

"We were in Tanjung [name of evacuation centre in Magelang Regency]. We didn't know that the road blockade was removed by some volunteers. If only we knew, we might have had something to do with our *zalacca* crops. Or maybe not, he [her husband] is the head of hamlet. We were busy organising our people"

All participants reported that farming business was far less important during evacuation period. They must have been prioritising their life safety over other activity. Said by informant 6:

"You know when it [lahar] came, everything was like… shaken, the glass window, .. trembled. Really terrifying. No way I thought about something else".

Different situation happened to another informant. Informant 3 reported that during being evacuated, albeit his role as community leader, he could send some family members home to do cropping.

Those two narrations provided reasoning how evacuation gave context to the choice of strategy. **Figure 5.4** illustrates the evacuation spot for residents whose houses are devastated during lahar flood event. For them, it was perceivable that time period of being evacuated would be much longer than the others.

As many 8 people as informants were evacuated during eruption period in October to December 2010 while not being evacuated in lahar flood event. The other 7 people were evacuated during lahar flood but not during the eruption event, with period of being in evacuation varied, reached up to a year time span from the occurrence of eruption in October 2010 (up to the time of interview being carried out). The other 3 people were not evacuated in both events, and the rest 2 people were evacuated in both events. In addition to seeking refuge, time spent in evacuation was also for participating in voluntary community service in providing assistance for evacuees (informant 1, 2, 8).

Season also gave influence to the development of strategy. In this part of Java tropical climate area, there are two seasons, dry season and rain season. The contribution of season in developing strategy was reflected within speech of informant 4, which was also supported by speech of other informants (informant 12, 14), as follows:

> "With irrigation stopped, I have to look at the situation. Well, I need water. I need to see if it will rain or not. Months ago I panted chili. There was no good crop. It [the weather] was too hot"

Price fluctuation category shared intervening influence for the development of strategy through two properties, being agriculture production cost and fluctuation on yield market price. Increasing agriculture production cost influenced the development of strategies in some ways. With subcategories being cost of livestock feed, fertiliser, seed, labour, and water, emergence of this category was present within the speech of informant 12 and also echoed by the other 6 informants. Cost of fertiliser, seed, and labour forced them carefully decide what strategy to take in facing phenomena of interruption on farming production. This cost of production was amplified by the necessity of spending money to obtain water in the aftermath of 2010 Merapi volcanism events, as expressed by informant 12:

> "If I want water, I have to pay Rp 20,000.- for renting electric water pump. Only for an hour. How can you think everything not expensive, I used to pay nothing for water! Labour is not cheap either. Twenty-five thousand rupiahs per day per person, if I provide them with meal. Thirty thousand, if I don't. Then fertilisers, seeds.. So expensive"

For some commodities, selling price is highly fluctuated. Commodities in this category include chili and vegetables. Chili, for example, at one time was sold up to Rp 30,000.- or even more per kilogram while at the other near times the price could be far lower, ranging from Rp 3,000.- to Rp 10,000.-. Some circumstances influencing this fluctuation were expressed within interview, being massive production at a time point, plant disease, and problems in distribution.

Characteristics of lahar, being continuous and destructive, built moderating situations to the development of strategies. As said by informant 7:

> "I am afraid of lahar coming over again. And it likely will. There is no use of planting again if it will just be swept away".

Relatively similar response was also found within interview with informant 5, 11, and 19. Other than this, different types of materials carried by lahar also shaped the strategies. Informant 9 expressed:

> "It's not like there, in Salakan [name of hamlet in Sirahan Village]. People [could] enjoy the lahar. It sent them sand, but in my situations, I got only gravels. Difficult to sale".

Local government policy that influenced the development of strategy comprised of: 1) prohibition of using heavy equipment to extract sand; and 2) normalisation of Putih River. Prohibition of using heavy equipment to extract sand raised influence to the development of strategy in facing the resultant phenomena of lahar flood impact, as expressed through the following comment:

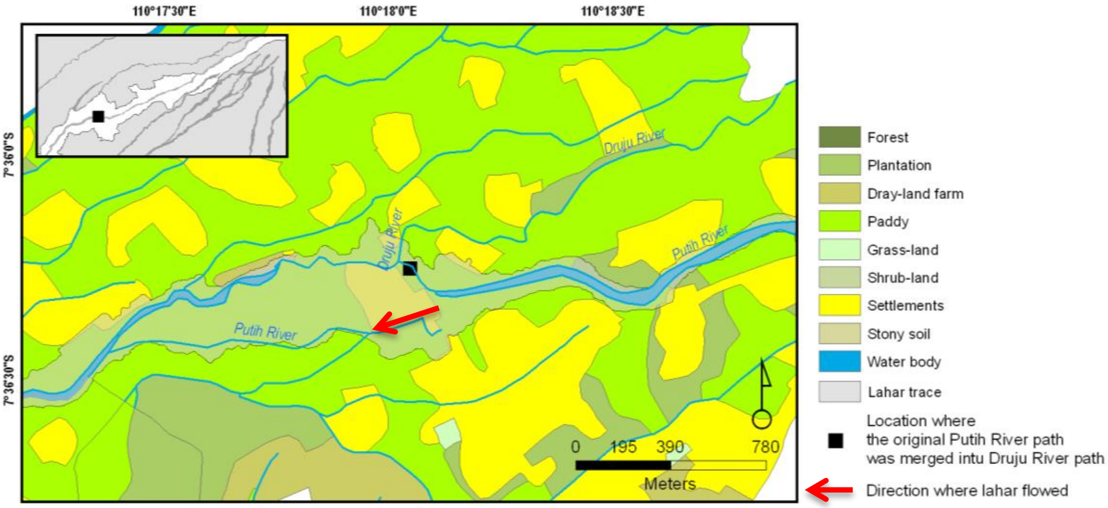
> "It is… problematic. The government prohibits the use of backhoe. In fact, there is no way of clearing up the farm quickly with manual technique. It is problematic. It will take months to get my farm clean, for example. I think they [the government] are in debate too" (informant 1)

Second policy was in relation with normalisation of Putih River flow path to its original flow path. Flow path of Putih River was modified for engineering work purposes. As nothing happened within long period, the original flow path area was human occupied and developed into settlement and farm area. During lahar flood event, lahar did not flow through the new path; rather, it flowed following the original path. As a result, settlements and farm land within the vicinity of this original path were completely devastated. Following this, local government made a decision to restore Putih River to its original path. How this policy influenced strategy of facing phenomena resulted from the causal conditions was expressed through the following part of speech:

> "My farm land lies within the old [original] river path. As you can see, the government is to restore the river [to its original path]. Then it is impossible for me to do something to my land. I mean, there's no use, is it? I will lose it anyway". (informant 8)

The following **Figure 5.5** illustrates the original path of Putih River, spot where it was merged into Druju River for engineering-work purposes and the direction where lahar flowed through the original river path.

Figure 5.5 Spot where Original Putih River Path Modified



The last intervening condition was the presence of external aid. The first external aid was in form of paid community service promoted by government. Within this scheme, residents participated in works of cleaning their neighbourhood from the trace of volcanism, repairing community infrastructure (ditches, hamlet bridge, etc.) and receiving payment as much as Rp 30,000.- per person per day. The duration of programme varied, from several days to weeks, depending on decision of responsible institution. The second external aid was productive economy stimuli given by some non-governmental organisation. Informant 16 said that he received chickens while his wife was involved in a workshop of making handicrafts. The third external aid was in form of daily needs supply. This code emanated primarily when discussing evacuation. One of the informants said:

> "Everything was provided. Even the leader of district came himself to give us blanket. We received some soap, rice, clothes" (informant 9).

Daily needs supply also came from family member and could last for quite long time. Said by informant 15, in the aftermath of volcanism events his son continuously provided supply for his needs, in the form of food and money until the time of interview being held (10 month after eruption event).

Another external aid was present as loan, primarily from bank. Informant 5 said;

> "The bank, they helped me dealing with my chickens. …. I borrowed some [money] from them"

5.3.5 Strategies in Dealing with Interruption on Farm Production

Eight categories emerged from data as strategies in dealing with phenomena resulting from the causal conditions, comprising of: 1) saving commodity; 2) absorbing loss; 3) adding labour force; 4) repairing farm; 5) having alternatives for source of water; 6) restarting farming activity; 7) having new economic activity; and 8) relying on non-farming economy source.

Saving commodity was done to keep the farm products away from harm caused by volcanism events. Informant 3 cropped his *zalacca* yield during eruption period before the eruption climax on 5 November 2010 that brought about most severe tephra fallout to the region. He cropped immature fruits he scheduled to be cropped within the next several days. With this strategy, he managed to yield 700kg fruits that later he sold. Another informant expressed an action resembling this too. Informant 5 covered his livestock cages with plastic when volcanic ash and tephra rained the region.

Absorbing loss strategy manifested in three ways. Doing nothing was the first. This action lasted from short period up to longer period. All research participants went through this strategy, at least at some time when disastrous event happening. Within this course of action, no active measure was taken to face with the impact of 2010 Merapi volcanism events. The second action realised as selling owned asset. Informant 5 for example, said:

> "After everything [livestock] gone [swept by lahar], I sold my car, my property [land], and the rest of them [chickens]. That's the only way .... I had to.. "

Another action to absorb loss was consuming the low-quality crops that were produced during eruption event. As many 2 as informants expressed this way. They took the crops, all of them were paddy, for their own consumption purposes instead of trying to sell them. Other than all of those, using personal savings to fulfill needs in the aftermath of volcanism events also emerged from 2 informants.

Having addition to labour force also constituted strategies to facing resultant phenomena of tephra fallout, lahar, and water supply problems. Informant 2 for example, used two workers to help preparing her land. This was expressed as follows:

> "I asked two people around here to help. Planting *zalacca* was easy, you know. You just wait. So we never used help of workers".

Relatively similar response was also expressed by informant 12 who employed more workers to clear his farm from sand.

The next strategy, repairing farm, emanated from three codes: 1) cleaning farm from plants remnants; 2) removing sand on farm; and 3) plowing land. Said by informant 2:

> "I started to clean the collapsed plants. Not easy. You can imagine those zalacca plants with some thorns. It took days. Then hoeing…"

In addition to this, informant 7 described his experience cleaning sand covering 25% of his farm land before plowing it for planting paddy.

The fifth strategy, being seeking for alternative source of water, was motivated by the absence of regular water service for farming. As many as 4 research participants mentioned that they took measure of renting electric water pump to flow water from either Putih River or the neighbouring river (Blongkeng River). Another research participant used rented electric water pump to flow water from her well at her house to the farm land. While as many as 5 research participants simply relied on precipitation to water their farm.

Restarting farming activity was carried out at short and long timespan from the happening of causal conditions and their resultant phenomena. Informant 2 as example, restarted her *zalacca* farming in February 2011, while informant 9 began to plant chili for the first time after lahar damaged part of his farm in May 2011. Informant 1 started planting corns on his farm in September 2011. On the other hand, there were some informants who have not at all restarted cultivation on their farm until a year after the eruption event.

There were two types of farm-restart, first being with change to cropping pattern (either commodity or planting schedule), and second being with no change to cropping pattern.

Farmers changed their cropping pattern as a strategy in facing with phenomena resulting from the impact of 2010 Merapi volcanism events. This strategy realised into change in planting schedule and change in commodity. With the absence of irrigation service and precipitation was considerably low during the year, informant 9 chose to plant chili at time that he used to plant paddy. The emerged type of commodity change was from perennial plants to seasonal plants that have shorter life cycle with main purpose being more quickly money-making. Informant 2 for example, changed *zalacca* plants as her used-to-be main and only commodity to chili, corns, and beans in the aftermath of 2010 Merapi Volcanism events. She said:

> "It is impossible to await my zalacca plants yielding. It will take more than a year [to crop] after this devastation. Even though this seasonal one [plants] is less profitable, I had better start producing".

Relatively similar action was also taken by informant 12 and informant 14 who cultivated different commodities from the old ones. They used to have teak and *sengon* timber plants as main commodity and in the aftermath of causal conditions happening they have chili and beans in their farm. Another change was from commodity that is water demanding to commodity that is less water demanding. Informant 7 for example, used to have paddy as his main product, but since he encountered problems with water insufficiency, he cultivated chili and bean as the main product. For livestock commodity, breeding chickens with less sensitivity to surrounding disturbance was the way. Informant 8 breeds local chicken (*Gallus domesticus*) as substitution to egg-layer chickens he used to breed.

No change in cropping pattern was also present. Farmers experienced this. As many as 3 farmers with old agriculture products being dry-land farming commodities continued their old farming practice after the volcanism events.

Having new non-farming economic activity also constituted the strategy in facing resultant phenomena of causal conditions. As many as 8 farmers reported that they were involved in new economic activity. The emerging types of activities were: 1) sand-mining work; 2) manual labour; and 3) starting a neighbourhood-level daily needs retail. In particular with sand-mining sector, activity ranged from laboring, getting involved to community-managed sand-mining activity with other residents within similar hamlet, and receiving compensation from sand-extracting activity conducted in their farm. Amongst these 8 people, 5 said that the new activity was a complementary to their business as farmer, while the rest reported that the activity was to be substitution.

The last category of strategy was relying on the old non-farming economy source. This strategy was carried out by research participants having diversification in their households' business. From the data, type of this strategy included relying on economic activity as teacher, carpenter, and public officer pensioner.

The following **Figure 5.6** illustrates realisation of some strategic measures taken:

Figure 5.6 Realisation of Strategic Measures in Dealing with Agricultural Business Interruption

			
Doing nothing to farm: grass grew in land used to be a farm	Restarting paddy production in the remaining arable land	Having dry-land farming commodity as complementary to restoration of zalacca plants	Getting involved in sand-mining activity

Source: (Author's documentation, 2011)

5.3.6 Consequences of Strategies for Dealing with Interruption on Farm Production

Strategies carried out by research participants led to consequence. This consequence was themed as households economic functioning, with properties being: 1) farm yield; and 2) economic outcome.

The first economic functioning properties, being farm yield, encompassed the aspects of crop types and amount. As data spoke, type of crops varied, but mainly ranged from paddy to dry-land farming product. For some farmers, the type of yield was different from the old one they used to have. Amount of yield was within range of kilograms to quintals. Another unique farm yield was sand. This was the resultant of sand-mining activity carried out in farm location that covered by lahar materials.

The second property of economic functioning category is economic outcome. Economic outcome was derived from selling farming products, sand, and or non-farming jobs carried out as complementary or substitution to farming activity.

5.4 DISCUSSION

The previously-described works present comprehensive explanation about the process in which households' economic functioning in the aftermath of disastrous events is developed. This explanation starts with the causal conditions, resultant phenomena of causal conditions, strategy in facing resultant phenomena along with its contextual and intervening conditions, and ends with the consequence of strategy.

Causal conditions of being physical damage from disaster impacts and the issue of water supply emerged from this research support the work of Tierney (1995) in which she found that unavailability of water became one of reasons leading to business closure in the aftermath of 1993 Midwest flood (64% of surveyed firms reported unavailability of water as reasons for closure), while damage to business property occupied smaller proportion in the survey. Another research result mentioned that the degree of physical damage of business property contributed influence to the recovery of business (Webb, Tierney, & Dahlhamer, 2002). In respect with intensity or degree of disastrous agent (denoted by thickness and height of tephra and lahar ground-deposit), other studies on economic impact assessment usually subsume this issue into physical damage of business properties. Physical damage will probably be the main departure point of economic impact and special attention to the degree of disastrous agent (e.g. water depth in flood event) is less necessary because this has been represented through the degree of physical damage (see e.g. Tierney, 1995; Webb, Tierney, & Dahlhamer, 2002; Xiao, Wan, & Hewings, 2011). Deviant from this trend, result from this research positions degree of disastrous agent (in term of thickness and height of tephra fallout and lahar ground-deposit) in special spot within causal conditions frame. This seems logical based on some reasons:

1. The type of business being studied in this research is agriculture, with inevitable reference to land as business properties. Compared to other business properties, primarily buildings, land for farming is not normally strengthened by special structural-engineering feature that enables it to resist from natural shocks. Therefore, degree of disastrous event will be the only influence for any detrimental effects happened to it.
2. What being explored through this study is the development of *economic process*, not merely fixed measure of economic impact as aggregate. With reference to the characteristics of lahar, being absolutely destructive and unable to be removed without human intervention, it is logical that the intensity of disastrous event gains specific attention because it is highly likely to influence the development of process in facing the disastrous event. Also, even though detrimental effect of tephra ground-deposit can be minimised by the inherent plants resistance, human effort in minimising its negative impact is still necessary if reference to its presence on land is made.

Resultant phenomena of interruption on farming production being revealed within this research concurs with the result of study in Mayon and Pinatubo Volcano (the Philippines), which implies that in the aftermath of volcanism, no farming production was present (Lebon, 2009).

Business characteristics and price fluctuation support the use of firms characteristics and owner-perceived economic climate as variables for predicting business recovery level in study of Webb, Tierney, & Dahlhamer (2002). This finding is also consistent with general economic clause that macro economy situations will affect micro economy situations. Still in this contextual and intervening conditions frame, the emergence of job diversification as surrounding situations to the decision on strategy of facing economic loss supports the employment of job diversification and income-source dependency index as indicator for measuring households' ability to absorb loss and recover quickly from the influence of climate change shocks within the study of Zhou, Wang, Wan, & Jia, (2010) and Sun, Zhou, Wang, & Yuan (2011). The latter study also used size of farm as indicator. Intervening conditions emanating from government policy shows congruency with the work of Rose & Lim (2002) which mentions policy as one of the two influential factor in disaster economic loss. The presence of external aid as influence to the development of strategy in facing business economic loss is also in agreement with the result of survey in Tierney (1995) study, although the kind of aid shows dissimilarity, in which she found the involvement of insurance claims and business loan in the attempt of firms business recovery. Types of external aid emerging from this grounded-theory-based investigation show common practice of disaster relief situations in Indonesia, for example as happened in the Yogya Earthquake May 2007, in which involved paid community works and provision of productive economy stimuli.

Other contextual and intervening conditions present as result in this research may be specific to the object and type of disastrous event being studied. On the other hand, although studying similar disastrous event (volcanism with involvement of tephra fallout and lahar flood event), study by Lebon (2009) does not mention the role and position of evacuation in discussing impact of volcanism on farmers. Other study in

Pinatubo Volcano only mentions that farming was the purpose of evacuees to return home after evacuation period over (Gaillard, 2008).

Strategy being taken in facing the resultant phenomena of causal conditions all shows agreement with the result of other studies. Rose (2004, 2007, 2009) provides some category of possible actions taken by individual economic entity to dampen economic loss and continue functioning in the aftermath of shocks. These categories of actions include: 1) conservation; 2) input substitution; 3) import substitution; 4) inventories; 5) excess capacity; 6) input unimportance; 7) relocation; 8) production recapture; 9) technological change; and 10) management. Early cropping strategy emanating from this research presents an agreement with concept of inventories. The crops early cropped were stored for later selling. The use of electric generator to pump and flow water for watering farm resembles the concept of input substitution, of which the ordinary input for water (irrigation service) is replaced by this action. The use of additional labour force and repair of farm represents the excess capacity in which concept of system redundancy is implied. Restarting farming gives example for production recapture category. Finally, change in commodity shows representation to technological change, which alteration to the characteristics of product is implied within. Besides, changing commodity from the one which is water-demanding to the one less water-demanding can also be said to represent the concept of input unimportance since it decreases dependency to the provision of water as input. Next, the presence of new economic activity in sand-mining sector indicates the presence of new economic opportunity brought by volcanism event. This provides support to the previous works in seeking balancing perspective towards environmental feature and volcanoes in particular, being not merely seen as hazard or threat, but also benefit (Kelman & Mather, 2008). The new economic activity emerging from volcanism event adds advantageousness of volcanoes besides fertile soil and wealth of water (Shoji & Takahashi, 2002; Wilson, Kaye, Stewart, & Cole, 2007; Lebon, 2009). The new economic activity in sand mining sector becomes a balance to agricultural losses, and this is congruent with what having been disclosed in the case of Ruapehu Volcano, New Zealand, in which agricultural and tourism benefit can balance losses on ski resort industries (Becker, Smith, Johnston, & Munro, 2001). The advantageousness of volcanoes in term of providing mining input is also documented in Soufrière Volcano (Robertson, 1995). Strategy of absorbing loss agrees with the finding of Tierney (1995) work, in which she described that some business firms simply absorbed the effect of Midwest flood and Northridge earthquake using business owners' personal savings to compensate the economic loss. Relying on non-farming economy source, on the other hand, once again supports the use of income-source diversification and dependency as predicting variables in estimating resilience to drought in China (Zhou, Wang, Wan, & Jia, 2010; Sun, Zhou, Wang, & Yuan, 2011).

Last, consequence from all of the interacting categories that realise into strategies closes the process. Agricultural household economic functioning denoted by the level of farm yield and general economic outcome constitute this category. This consequence represents the ability of agricultural households to avoid collapse and remain economically productive. This consequence resembles the concept of economic resilience emanating from the work of Rose (2007, 2009) which defines economic resilience as the ability to soften loss and continue functioning. The two properties of this category are in agreement with the use of business outcome level as proxy to measure the economic functioning level.

Albeit the fact that findings presented in this grounded-theory work are mostly in agreement with the previous works, i.e. not many new things emerged, this work provides better insight and detail to actual circumstance present in the event and object being studied. What worth appreciation from this work is its attempt to comprehensively describe and explain the process in which such attainment of economic functioning level is developed. However, it is truly admitted that due to researcher's considerable unfamiliarity with inductive research process, literatures and deductive thinking may influence the development of theory. The abundance of data and resource being spent within this grounded-theory work can also be regarded as being be far less if compared to other more advanced work of grounded-theory work (see e.g. in Creswell, 2007).

5.5 HYPOTHESES

Based on the connections developed within the construction of economic resilience theory, it is then hypothesised that:

1. Economic resilience level (or the level of business economic functioning) positively correlates with the intensity and value of active measures in facing business interruption being implemented.
2. Economic resilience level (or the level of business economic functioning) positively correlates with the business turnover in normal condition.
3. Economic resilience level (or the level of business economic functioning) negatively correlates with proximity to River Putih.
4. Economic resilience level (or the level of business economic functioning) negatively correlates with the length of being inactive from productive economic activity.
5. Economic resilience level (or the level of business economic functioning) negatively correlates with the degree of physical damage on farm.

6 MEASURING AND MODELLING ECONOMIC RESILIENCE

This section presents the result of survey and analysis in measuring the level of economic resilience of agricultural households along Putih River as well as in developing the economic resilience model. This section is structured as follows:

1. Description of samples;
2. Measurement of agricultural households' economic resilience level;
3. Development of economic resilience model; and
4. Discussion.

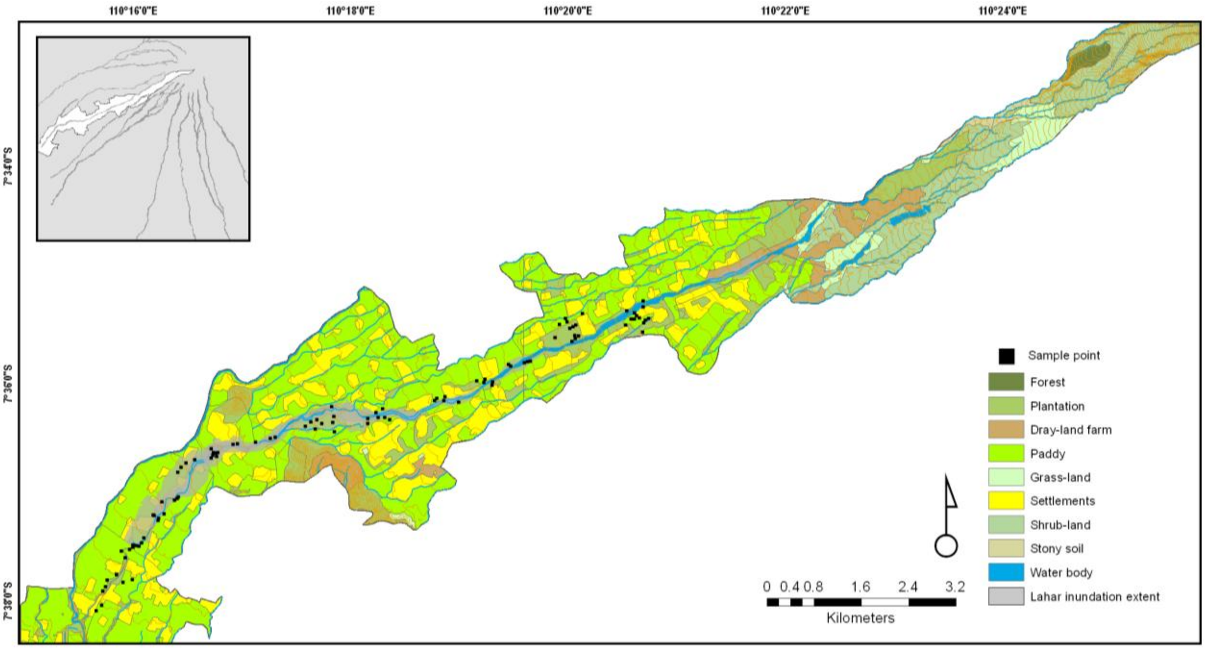
6.1 DESCRIPTION OF SAMPLES

As many 100 people as respondents were involved in the measurement and modelling of agricultural households' economic resilience. **Table 6.1** summarises the demographic structure of survey samples, in terms of their gender and age, and **Figure 6.1** illustrates respondents' spatial distribution over a land-use map of the study area.

Table 6.1 Respondents' Demographic Structure

CATEGORY	PERCENTAGE
Gender	
Male	78
Female	22
Age	
Younger than 30	0
Between 30 and 39	16
Between 40 and 49	31
Between 50 and 59	42
Older than 60	11

Figure 6.1 Respondents' Distribution



6.2 MEASUREMENT OF AGRIBUSINESS HOUSEHOLDS' ECONOMIC RESILIENCE LEVEL

6.2.1 Indicators and Parameters

Referring to what has been described within section **4.2.3 Unit of Analysis in Determining the Level of Economic Resilience**), the following indicators are required in order to operate the DSER calculation formula:

1. Amount of business output in normal state, as a standard for determining possible maximum loss and amount of business output in the aftermath of shocks as proxy to business actual loss;
2. Estimates of business input material curtailment; and
3. Amount of business possible maximum output reduction.

Within this research, amount of business output in normal state took annual average agribusiness households economic output before the 2010 Merapi volcanism events and amount of households' economic output after volcanism events as proxy to maximum and actual economic loss. The households' economic output was defined as the amount of money resulted from any economic activity by households and was not limited to only financial output from farming production. The inclusion of all economic activities was meant to see households as a complete existence of business entity, thus involving only output from farming production would be inadequate. Monetary unit was necessary to aggregate broad-range of economic activity output types. While acknowledging certainty that monetary value of such economic activity output fluctuates through time, this research did not take actual rates for its measurement (e.g. using different monetary value in pre and post-volcanism event for similar type of business output), rather, it employed similar monetary value for similar type of business output for both periods, using pre-volcanism event price based on respondents' information. This was because albeit the value of an economic activity may rise through time, the function of this value, e.g. for fulfilling daily needs, is likely to be equal as some period before since prices of other goods and service increase as well. Therefore, using the similar monetary standard for similar type of economic activity output in different period was meant to amplify the intent of comparing economic *functioning* rather than economic output, congruent with what being conveyed through the conceptualisation of economic resilience. In addition to this, it is necessary to stress that the economic output here did not mean to represent business profit. This research believes that the concept of economic resilience represents the level of functioning, and using business profit instead of outcome seems to go too far because the generation of profit may involve factors more than functioning and it seems to be more applicable in conditions of no shocks to business. Besides, business outcome can inevitably subsume profit within, since large output may contain large profit as well.

As confidentiality issue does matter within the revelation of households' monetary economic output, with consideration to the characteristics of agriculture business, being that they are likely to involve more than one agriculture commodities, this research employed such strategies to deal with this problem, as follows:

1. Economic output from farming was quantified by multiplication of average amount of yield for each crop type in one cropping period by price per weight unit and by frequency of cropping.
2. Total households economic output was quantified through division of farming economic output by contribution or factor of importance of this farming economic output to households' revenue based on respondents' perception.
3. In post-volcanism event case, of which some households might not have started their farming activity yet, thus the revelation of farming economic output in post-disaster period was unlikely, respondents were to be asked to mention one of their economic activity, along with its frequency and monetary yield per doing and the factor of importance of this activity to their current economy. Applying similar technique to what being mentioned in point number 2, total households' business output while farming production output was absence could still be known.

As no repair on irrigation system has been made and threat of devastating lahar was still continuing during the undertaking of this research (refer to narrative analysis in the previous chapter), a 100% input material curtailment was assumed. Thus, the possible maximum loss would be 100%, meaning that equal amount to households' economic output pre-volcanism events was the likely amount of economic loss in post-volcanism event period.

To cover the dynamics representation of economic resilience, a four-month period was used as timespan. This timespan is considerably ideal as it can represent the average period for one-round yield of seasonal plants, thus economic output could be generated and computed from this timespan. The starting point of economic resilience observation was January 2011, as this was the time point after status of Merapi Volcano was pronounced stable and the ending point was December 2011 due to this research time limitation. Based on this, there would be three time-spans in post-disaster period.

The following **Table 6.2** summarises indicators and parameters in measuring households' economic resilience:

Table 6.2 Indicators and Parameters in Measuring Agribusiness Households' Economic Resilience

INDICATOR	PARAMETER	UNIT
Agribusiness households business economic output	Farming economic output (both pre and post-volcanism event)	Rupiah
	Factor of importance of farming to households' economy	Percent
	Non-farming economic output (in the aftermath of volcanism event)	Rupiah
	Factor of importance of non-farming economic output to households' economy at that time (in the aftermath of volcanism event)	Percent
Maximum possible loss	100% output reduction, since 100% curtailment to business input existed	
Time dynamics	Three four-month timespans after volcanism event	

With all of those parameters, the following **Table 6.3** describes the operational calculation formula that was used within this research:

Table 6.3 Operational Calculation Formula for Economic Resilience Measurement

NOTATION AND MEANING	CALCULATION FORMULA
Y_{FN} Annual households' economic output from farm production in pre-disaster period	$Y_{FN} = \sum_{i=1}^{n} (a_i f_i p_i)$ .... (1) a_i = amount of yield of commodity I per cropping (kg) f_i = frequency of cropping of commodity I in a year p_i = price of crop of commodity I (Rp/kg)
C_N Factor of importance of farm production to total households' economic output in pre-disaster period	-
Y_{TN} Annual households' economic output from total business activity in pre-disaster period	$Y_{TN} = Y_{FN} / C_N$ .... (2)
y_N Four-month period households' averaged economic output from total business activity in pre-disaster period	$y_N = Y_{TN} / 3$ .... (3)
ΔDy^m Maximum possible business output reduction in four-month period of time	$\Delta Dy^m = y_N$ .... (4) (assumption = input material curtailment is 100%)
y_1 y_2, y_3 First, second, third four-month period households' economic output from total business activity in post-disaster period	(refer to equation 1 and 3)
ΔDy Actual business output reduction in four-month period of time in post-disaster period	$\Delta Dy_1 = y_N - y_1$ .... (5) $\Delta Dy_2 = y_N - y_2$ .... (6) $\Delta Dy_3 = y_N - y_3$ .... (7)

to be continued

Table 6.3 continued

NOTATION AND MEANING	CALCULATION FORMULA
ER_1 Economic resilience in first four-month post-disaster period (min = 0; max = 1)	$ER_1 = \frac{\Delta Dy^m - \Delta Dy_1}{\Delta Dy^m} = \frac{y_N - (y_N - y_1)}{y_N} = \frac{y_1}{y_N}$ ..... (8)
ER_2 Economic resilience in second four-month post-disaster period (min = 0; max = 1)	$ER_2 = \frac{y_2}{y_N}$ .... (9)
ER_3 Economic resilience in third four-month post-disaster period (min = 0; max = 1)	$ER_3 = \frac{y_3}{y_N}$ .... (10)
ER Aggregated economic resilience, being economic resilience value throughout a year period post-disaster occurrence (min = 0; max = 1)	$ER = \frac{y_1 + y_2 + y_3}{Y_{TN}}$ .... (11)

Application of parameters and calculation can be seen in survey questionnaire in **Appendix 1** (item number 3, 4, 6, 7, for pre-disaster period case, and item number 13-19, 22-28, 21-37 for post-disaster period case)

6.2.2 Economic Resilience of Agribusiness Households in Putih River Region

The following **Table 6.4** describes the range and proportion of households' economic output being used as proxy to households' business functioning. It should be noted that this figure was the result of estimation based on constant price, i.e. using averaged rates to value agriculture products and ignoring the logic probability of price fluctuation. Classification in the following table does not show the application of consistent equal-interval grouping as some values were truly deviant from the others.

Table 6.4 Ranges of Agribusiness Households' Economic Output (Constant Price)

DESCRIPTION	%
Annual households' output (Y_{TN})	
less than Rp 2,400,000	0
Rp 2,400,000 - Rp 7,300,000	24
Rp 7,300,001 - Rp 12,200,000	34
Rp 12,200,001 - Rp 17,100,000	14
Rp 17,100,001 - Rp 22,000,000	12
Rp 22,000,001 - Rp 26,900,000	12
more than Rp 26,900,000	4
First four-month post-disaster households' output (y_1)	
Rp 0 - Rp 400,000	42
Rp 400,001 - Rp 800,000	17
Rp 800,001 - Rp 1,200,000	15
Rp 1,200,001 - Rp 1,600,000	12
Rp 1,600,001 - Rp 2,000,000	8
more than Rp 2,000,000	6

DESCRIPTION	%
Second four-month post-disaster households' output (y_2)	
Rp 0 - Rp 1,160,000	60
Rp 1,160,001 - Rp 2,320,000	12
Rp 2,320,001 - Rp 3,480,000	10
Rp 3,480,001 - Rp 4,640,000	5
Rp 4,640,001 - Rp 5,800,000	7
more than Rp 5,800,000	6
Third four-month post-disaster households' output (y_3)	
Rp 0 - Rp 1,360,000	46
Rp 1,360,001 - Rp 2,720,000	32
Rp 2,720,001 - Rp 4,080,000	6
Rp 4,080,000 - Rp 5,440,000	8
Rp 5,440,001 - Rp 6,800,000	5
more than Rp 6,800,000	3

Table 6.4 shows how households' business output fluctuated during the three four-month periods (denoted by y_1, y_2, and y_3). The proportion of households being in the state of low business output tends to decline over time. This is shown by the change in class interval as well as the percentage of households being in the low-class category. At first sight, this can be a glance to the rise of economic resilience, since the measurement of economic resilience used business output as proxy. **Table 6.5** below describes the range of economic resilience value:

Table 6.5 Ranges of Economic Resilience Value

DESCRIPTION	%	DESCRIPTION	%
Aggregated economic resilience (ER)		**Second four-month post-disaster economic resilience (ER_2)**	
0.000 - 0.17	29	0.000 - 0.18	32
0.171 - 0.35	26	0.181 - 0.36	13
0.351 - 0.52	32	0.361 - 0.54	29
0.521 - 0.70	9	0.541 - 0.72	18
0.701 - 0.87	4	0.721 - 0.90	8
First four-month post-disaster economic resilience (ER_1)		**Third four-month post-disaster economic resilience (ER_3)**	
0.000 - 0.10	42	0.000 - 0.20	29
0.101 - 0.20	18	0.201 - 0.40	14
0.201 - 0.30	17	0.401 - 0.60	35
0.301 - 0.40	15	0.601 - 0.80	16
0.401 - 0.50	8	0.801 - 1.00	4
		more than 1.00	2

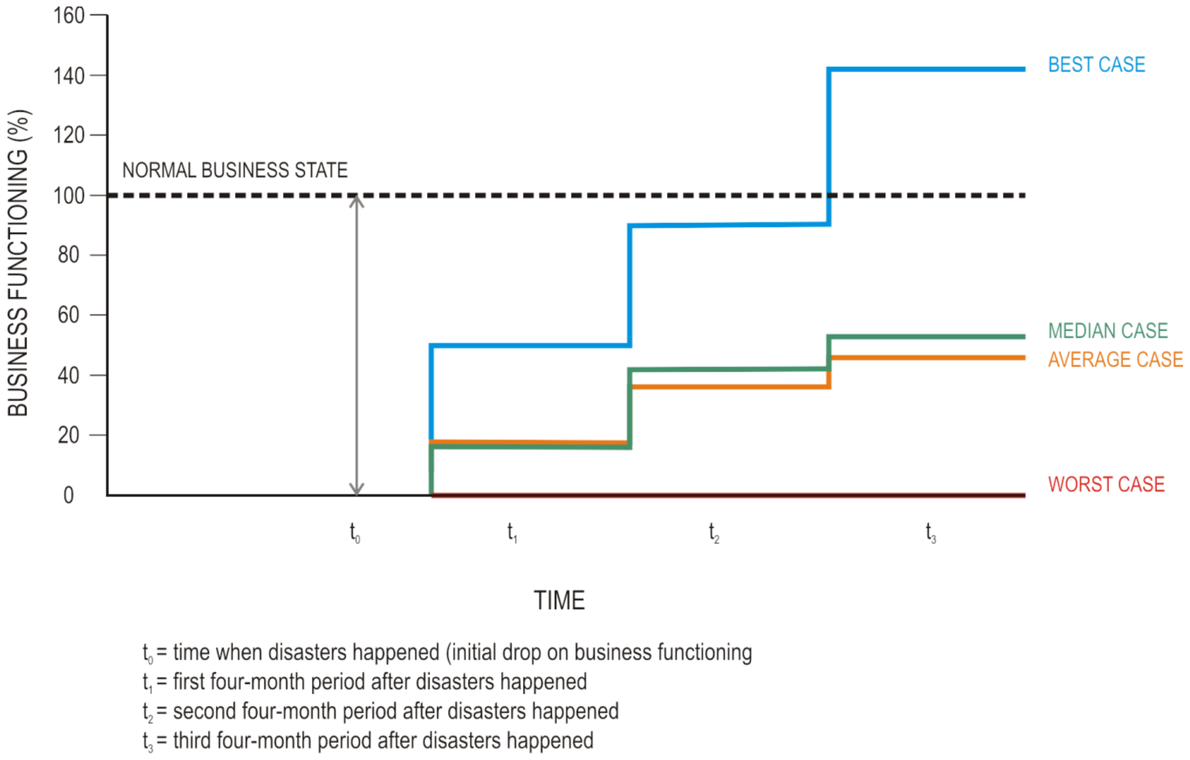
The following **Table 6.6** describes the maximum, minimum, mean, and median value of economic resilience from 100 agribusiness households' samples according to the calculation formula having been described in **Table 6.3**:

Table 6.6 Agribusiness Households' Economic Resilience Value

	ER_1	ER_2	ER_3	ER
Maximum	0.50	0.90	1.42	0.87
Minimum	0.00	0.00	0.00	0.00
Mean	0.17	0.37	0.46	0.33
Median	0.16	0.42	0.53	0.35

The best-case value of aggregated economic resilience (notated by maximum value of ER), being 0.87, means that during a year time period post-disaster events, households in this category were capable of approaching their initial economic functioning level. However, at average, the aggregated capability of agribusiness households in Putih River region to maintain their economic functioning reached only one-third of initial functioning level (mean value of ER = 0.33). In contrast to best-case households, the worst-case households were also possibly to perform no economic resilience at all throughout the year (minimum value of ER = 0.00). Economic resilience value tends to incline with time moving away from the time-point of disasters occurrence, either in best-case scenario, worst-case scenario, or average case (see the changes in ER_1, ER_2, ER_3). Over temporal dimension, agribusiness households' economic resilience is illustrated as appeared in the following **Figure 6.2**:

Figure 6.2 Temporal Pattern of Economic Resilience Value



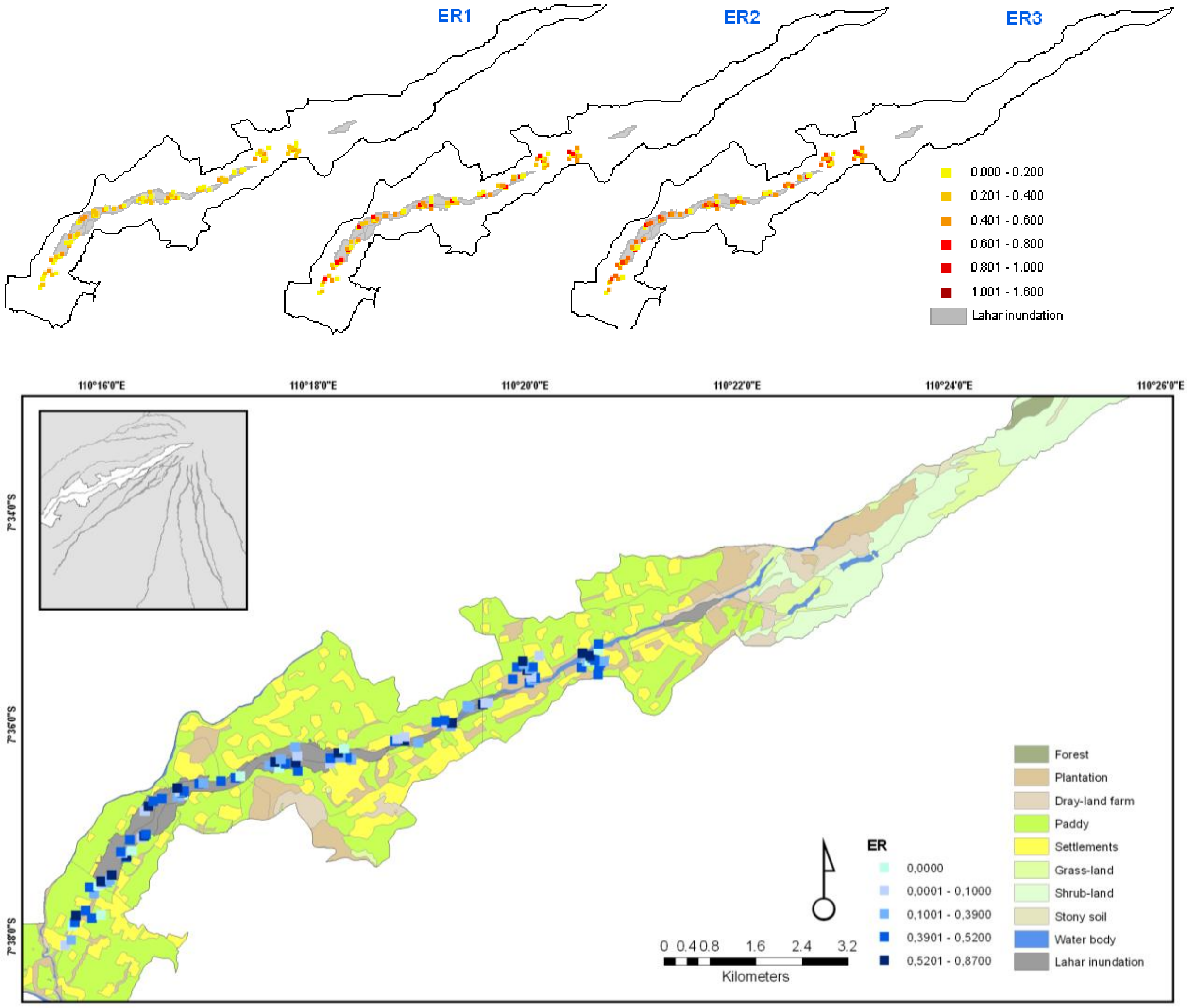
The trend of economic resilience inclination over time encourages interpretation that with time gaps to the disasters event going greater, the degree of business economic functioning, approached from the output of business, tends to rise. At best case, the value of economic resilience in third four-month timespan after the disaster events even shows business functioning level that exceeds normal business state if disaster had never happened (there are two cases of ER3 exceeding 1). Despite of this, calculation also shows the presence of worst cases where the value of economic resilience in all timespans was constantly zero, meaning that households' business functioning totally ceased.

Illustrated spatially, the value of economic resilience dynamics as well as the aggregated economic resilience is presented in Figure 6.3:

The variability of economic resilience value over spatial dimension seems not following particular features. In a nearby place of lahar inundation area, the value of economic resilience value varies, not showing any inclination to clustering to a particular value. This is visible in economic resilience value in all timespans as well as applicable to one-year period aggregated economic resilience value.

This variability of economic resilience value over time is likely due to behavior dynamics, because, being also supported by literatures, the result of grounded-theory work presents how households' business functioning is directly related to strategies being implemented in dealing with the impact of disastrous events, which denoted this behaviour dynamics. This assumption is strengthened through spatial visualization of economic resilience value that shows the random spread of economic resilience over spatial dimension. In order to prove this, as well as to know what most influential to economic resilience, modelling work is then implemented.

Figure 6.3 Spatiotemporal Pattern of Economic Resilience Value



6.3 DEVELOPMENT OF ECONOMIC RESILIENCE MODEL

6.3.1 Predicting Variables

Although previous chapter describes so many conditions that contribute influence and relate to the level of households economic functioning level, to include all of them within the statistical model will be redundant and will possibly cause difficulties in perceiving. Thus, only some variables were selected amongst possible options to be predictors to (aggregated) economic resilience value. The following **Table 6.7** describes the predicting variables, measurement scale, and reasons to include them. With support from the previous chapter that has explained how such variables possibly influence economic resilience, reasons to include the selected variables mainly emanate from their presence within other studies, so that result of this research can be comparable to initial studies.

Table 6.7 Variables in Developing Model for Aggregated Economic Resilience

VARIABLE	SCALE	REASONING
Dependent variable		
Aggregated economic resilience (ER)	Ratio	-
Independent variables		
Farm elevation (m)	Ratio	These two variables represent the influence of environmental features to economic resilience.
Physical damage to farm* (%)	Ratio	
Farm area size** (in square metres)	Ratio	These variables represent the influence of scale of business to the level of economic resilience. Tierney (1995) and Webb, Tierney, & Dahlhamer (2002) discussed how the scale of business relate to the recovery of business in the aftermath of disastrous events.
Normal business economic output (Rupiah)	Ratio	
Importance of irrigation service (%)	Ratio	Rose & Lim (2002) and Rose (2009) include the influence of utility service importance to economic sector operation in predicting loss on business operation due to disastrous events.
Length of being inactive from farming (month)	Ratio	Webb, Tierney, & Dahlhamer (2002) include duration of business closure in predingting long-term business recovery from natural disaster events.
Number of non-farming jobs possessed before volcanism event	Ratio	Zhou, Wang, Wan, & Jia (2010) use the variable of income-source diversification as an indicator to resilience in case of agricultural drought in China.
Importance of farming to households' economy (%)	Ratio	
Number of active measures taken in dealing with volcanism events' impact***	Ratio	Briguglio, Cordina, Farrugia, & Vella (2008) present resilience as nurtured ability. This means that it will be dependent on the active measures taken to deal with disaster impact. This is also congruent with conceptualisation of economic resilience in Rose (2004, 2007, 2009)

** = physical damage to farm refers to the percentage of farm getting damaged from the perceived-most severe source of damage. For example, a farm might have experienced damage from tephra fallout, but not from lahar. What then be accounted was the damage from this tephra fallout. On the other hand, if a farm got struck by both tephra fallout and lahar, percentage of damage that was accounted was the one sourced from what perceived as the most severe impact. If this farm, for example, was struck by tephra fallout resulting in 100% plants in it damaged, then it got hit by lahar flood that caused 60% of its area destroyed and the farmer felt this later event resulted more severe impact, the amount of physical damage accounted would be 60%.Physical damage was counted from the total size of farm under possession (see the following explanation about farm size).*

*** = farm size refers to the total farm area under possession. As some farmers might have their farm split in some locations, the farm size accounted was the aggregate of all farm land parcels.*

**** = number of active measures was the accumulation of active actions implemented as strategies during three timespans post-disaster period. The type of strategies being accounted is presented in **Table 6.6.***

The implementation of these predictors can be seen within the survey questionnaire (see **Appendix 1** item number 1, 2, 5, 6, 7, 8, 9, 10, 38).

Attention was also given to the contribution of behaviour dynamics to economic resilience dynamics (economic resilience variability over time). This was to support conceptualisation that economic resilience is a nurtured condition born by active measures (Briguglio, Cordina, Farrugia, & Vella, 2008), which is also implied within the economic resilience theory constructed in this research through the presence of strategies in facing disasters impact. In addition to this, Rose (2009) gives hypothetical concept on how effectiveness of particular actions in building economic resilience can decline over time. Therefore, seeing economic resilience dynamics from behavioral measure dynamics is worth doing since the result can provide empirical proof on how behaviour dynamics relate to economic resilience dynamics.

Economic resilience dynamics models for each timespan were then established. Strategies in facing disasters impact being implemented in each timespan were used as predictors to economic resilience at corresponding timespan. These predictors were determined based on the result of grounded-theory work, therefore any forms of actions that did not emerge within the economic resilience theory resulted in this research were not used although they exist in literatures. This was meant to raise the practicality of predictors in survey work, as they have been localised according to the empirical situations. However, only selective strategies from the result of economic resilience construction were employed as predictors. This was, again, due to intent to keep the statistical model adequate without being redundant. Subsequent to this, the use of measuring scale considered the ease of data attainment. Boolean scale was used for all predictors because such measurement in ratio scale was simply not practical (e.g. it would be impractical to get precise measure about how much water people could obtain from implementing strategy of using alternative water source). Ordinal scale was also inappropriate because with multiple predicting variables to use, utilising ordinal measure would result in too many dummy variables that cause complication to the model. Boolean measure will be capable of providing insight on *what type* of strategies is most influential to economic resilience at a timespan although cannot reflect its degree. The following **Table 6.8** describes the variables in development of economic resilience dynamics model:

Table 6.8 Variables in Developing Model for Economic Resilience Dynamics

VARIABLES	SCALE
Dependent variable	
Economic resilience in three timespan post disaster event (ER_1 ER_2, ER_3)	Ratio
Independent variables	
Whether or not adding labour force in each corresponding timespan was implemented	Boolean (Yes/No)
Whether or not obtaining water for farming from non-irrigation system sources in each corresponding timespan was implemented	Boolean (Yes/No)
Whether or not continuing old cropping pattern practice in each corresponding timespan was implemented	Boolean (Yes/No)
Whether or not changing farming and or commodity pattern in each corresponding timespan was implemented	Boolean (Yes/No)
Whether or not doing new economic activity in sand-mining sector in each corresponding timespan was implemented	Boolean (Yes/No)
Whether or not doing new economic activity in non-sand-mining and non-agriculture sector in each corresponding timespan was implemented	Boolean (Yes/No)

The implementation of these behavioral predictors can be seen in the survey questionnaire (see **Appendix 1** item number 11, 20, 29).

6.3.2 Economic Resilience Model for Agribusiness Households in Putih River Region

A. Model for Aggregated Economic Resilience

The statistical analysis technique performed to establish model for aggregated economic resilience was Backward Multiple Regression. (Complete result of analysis is present within **Appendix 2**).

Although containing predictors not significantly influence the dependent variable, inclusion of the whole 9 predictors in the model resulted in high R^2 value (0.971). On the other hand, ruling out all non-significant predictors still resulted in high R^2 (0.967). This reflects the goodness of the model, in which predictors being used in the development of economic resilience model were capable of explaining variance in economic resilience value. (Reference is to be made to **Table 9.2** in **Appendix 2**).

It was revealed that only three predicting variables having significant influence to (aggregated) economic resilience value. The three variables are: 1) the length of business interruption (period of time being inactive from farming); 2) number of active measures taken in dealing with volcanism impacts; and 3) normal business economic output that denotes the economic size of households' business. The following **Table 6.9** describes the evaluation based on Backward Multiple Regression analysis result in the disclosure of influential predictors (derived from **Table 9.4** in **Appendix 2)**:

Table 6.9 Influential Predictors to Aggregated Economic Resilience Value

PREDICTORS*	NOTATION	SIGNIFICANCE	EVALUATION
Elevation	Elev	0,356	Not influential
Physical damage to farm	Phys_damag	0,764	Not influential
Irrigation importance	irrigation	0,832	Not influential
Length of being inactive from farming	Interrupt	0,002	Influential
Number of non-farming jobs possessed before volcanism events	Nr_divers	0,257	Not influential
Importance of farming to households economy	Farm_impor	0,778	Not influential
Number of active measure taken to deal with volcanism impacts	Nr_active	0,000	Influential
Farm area	Farm_size	0,602	Not influential
Normal households business output	YTN	0,020	Influential

* Dependent variable = aggregated economic resilience (ER)

Result of modelling work presents no significant contribution from physical-environmental feature to aggregated economic resilience value. Farm elevation and physical damage on farm that can reflect the degree of physical impact brought about by environmental events show no significant correlation with the aggregated economic resilience. Hence, economic resilience does not seem to vary based on spatial characteristics. Economy diversification and dependence to utility service that has been disrupted in the disastrous events are found not influential either. One feature of business characteristics, being farm size, is also known to be not influential to aggregated economic resilience.

Type of relationship between significant predictors to aggregated economic resilience and the unique effect of each significant predictor (effect given by each predictor while controlling for other predictors) are as follows:

1. Length of business interruption (length of being inactive from farming) negatively influences the aggregated economic resilience (partial correlation coefficient = -0.614), gives -0.237 effect portion (Beta value) to aggregated economic resilience value.
2. Number of active measures taken to deal with volcanism impacts positively influences the aggregated economic resilience value (partial correlation coefficient = 0.953), gives 1.018 effect portion (Beta value) to aggregated economic resilience value.

3. Normal households' business output positively influences the aggregated economic resilience value (partial correlation coefficient = 0.480), gives 0.172 effect portion (Beta value) to aggregated economic resilience value.

(Reference is to be made to **Table 9.4** in **Appendix 2**).

The resultant model for aggregated economic resilience with including only significant influential predictors is as follows:

$$ER = -0.009\ Interrupt + 0.054\ Nr\_active + 3.642.10^{-9}\ Y_{TN}$$

Collinearity diagnostic test to the latter regression formula presents no multicollinearity amongst the three predicting variables. With this, it can be said that the regression formula involving those three significant predictors satisfies the demand of ideal regression analysis. (Reference is to be made to column Collinearity Statistics in **Table 9.4** in **Appendix 2**).

Focal point emerged from the establishment of aggregated economic resilience model is how number of active measures taken in dealing with disasters impact highly influence the aggregated economic resilience. As showing high-degree of agreement with the notion that economic ability in the aftermath of disasters is the main product of behavioral dynamics, it is then interesting to reveal what type of active measures give most influence in the development of economic resilience value in each predetermined timespan in the aftermath of disasters. The following presentation performs this matter.

B. Model for Economic Resilience Dynamics

Using the similar statistical analysis technique (Backward Multiple Regression), the influence of each type of active measure within a timespan in the aftermath of disasters to the economic resilience value in corresponding timespan was revealed. Complete statistical analysis result is present in **Appendix 3, 4,** and **5** for first, second, and third four-month period after disasters, respectively.

Looking at the model summary (**Table 10.2**, **Table 11.2**, **Table 12.3**), the overall performance of the three economic resilience dynamics model, either with inclusion or exclusion of insignificant predictors, is good, with value of R^2 ranges from 0.7 to 0.8. It is then interpreted that the use of selected behavioral actions as predictors to economic resilience dynamics in each timespan is appropriate.

The following **Table 6.10** presents the evaluation on what type of active measures being influential to the level of economic resilience in three timespans post-disasters period. (Reference is to be made to **Table 10. 4, Table 11.4**, and **Table 12.4** in **Appendix 3, 4, 5** respectively).

Table 6.10 Influential Predictors to Economic Resilience Dynamics

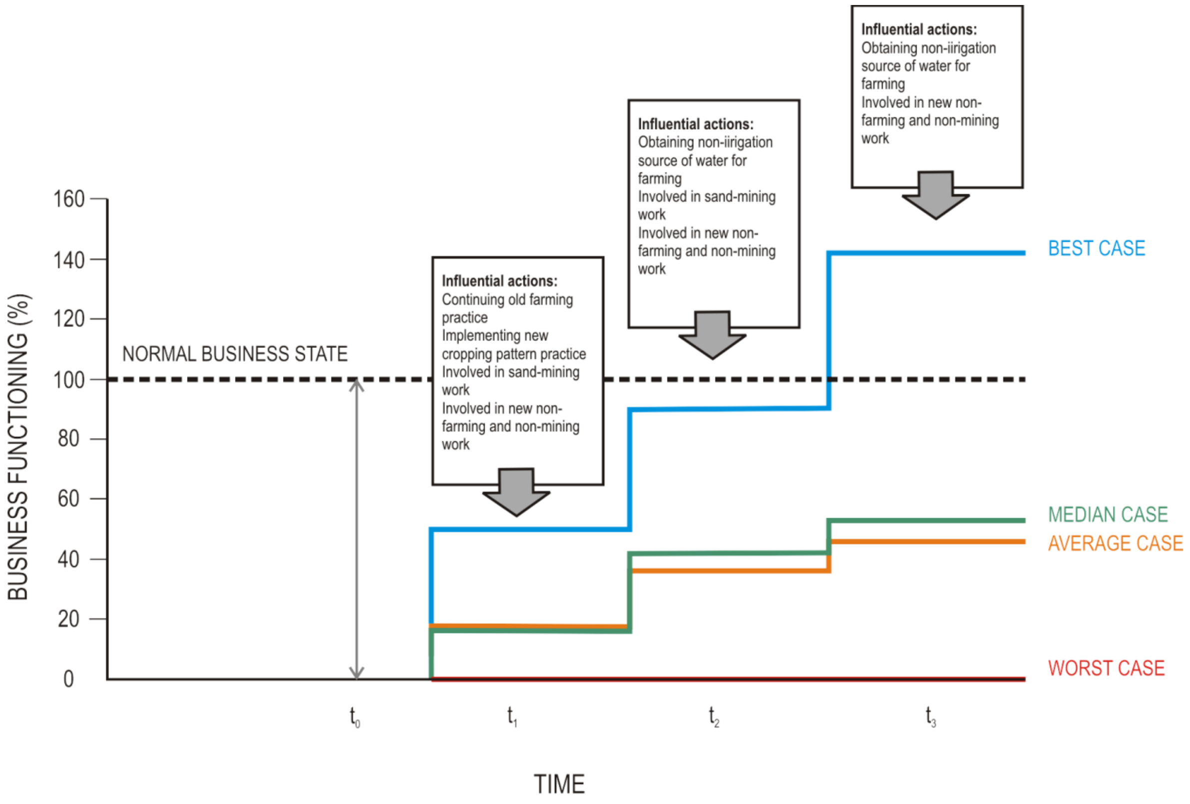
PREDICTORS	ER1 Sig.	ER1 Evaluation	ER2 Sig.	ER2 Evaluation	ER3 Sig.	ER3 Evaluation
Labour	0,237	Not influential	0,478	Not influential	*	*
No_irrig	0,173	Not influential	0,001	Influential	0,000	Influential
Old_farm	0,002	Influential	0,972	Not influential	0,561	Not influential
New_farm	0,001	Influential	0,861	Not influential	0,080	Not influential
Mining	0,000	Influential	0,003	Influential	0,055	Not influential
Non_mine	0,000	Influential	0,000	Influential	0,004	Influential

* = detected as constant, since no variation across dataset was found
Labour = whether or not adding labour force was implemented
No_irrig = whether or not water for farming from non-irrigation service sources was obtained
Old_farm = whether or not continuing old cropping pattern was implemented
Mining = whether or not being involved in sand-mining industry
Non_mine = whether or not having new non-farming and non-mining jobs in the aftermath of disasters

Type of relationship between influential active measures and economic resilience value at corresponding timespan is all positive. (reference is to be made to **Table 10.4**, **Table 11.4**, and **Table 12.4**).

Having the dynamics of influential behaviour known, visualisation of economic resilience dynamics can be improved to include what active measures being influential to the level of economic resilience at each timespan, as performed by the following **Figure 6.3**:

Figure 6.4 Dynamics of Economic Resilience and Its Influential Behaviour



t_0 = time when disasters happened (initial drop on business functioning
t_1 = first four-month period after disasters happened
t_2 = second four-month period after disasters happened
t_3 = third four-month period after disasters happened

Model of economic resilience dynamics performs the variability of active measures' influence in the development of economic resilience throughout timespans. With reference to the result of grounded-theory work, a narrative explanation can be made to describe this dynamics.

In timespan 1 (first four-month after disasters event), what being influential to the development of economic resilience was the ability to take active actions, either in the form of continuing old cropping pattern practice, implementing new cropping pattern practice, or being involved in mining or non-mining jobs. Within this timespan, households might still have been dealing with the emergency situations (as lahar flood was still happening until April 2011), trauma, or being in evacuation, thus whether or not active measures, both in relation to farming and non-farming activities, could be taken was influential to the development of economic resilience. As farming practice might have been restarted, in timespan 2 the presence of ability to obtain water from non-irrigation service source became influential to the degree of developed economic resilience. Furthermore, during this timespan (May-August 2011), very low precipitation was present, thus whether or not sufficient water for faming could be obtained became influential. This influence of water source persisted until timespan 3, when part of this period was still under low precipitation situations (rain just started in the end of October 2011). Some types of actions were no longer influential to the level of economic resilience at subsequent timespan possibly due to the rise in the number of households implementing them thus causing no unique effect to the variance of economic resilience.

With reference to overall model performances, the remaining niches in R^2 value can be presumed to have correlations with other dynamic situations. The result of grounded-theory work in this research presents the change in soil fertility in the aftermath of disaster. With support from literatures (Shoji & Takahashi, 2002; Rees, 1979; Wilson, Kaye, Stewart, & Cole, 2007), saying that volcanism brings positive impact on soil fertility but this positivity takes time, assumption that the dynamics condition of physical-environmental properties in the aftermath of disasters influences economic resilience, particularly to those of agricultural business, can be built.

6.4 DISCUSSION

Economic resilience measurement performed by this research witnesses the presence of business functioning in the aftermath of disasters that goes beyond the level of functioning in normal state. Although this research did not perform difference-in-difference analysis to assess the net impact of disasters on business, this result can add support to findings that at some aggregate level, the impact of disasters to business can be positive (Leiter, Oberhofer, & Raschky, 2009; Xiao, Wan, & Hewings, 2011). Notwithstanding this finding, the presence of zero economic resilience value, in contrast, reflects the cessation of productive economy in the aftermath of disasters. Economic resilience theory being developed in this research explains the existence of "absorbing loss" strategy in facing the impact of disasters on economy. Amongst some possibilities, the possession of personal savings as well as the presence of external support can be the reason and background of this. The average value of one-year period aggregated economic resilience, being 0.33, shows difference from generic recapture factor for agriculture sector in US-FEMA HAZUS - cited in (Park, Cho, & Rose, 2011, p. 178), saying the value to be 0.75. Recapture factor explains the portion of normal business output can be regained through efforts of recapturing production lost after disaster happened, like overtime work (recapture factor 1 means 100% normal business output can be regained). While this research witnesses that over a year period after disaster the agriculture households economic output reached only 33% of normal economic output, the HAZUS value estimates the output can be regained to be 75% of normal from only making overtime work and extra shift (with including other resilience factor, the proportion can be greater). It has to be noted that HAZUS generic recapture factor is oriented for earthquake events which seem not to lead to total devastation to agricultural land as happened with volcanism. This is confirmed by the generic recovery time given for agriculture business properties in HAZUS, being 120 days for complete damage state, which shows far less recovery time needed in case of volcanism events that involved lahar as empirically observed by this research.

For the entire year period, the aggregated economic resilience value is found to be most influenced by the implementation of active measures in dealing with the impacts of disasters. This shows congruence with the economic resilience theory constructed within this research that explains how those two variables directly connected. This finding also supports the notion that resilience is nurtured condition, resulted from the affected agents' behaviour (Briguglio, Cordina, Farrugia, & Vella, 2008; Rose, 2004; 2007; 2009). The emergence of length of business disruption and business economic size as other significant influential factor to this aggregated economic resilience indirectly supports findings of initial works that revealed the both factors as influential to long-term business recovery (Webb, Tierney, & Dahlhamer, 2002).

Claim for applicability of economic resilience model generated in this research to other place or types of disasters emanates from the nature of inferential-statistics work, being to result in generalisation. The three factors appear in the model have gone through multicollinearity test, meaning that those three factors are the real independent factors with unique contributions. Other factors can be represented by those three factors. For example, degree of physical damage can be subsumed into the length of business interruption, with greater damage means longer interruption period. This possibility causes the presence of multicollinearity across predictors in other models before the final model resulted by Backward Multiple Regression Analysis.

With reference to division of economic resilience types present in the work of Rose (2004, 2007, 2009), being inherent and adaptive resilience, this research presents the main emergent resilience being adaptive resilience, denoted by high-degree of active measures' influence in the development of households' business functioning in the aftermath of disasters. Inherent features that can be a source of resilience, being business diversification, importance of input material (utility service), and dependence on the source of economy, were revealed to not being significantly influential to the development of economic resilience. That active measures became the most influential factor to the development of economic resilience, and amongst those active measures, change was involved (e.g. change in cropping pattern, change in jobs), is in agreement with works of Leiter, Oberhofer, & Raschky (2009), saying that change in input factor composition and technology contributes influence to the growth of business in the aftermath of shocks.

Rose (2009) describes the hypothetical effectiveness of some actions in shaping economic resilience over temporal dimensions following the occurrence of such disastrous events. Amongst his description, the application of new method, technique, or business practice, has the long-lasting effectiveness. By showing that the presence of new non farming business in the aftermath of disasters contributes continuous influence to the level of economic resilience, this research provides support to that notion.

7 CONCLUSION

7.1 FINAL REMARK

This research witnesses the presence of business' economic resilience, being the ability to soften loss resulting from the impact of disastrous events and to continue its existence and functioning in the aftermath of those disastrous events.

Exploration through grounded-theory study presents a theoretical framework describing the process in which this ability developed. Economic resilience is present as a consequence of implementing such strategies in facing the disastrous events' impact on business. These strategies, which are mainly in the form of active measures taken to deal with disastrous events' impact, are shaped through the interactions of contextual conditions, being the mediating situations to the development of strategies and mainly reflect an internal character of business, as well as intervening conditions, being the moderating situations to the development of strategies and mainly reflect the external situations that have relevance to business. The length of business interruption also shapes the strategies being developed and thus indirectly is influential to economic resilience. Finally, as being directly related to this business interruption, causal conditions, being the physical damage, severity of disastrous events, and disruption to utility service, as well contribute influence to the development of strategies and therefore affect the economic resilience.

Empirical measurement on households' economic resilience level witnesses the presence of wide-range economic resilience value, from the one denoting the total cessation of households business functioning, to the one denoting best-case scenario which presents the ability to exceed functioning level in the state of disasters' absence. At average, the economic resilience value shows tendency to rise as time moves away from the occurrence of disaster. The variability of economic resilience is mainly influenced by the active measures being implemented in facing the impact of disastrous events. Amongst types of active measures, the one denoting change or adaptation in business practice was revealed to be continuously influential through time.

Being congruent with other studies, those conceptualised research findings suggest that businesses do not passively react to such shocks and disruption, rather, they take active measures so that their economic functioning can be preserved. The presence of these active measures will then be a great deal of contribution to the minimisation of natural disaster detrimental aggregate impact on economy. With this research being presented within a condition in the absence of physical asset recovery (i.e. irrigation utility reconstruction), the existing economic resilience is truly sourced from households' innate capability. This supports the idea that economic loss is not only sourced from the vulnerability in the pre-disaster event period, but is also influenced by the capability to take active measure in the aftermath of disasters. Therefore, such action to promote the nurture of these active measures is worth making.

With the type of economic entity being observed is households, attention to the concept of livelihood is inevitably emerging. The presence of households' economic resilience, regardless its level, provides proof to the idea of capability of living with natural disaster risk. One of findings within this research, being the emergence of new economic activity resulting from the occurrence of extreme natural phenomenon, witnesses that apart from their destructive effects, environmental activity actually also bring opportunity, thus idea of living with risk, instead of avoiding risk, can be supported. However, deeper scrutiny in any strategic decision making is necessary, particularly in relation to deciding what degree of living with risk can be supported, with life safety should be prioritised over economic opportunity.

Following this concluding remarks, implication of this research to public policy and suggestion for further research are presented hereafter.

7.2 POLICY IMPLICATION

Agenda of promoting economic resilience within nationwide disaster management practice has appeared in certain degree within the Indonesian Government Regulation No. 21/2008 about Disaster Countermeasure. The economic resilience-promoting agenda is present in some action formats, being educative measures (Clause 71, Clause 88); counselling (Clause 71); and provision of productive economy stimuli (Clause 71). The spatial management (planning, implementing plan, monitoring) also emerges as the measure to promote hardiness towards disastrous events (Clause 9, Clause 13). While these may represent the presence of attention to encourage the development of economic resilience in the aftermath of disastrous events, the notion of 'resilience' seems not to appear in considerable similar proportion of importance if comparison to other disaster-management notions is to be made. For example, this regulation does not specify the term 'resilience' within its definition section while it puts special attention to other disaster management terminology, such as preparedness and mitigation. As this research witnesses the value of promoting resilience in general and economic resilience in particular, public policy needs accommodate this.

In addition to educative measure being already present within this regulation, other actions to nurture resilience, such as providing political context that enables the development of loss minimisation strategy in the aftermath of disaster event can be made. Attention should be made, however, while such mitigation actions in form of physical development can reduce the probability of loss, it can also erode the resilience since element at risks feel that they are already safe or get unfamiliar with the disastrous events with the presence of this preventive measure (see discussion about this in Rose, 2007; 2009 and Kelman & Mather, 2008).

Another implication this research can bring is the involvement of economic resilience index or value in assessing disaster economic loss in Indonesia. This seems not to be in current practice. With reference to the Preliminary Report of Damage and Loss Assessment of the 2007 Yogyakarta Earthquake (Bappenas; the Provincial and Local Governments of D.I. Yogyakarta and Central Java; International Partners, 2006), economic loss on flow of economy is measured (such as) by reduced incomes and increased expenditures over the time period until the asset recovery finishes. This method considers the maximum likelihood of economic loss with excluding influence of micro enomomic entities' immanent ability to soften the loss on their own. With the inclusion of economic resilience value or index, closer proxy to the amount of economic loss that is truly unlikely to be regained can be made. This will possibly interest the insurance company to invest in disaster risk sector as the amount of claim possibly made seems more affordable.

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7.3 FUTURE RESEARCH

This research takes agriculture sector at micro economic level as the object of observation. Future research can take other micro economic sectors to observe how economic resilience developed and how intense it can be. Having overall sectors observed, assessment towards disaster economic loss in meso and macro-economic level that involves the empirical economic resilience can be made in order to provide better proxy to the amount of economy that cannot be saved from loss at wider level. This can be a comparison to disaster impact assessment that considers only the maximum likelihood of economic loss.

Future research should pay attention to the spatial and temporal dimension in which economic resilience assessment to be conducted. While natural disastrous events are most likely to happen following geomorphological pattern of spatial setting, the activity of economy does not seem to follow similar pattern, rather, it seems to be congruent with man-made spatial boundary (such as administrative area). In addition to this, the timespan, in which economic resilience should be estimated, also gains considerable dispute. Whether or not it is enough to take a year timespan as temporal setting, for example, can be a debate. Timespan in which properties and utility reconstruction finishes can provide an interesting temporal setting since observation towards the dynamics of loss minimisation ability in the presence and absence of physical asset reconstruction can be made.

Issues with data collection may occur, particularly if economic resilience assessment is to be carried out at micro-economic level, since time-sensitive data about economic activity may be difficult to obtain, in addition to the matter of confidentiality. How to compromise all of these matters will contribute methodological value in academic work concerning the economic impact of disasters.

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8 Appendix 1

AGRIBUSINESS HOUSEHOLDS' ECONOMIC RESILIENCE SURVEY

Date : ....

Surveyor : ....

Respondent number/code					
Age					
Sex					
Farm location		Longitude : .... Latitude : .... Altitude :			(1)
Size of farm land		....			(2)
Name your farming commodities, how much did your farm yield for each commodity in a year period before the 2010 Merapi volcanism event? *(fill in the table)*	Commodities	Annual frequency of cropping (3a)	Average amount per cropping (3b)	Average selling rate per kg (3c)	
	....	....	....	....	(3.1)
	....	....	....	....	(3.2)
	....	....	....	....	(3.3)
	....	....	....	....	(3.4)
	....	....	....	....	(3.5)
	....	....	....	....	(3.6)
	....	....	....	....	(3.7)
Estimates of households agricultural business outcome *(to be filled by surveyor)* households farming outcome = $\sum_{i=1}^{n}((3a)_i * (3b)_i * (3c)_i)$		.... Rupiahs			(4)
How many non-farming jobs present both prior to and after the 2010 Merapi volcanism event do you have? *(fill in the blank, bottom limit should be 0)*		....			(5)
How important do you perceive your farm-production contribution to your households' economy? *(fill in the blank with percentage number)*		....			(6)
Estimates of total households business outcome *(to be filled by surveyor)* $answer\ (3)$ $answer\ (5)$		.... Rupiahs			(7)
How many percent of your total farm area did get damaged by Merapi volcanism events? *(fill in the blank with percentage value)*		....			(8)
How important do you think irrigation service for your regular farming activity?		....			(9)

(fill in the blank with percentage value)					
How long were you being inactive from farming activity? *(fill in the blank with number)*	.... month				(10)
First four-month period post volcanism events					
From the following strategies of dealing with farming activity interruption due to the 2010 Merapi Volcanism events, which ones did you implement during this timespan? *(to choose more than one answer is possible)*	☐ Adding the number of labour ☐ Having water supply for farming from non-irrigation sources ☐ Continuing old cropping pattern practice ☐ Changing cropping pattern and or farming commodity ☐ Having new business activity in mining sector ☐ Having new business activity in non-mining and non-agriculture sector				(11)
Number of active measures in this timespan *(to be filled by surveyor, count the number of √ in the previous question)*	....				(12)
Name your farming commodities, how much did your farm yield for each commodity in this timespan? *(fill in the table)*	Commodities	Annual frequency of cropping (13a)	Average amount per cropping (13b)	Average selling rate per kg (13c)	
	....	....	....	....	(13.1)
	....	....	....	....	(13.2)
	....	....	....	....	(13.3)
	....	....	....	....	(13.4)
	....	....	....	....	(13.5)
	....	....	....	....	(13.6)
	....	....	....	....	(13.7)
Estimates of households agricultural business outcome in this timespan *(to be filled by surveyor)* $\sum_{i=1}^{3}((13a)_i * (13b)_i * (13c)_i)$	.... Rupiahs				(14)
How important do you perceive your farm-production contribution to your households' economy during this timespan? *(choose one from options)*	....				(15)
Name one of your non-farming economic activity and average of its outcome *(fill in the table)*	Activity	Frequency of doing (16a)	Average amount of activity (16b)	Average rates/wages per amount of activity (16c)	
	....	....	....	....	(16)
Estimates of households non-agricultural business outcome in this timespan *(to be filled by surveyor)* $\sum((16a) * (16b) * (16c))$	.... Rupiahs				(17)
How important do you perceive your non-farming activity contribution to your households' economy during this timespan? *(fill in the blank with percentage value)*	....				(18)

Estimates of total households business outcome during this timespan *(to be filled by surveyor)* $answer\ (14)$ $answer\ (15)$ or $answer\ (17)$ $answer\ (18)$	.... Rupiahs				(19)
Second four-month period post volcanism events					
From the following strategies of dealing with farming activity interruption due to the 2010 Merapi Volcanism events, which ones did you implement during this timespan? *(to choose more than one answer is possible)*	☐ Adding the number of labour ☐ Having water supply for farming from non-irrigation sources ☐ Continuing old cropping pattern practice ☐ Changing cropping pattern and or farming commodity ☐ Having new business activity in mining sector ☐ Having new business activity in non-mining and non-agriculture sector				(20)
Number of active measures in this timespan *(to be filled by surveyor, count the number of √ in the previous question)*	....				(21)
Name your farming commodities, how much did your farm yield for each commodity in this timespan? *(fill in the table)*	Commodities	Annual frequency of cropping (22a)	Average amount per cropping (22b)	Average selling rate per kg (22c)	
	....	....	....	....	(22.1)
	....	....	....	....	(22.2)
	....	....	....	....	(22.3)
	....	....	....	....	(22.4)
	....	....	....	....	(22.5)
	....	....	....	....	(22.6)
	....	....	....	....	(22.7)
Estimates of households agricultural business outcome in this timespan *(to be filled by surveyor)* $\sum_{i=1}^{3}((22a)_i * (22b)_i * (22c)_i)$	.... Rupiahs				(23)
How important do you perceive your farm-production contribution to your households' economy during this timespan? *(choose one from options)*	....				(24)
Name one of your non-farming economic activity and average of its outcome *(fill in the table)*	Activity	Frequency of doing (25a)	Average amount of activity (25b)	Average rates/wages per amount of activity (25c)	(25)
	....	....	....	....	
Estimates of households non-agricultural business outcome in this timespan *(to be filled by surveyor)* $\sum((25a) * (25b) * (25c))$	.... Rupiahs				(26)
How important do you perceive your non-farming activity contribution to your households' economy during this timespan? *(fill in the blank with percentage value)*	....				(27)

Estimates of total households business outcome during this timespan *(to be filled by surveyor)* $answer\ (231)$ $answer\ (24)$ or $answer\ (26)$ $answer\ (27)$	.... Rupiahs				(28)
Third four-month period post volcanism events					
From the following strategies of dealing with farming activity interruption due to the 2010 Merapi Volcanism events, which ones did you implement during this time span? *(to choose more than one answer is possible)*	☐ Adding the number of labour ☐ Having water supply for farming from non-irrigation sources ☐ Continuing old cropping pattern practice ☐ Changing cropping pattern and or farming commodity ☐ Having new business activity in mining sector ☐ Having new business activity in non-mining and non-agriculture sector				(29)
Number of active measures in this timespan *(to be filled by surveyor, count the number of √ in the previous question)*	....				(30)
Name your farming commodities, how much did your farm yield for each commodity in this timespan? *(fill in the table)*	Commodities	Annual frequency of cropping (31a)	Average amount per cropping (31b)	Average selling rate per kg (31c)	
	....	....	....	....	(31.1)
	....	....	....	....	(31.2)
	....	....	....	....	(31.3)
	....	....	....	....	(31.4)
	....	....	....	....	(31.5)
	....	....	....	....	(31.6)
	....	....	....	....	(31.7)
Estimates of households agricultural business outcome in this time span *(to be filled by surveyor)* $\sum_{i=1}^{3}((31a)_i * (31b)_i * (31c)_i)$	.... Rupiahs				(32)
How important do you perceive your farm-production contribution to your households' economy during this time span? *(choose one from options)*	....				(33)
Name one of your non-farming economic activity and average of its outcome *(fill in the table)*	Activity	Frequency of doing (34a)	Average amount of activity (34b)	Average rates/wages per amount of activity (34c)	(34)
	....	....	....	....	
Estimates of households non-agricultural business outcome in this time span *(to be filled by surveyor)* $\sum((34a)*(34b)*(34c))$	.... Rupiahs				(35)
How important do you perceive your non-farming activity contribution to your households' economy during this time span? *(fill in the blank with percentage value)*	....				(36)

Estimates of total households business outcome during this time span *(to be filled by surveyor)* $answer\ (32)$ $answer\ (33)$ or $answer\ (35)$ $answer\ (36)$	.... Rupiahs	(37)
Total number of active measures in post-disaster period *(to be filled by surveyor, add answer number 12 to 21 then to 30)*	....	(38)

9 Appendix 2

AGRIBUSINESS HOUSEHOLDS' ECONOMIC RESILIENCE MODEL

Table 9.1 Entered/Removed Variables in Building Model for Aggregated Economic Resilience

Variables Entered/Removed[b,c]

Model	Variables Entered	Variables Removed	Method
1	YTN, Nr_divers, Irrigation, Nr_active, Interrupt, Farm_size, Phys_damag, Farm_impor, Elev[a]	.	Enter
2	.	Phys_damag	Backward (criterion: Probability of F-to-remove >= ,051).
3	.	Irrigation	Backward (criterion: Probability of F-to-remove >= ,051).
4	.	Farm_impor	Backward (criterion: Probability of F-to-remove >= ,051).
5	.	Farm_size	Backward (criterion: Probability of F-to-remove >= ,051).
6	.	Nr_divers	Backward (criterion: Probability of F-to-remove >= ,051).
7	.	Elev	Backward (criterion: Probability of F-to-remove >= ,051).

a. All requested variables entered.

b. Dependent Variable: ER

c. Linear Regression through the Origin

Table 9.2 Model Summary in Building Model for Aggregated Economic Resilience

Model Summary[i,j]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.985[a]	.971	.954	.06033	
2	.985[c]	.971	.956	.05860	
3	.985[d]	.971	.959	.05693	
4	.985[e]	.971	.961	.05546	
5	.985[f]	.970	.962	.05440	
6	.984[g]	.968	.962	.05490	
7	.983[h]	.967	.962	.05476	1.820

a. Predictors: YTN, Nr_divers, Irrigation, Nr_active, Interrupt, Farm_size, Phys_damag, Farm_impor, Elev

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Predictors: YTN, Nr_divers, Irrigation, Nr_active, Interrupt, Farm_size, Farm_impor, Elev

d. Predictors: YTN, Nr_divers, Nr_active, Interrupt, Farm_size, Farm_impor, Elev

e. Predictors: YTN, Nr_divers, Nr_active, Interrupt, Farm_size, Elev

f. Predictors: YTN, Nr_divers, Nr_active, Interrupt, Elev

g. Predictors: YTN, Nr_active, Interrupt, Elev

h. Predictors: YTN, Nr_active, Interrupt

i. Dependent Variable: ER

j. Linear Regression through the Origin

Table 9.3 Anova in Building Model for Aggregated Economic Resilience

ANOVA[i,j]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.838	9	.204	56.109	.000[a]
	Residual	.055	15	.004		
	Total	1.893[b]	24			
2	Regression	1.838	8	.230	66.902	.000[c]
	Residual	.055	16	.003		
	Total	1.893[b]	24			
3	Regression	1.838	7	.263	80.997	.000[d]
	Residual	.055	17	.003		
	Total	1.893[b]	24			
4	Regression	1.837	6	.306	99.559	.000[e]
	Residual	.055	18	.003		
	Total	1.893[b]	24			
5	Regression	1.836	5	.367	124.104	.000[f]
	Residual	.056	19	.003		
	Total	1.893[b]	24			
6	Regression	1.832	4	.458	151.991	.000[g]
	Residual	.060	20	.003		
	Total	1.893[b]	24			
7	Regression	1.830	3	.610	203.409	.000[h]
	Residual	.063	21	.003		
	Total	1.893[b]	24			

a. Predictors: YTN, Nr_divers, Irrigation, Nr_active, Interrupt, Farm_size, Phys_damag, Farm_impor, Elev

b. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

c. Predictors: YTN, Nr_divers, Irrigation, Nr_active, Interrupt, Farm_size, Farm_impor, Elev

d. Predictors: YTN, Nr_divers, Nr_active, Interrupt, Farm_size, Farm_impor, Elev

e. Predictors: YTN, Nr_divers, Nr_active, Interrupt, Farm_size, Elev

f. Predictors: YTN, Nr_divers, Nr_active, Interrupt, Elev

g. Predictors: YTN, Nr_active, Interrupt, Elev

h. Predictors: YTN, Nr_active, Interrupt

i. Dependent Variable: ER

j. Linear Regression through the Origin

Table 9.4 Coefficients in Building Model for Aggregated Economic Resilience

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	Elev	6.583E-5	.000	.093	.366	.720	.862	.094	.016	.030	33.802
	Phys_damag	.000	.001	.049	.306	.764	.618	.079	.013	.075	13.418
	Irrigation	.000	.001	-.045	-.366	.720	.567	-.094	-.016	.125	7.969
	Interrupt	-.011	.005	-.295	-2.197	.044	.668	-.493	-.096	.107	9.355
	Nr_divers	-.023	.028	-.052	-.807	.433	.326	-.204	-.035	.458	2.182
	Farm_impor	.000	.001	.058	.327	.748	.763	.084	.014	.062	16.166
	Nr_active	.052	.007	.979	7.797	.000	.972	.896	.342	.122	8.191
	Farm_size	-4.310E-6	.000	-.040	-.417	.683	.579	-.107	-.018	.209	4.780
	YTN	3.441E-9	.000	.163	1.324	.205	.790	.323	.058	.127	7.848
2	Elev	.000	.000	.148	.842	.412	.862	.206	.036	.059	17.060
	Irrigation	-7.931E-5	.000	-.018	-.215	.832	.567	-.054	-.009	.264	3.787
	Interrupt	-.010	.005	-.288	-2.240	.040	.668	-.489	-.095	.110	9.130
	Nr_divers	-.020	.026	-.047	-.775	.449	.326	-.190	-.033	.491	2.035
	Farm_impor	.000	.001	.042	.254	.803	.763	.063	.011	.068	14.710
	Nr_active	.051	.005	.958	9.331	.000	.972	.919	.397	.172	5.809
	Farm_size	-4.841E-6	.000	-.045	-.489	.632	.579	-.121	-.021	.215	4.645
	YTN	3.354E-9	.000	.158	1.336	.200	.790	.317	.057	.129	7.752
3	Elev	.000	.000	.158	.957	.352	.862	.226	.040	.063	15.904
	Interrupt	-.011	.004	-.303	-2.852	.011	.668	-.569	-.118	.152	6.585
	Nr_divers	-.024	.021	-.055	-1.136	.272	.326	-.266	-.047	.739	1.353
	Farm_impor	.000	.001	.045	.287	.778	.763	.069	.012	.069	14.547
	Nr_active	.051	.005	.953	9.839	.000	.972	.922	.407	.183	5.474
	Farm_size	-5.279E-6	.000	-.049	-.561	.582	.579	-.135	-.023	.225	4.449
	YTN	3.306E-9	.000	.156	1.361	.191	.790	.313	.056	.130	7.693
4	Elev	.000	.000	.180	1.277	.218	.862	.288	.051	.081	12.287
	Interrupt	-.010	.003	-.286	-3.305	.004	.668	-.615	-.133	.217	4.616
	Nr_divers	-.024	.020	-.054	-1.159	.262	.326	-.263	-.047	.740	1.352
	Nr_active	.051	.005	.948	10.172	.000	.972	.923	.410	.187	5.349
	Farm_size	-4.791E-6	.000	-.044	-.531	.602	.579	-.124	-.021	.232	4.304
	YTN	3.445E-9	.000	.163	1.486	.155	.790	.330	.060	.135	7.387
5	Elev	.000	.000	.183	1.322	.202	.862	.290	.052	.081	12.272
	Interrupt	-.011	.003	-.299	-3.647	.002	.668	-.642	-.144	.233	4.286
	Nr_divers	-.023	.020	-.054	-1.170	.257	.326	-.259	-.046	.740	1.351
	Nr_active	.051	.005	.960	10.817	.000	.972	.928	.428	.198	5.040
	YTN	2.589E-9	.000	.122	1.583	.130	.790	.341	.063	.262	3.818
6	Elev	8.642E-5	.000	.122	.944	.356	.862	.207	.038	.095	10.550
	Interrupt	-.010	.003	-.280	-3.457	.002	.668	-.612	-.138	.242	4.131
	Nr_active	.052	.005	.966	10.804	.000	.972	.924	.431	.199	5.023
	YTN	2.981E-9	.000	.141	1.846	.080	.790	.381	.074	.273	3.657
7	**Interrupt**	**-.009**	**.002**	**-.237**	**-3.564**	**.002**	**.668**	**-.614**	**-.142**	**.360**	**2.781**
	Nr_active	**.054**	**.004**	**1.018**	**14.415**	**.000**	**.972**	**.953**	**.574**	**.318**	**3.147**
	YTN	**3.642E-9**	**.000**	**.172**	**2.509**	**.020**	**.790**	**.480**	**.100**	**.337**	**2.970**

a. Dependent Variable: ER

b. Linear Regression through the Origin

Table 9.5 Collinearity Diagnostics in Building Model for Aggregated Economic Resilience

Collinearity Diagnostics[a,b]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions								
				Elev	Phys_damag	Irrigation	Interrupt	Nr_divers	Farm_impor	Nr_active	Farm_size	YTN
1	1	6.556	1.000	.00	.00	.00	.00	.00	.00	.00	.00	.00
	2	1.075	2.470	.00	.01	.01	.00	.25	.00	.00	.02	.01
	3	.442	3.851	.01	.00	.03	.00	.01	.00	.09	.19	.01
	4	.415	3.975	.00	.02	.07	.05	.28	.00	.01	.03	.04
	5	.227	5.379	.00	.01	.16	.06	.06	.04	.17	.00	.02
	6	.127	7.188	.02	.26	.03	.14	.24	.02	.04	.03	.12
	7	.089	8.581	.01	.05	.06	.01	.01	.05	.11	.70	.58
	8	.052	11.263	.01	.00	.13	.73	.15	.56	.01	.00	.20
	9	.018	19.003	.95	.65	.51	.00	.00	.33	.57	.01	.02
2	1	5.806	1.000	.00		.01	.00	.00	.00	.00	.00	.00
	2	.967	2.450	.00		.02	.00	.38	.00	.00	.02	.01
	3	.442	3.624	.01		.06	.01	.02	.00	.12	.20	.01
	4	.374	3.938	.00		.28	.07	.16	.00	.01	.03	.05
	5	.223	5.098	.01		.25	.10	.09	.05	.23	.00	.03
	6	.094	7.846	.00		.07	.01	.02	.01	.28	.73	.65
	7	.052	10.524	.11		.28	.82	.25	.41	.04	.00	.24
	8	.041	11.958	.87		.04	.00	.08	.52	.32	.01	.01
3	1	5.185	1.000	.00			.00	.01	.00	.01	.01	.00
	2	.900	2.400	.00			.00	.71	.00	.00	.02	.00
	3	.430	3.474	.01			.03	.15	.00	.10	.25	.02
	4	.273	4.361	.00			.24	.01	.02	.22	.00	.07
	5	.104	7.066	.03			.05	.01	.07	.41	.58	.38
	6	.067	8.780	.20			.61	.09	.20	.01	.12	.51
	7	.041	11.203	.76			.06	.03	.70	.26	.02	.00
4	1	4.270	1.000	.00			.01	.01		.01	.01	.01
	2	.898	2.181	.00			.00	.70		.00	.02	.01
	3	.428	3.160	.01			.04	.16		.11	.24	.02
	4	.251	4.124	.00			.53	.01		.18	.01	.08
	5	.096	6.672	.04			.01	.00		.47	.65	.61
	6	.058	8.569	.94			.41	.13		.23	.07	.28
5	1	3.640	1.000	.01			.01	.01		.01		.02
	2	.832	2.092	.00			.01	.81		.00		.02
	3	.257	3.764	.00			.54	.00		.04		.36
	4	.212	4.146	.00			.06	.04		.56		.42
	5	.060	7.790	.99			.38	.13		.39		.19
6	1	3.455	1.000	.01			.02			.01		.02
	2	.257	3.667	.00			.55			.03		.39
	3	.220	3.964	.01			.08			.50		.44
	4	.068	7.110	.99			.35			.45		.15
7	1	2.526	1.000				.05			.04		.04
	2	.256	3.139				.88			.06		.43
	3	.217	3.410				.07			.90		.53

a. Dependent Variable: ER

b. Linear Regression through the Origin

Table 9.6 Excluded Variables in Building Model for Aggregated Economic Resilience

Excluded Variables[g,h]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance	VIF	Minimum Tolerance
2	Phys_damag	.049[a]	.306	.764	.079	.075	13.418	.030
3	Phys_damag	.007[b]	.061	.952	.015	.157	6.376	.050
	Irrigation	-.018[b]	-.215	.832	-.054	.264	3.787	.059
4	Phys_damag	-.002[c]	-.021	.984	-.005	.170	5.866	.070
	Irrigation	-.020[c]	-.250	.805	-.061	.267	3.745	.072
	Farm_impor	.045[c]	.287	.778	.069	.069	14.547	.063
5	Phys_damag	-.001[d]	-.011	.992	-.002	.171	5.863	.070
	Irrigation	-.027[d]	-.352	.729	-.083	.277	3.610	.072
	Farm_impor	.029[d]	.192	.850	.045	.071	14.072	.064
	Farm_size	-.044[d]	-.531	.602	-.124	.232	4.304	.081
6	Phys_damag	-.053[e]	-.667	.513	-.151	.255	3.917	.070
	Irrigation	-.059[e]	-.948	.355	-.213	.408	2.453	.094
	Farm_impor	.025[e]	.165	.871	.038	.071	14.065	.071
	Farm_size	-.042[e]	-.501	.622	-.114	.232	4.302	.095
	Nr_divers	-.054[e]	-1.170	.257	-.259	.740	1.351	.081
7	Phys_damag	-.007[f]	-.100	.921	-.022	.344	2.903	.249
	Irrigation	-.064[f]	-1.039	.311	-.226	.411	2.432	.276
	Farm_impor	.080[f]	.611	.548	.135	.095	10.543	.095
	Farm_size	-.046[f]	-.546	.591	-.121	.233	4.292	.156
	Nr_divers	-.031[f]	-.714	.483	-.158	.861	1.161	.303
	Elev	.122[f]	.944	.356	.207	.095	10.550	.095

a. Predictors in the Model: YTN, Nr_divers, Irrigation, Nr_active, Interrupt, Farm_size, Farm_impor, Elev

b. Predictors in the Model: YTN, Nr_divers, Nr_active, Interrupt, Farm_size, Farm_impor, Elev

c. Predictors in the Model: YTN, Nr_divers, Nr_active, Interrupt, Farm_size, Elev

d. Predictors in the Model: YTN, Nr_divers, Nr_active, Interrupt, Elev

e. Predictors in the Model: YTN, Nr_active, Interrupt, Elev

f. Predictors in the Model: YTN, Nr_active, Interrupt

g. Dependent Variable: ER

h. Linear Regression through the Origin

10 Appendix 3

MODEL FOR ECONOMIC RESILIENCE DYNAMICS 1 (FIRST FOUR-MONTH PERIOD POST-DISASTER EVENT)

Table 10.1 Variables Entered/Removed in Building Model For Economic Resilience Dynamics Timespan 1

Variables Entered/Removed[b,c]

Model	Variables Entered	Variables Removed	Method
1	Non_Mine_01, Mining_01, New_Farm_01, Old_Farm_01, Labour_01, No_Irrig_01[a]	.	Enter
2	.	Labour_01	Backward (criterion: Probability of F-to-remove >= ,051).
3	.	No_Irrig_01	Backward (criterion: Probability of F-to-remove >= ,051).

a. All requested variables entered.

b. Dependent Variable: ER1

c. Linear Regression through the Origin

Table 10.2 Model Summary in Building Model for Economic Resilience Dynamics Timespan 1

Model Summary[e,f]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.912[a]	.831	.775	.11265	
2	.904[c]	.817	.769	.11412	
3	.893[d]	.798	.758	.11695	2.108

a. Predictors: Non_Mine_01, Mining_01, New_Farm_01, Old_Farm_01, Labour_01, No_Irrig_01

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Predictors: Non_Mine_01, Mining_01, New_Farm_01, Old_Farm_01, No_Irrig_01

d. Predictors: Non_Mine_01, Mining_01, New_Farm_01, Old_Farm_01

e. Dependent Variable: ER1

f. Linear Regression through the Origin

Table 10.3 Anova in Building Model for Economic Resilience Dynamics Timespan 1

ANOVA[e,f]

Model		Sum of Squares	df	Mean Square	F
1	Regression	1.127	6	.188	14.797
	Residual	.228	18	.013	
	Total	1.355[b]	24		
2	Regression	1.108	5	.222	17.011
	Residual	.247	19	.013	
	Total	1.355[b]	24		
3	Regression	1.082	4	.270	19.767
	Residual	.274	20	.014	
	Total	1.355[b]	24		

a. Predictors: Non_Mine_01, Mining_01, New_Farm_01, Old_Farm_01, Labour_01, No_Irrig_01

b. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

c. Predictors: Non_Mine_01, Mining_01, New_Farm_01, Old_Farm_01, No_Irrig_01

d. Predictors: Non_Mine_01, Mining_01, New_Farm_01, Old_Farm_01

e. Dependent Variable: ER1

f. Linear Regression through the Origin

Table 10.4 Coefficients in Building Model for Economic Resilience Dynamics Timespan 1

Coefficients[a,b]

		Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
Model		B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	Labour_01	.081	.066	.209	1.224	.237	.610	.277	.118	.320	3.125
	No_Irrig_01	-.174	.093	-.334	-1.870	.078	.546	-.403	-.181	.294	3.403
	Old_Farm_01	.193	.070	.331	2.740	.013	.361	.543	.265	.643	1.556
	New_Farm_01	.532	.138	.457	3.860	.001	.378	.673	.373	.667	1.500
	Mining_01	.378	.084	.563	4.506	.000	.471	.728	.436	.600	1.667
	Non_Mine_01	.401	.070	.596	5.706	.000	.551	.802	.552	.857	1.167
2	No_Irrig_01	-.112	.079	-.215	-1.417	.173	.546	-.309	-.139	.417	2.400
	Old_Farm_01	.238	.060	.409	3.941	.001	.361	.671	.386	.893	1.120
	New_Farm_01	.552	.139	.474	3.976	.001	.378	.674	.390	.676	1.480
	Mining_01	.391	.084	.582	4.638	.000	.471	.729	.455	.610	1.640
	Non_Mine_01	.407	.071	.606	5.740	.000	.551	.796	.563	.862	1.160
3	Old_Farm_01	.210	.058	.361	3.591	.002	.361	.626	.361	1.000	1.000
	New_Farm_01	.440	.117	.378	3.762	.001	.378	.644	.378	1.000	1.000
	Mining_01	.317	.068	.471	4.690	.000	.471	.724	.471	1.000	1.000
	Non_Mine_01	.370	.068	.551	5.480	.000	.551	.775	.551	1.000	1.000

a. Dependent Variable: ER1

b. Linear Regression through the Origin

Table 10.5 Collinearity Diagnostics in Building Model for Economic Resilience Dynamics Timespan 1

Collinearity Diagnostics[a,b]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions					
				Labour_01	No_Irrig_01	Old_Farm_01	New_Farm_01	Mining_01	Non_Mine_01
1	1	2.474	1.000	.04	.04	.02	.03	.03	.01
	2	1.068	1.522	.01	.01	.42	.05	.06	.02
	3	1.000	1.573	.00	.00	.00	.16	.00	.65
	4	1.000	1.573	.00	.00	.00	.26	.30	.10
	5	.274	3.007	.30	.09	.46	.42	.50	.18
	6	.184	3.662	.64	.86	.10	.09	.10	.04
2	1	1.764	1.000		.12	.02	.07	.08	.03
	2	1.000	1.328		.00	.43	.30	.05	.00
	3	1.000	1.328		.00	.37	.12	.25	.00
	4	1.000	1.328		.00	.01	.03	.04	.76
	5	.236	2.732		.88	.16	.49	.59	.21
3	1	1.000	1.000			1.00	.00	.00	.00
	2	1.000	1.000			.00	1.00	.00	.00
	3	1.000	1.000			.00	.00	1.00	.00
	4	1.000	1.000			.00	.00	.00	1.00

a. Dependent Variable: ER1

b. Linear Regression through the Origin

Table 10.6 Excluded Variables in Building Model for Economic Resilience Dynamics Timespan 1

Excluded Variables[c,d]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
2	Labour_01	.209[a]	1.224	.237	.277	.320	3.125	.294
3	Labour_01	.036[b]	.234	.817	.054	.454	2.204	.454
	No_Irrig_01	-.215[b]	-1.417	.173	-.309	.417	2.400	.417

a. Predictors in the Model: Non_Mine_01, Mining_01, New_Farm_01, Old_Farm_01, No_Irrig_01

b. Predictors in the Model: Non_Mine_01, Mining_01, New_Farm_01, Old_Farm_01

c. Dependent Variable: ER1

d. Linear Regression through the Origin

11 Appendix 4

MODEL FOR ECONOMIC RESILIENCE DYNAMICS 2 (SECOND FOUR-MONTH PERIOD POST-DISASTER EVENT)

Table 11.1 Variables Entered/Removed in Building Model For Economic Resilience Dynamics Timespan 2

Variables Entered/Removed[b,c]

Model	Variables Entered	Variables Removed	Method
1	Non_Mine_02, Mining_02, New_Farm_02, Labour_02, Old_Farm_02, No_Irrig_02[a]	.	Enter
2	.	Old_Farm_02	Backward (criterion: Probability of F-to-remove >= ,051).
3	.	New_Farm_02	Backward (criterion: Probability of F-to-remove >= ,051).
4	.	Labour_02	Backward (criterion: Probability of F-to-remove >= ,051).

a. All requested variables entered.

b. Dependent Variable: ER2

c. Linear Regression through the Origin

Table 11.2 Model Summary in Building Model for Economic Resilience Dynamics Timespan 2

Model Summary[f,g]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.881[a]	.777	.702	.24556	
2	.881[c]	.777	.718	.23902	
3	.881[d]	.776	.732	.23316	
4	.878[e]	.771	.738	.23051	1.868

a. Predictors: Non_Mine_02, Mining_02, New_Farm_02, Labour_02, Old_Farm_02, No_Irrig_02

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Predictors: Non_Mine_02, Mining_02, New_Farm_02, Labour_02, No_Irrig_02

d. Predictors: Non_Mine_02, Mining_02, Labour_02, No_Irrig_02

e. Predictors: Non_Mine_02, Mining_02, No_Irrig_02

f. Dependent Variable: ER2

g. Linear Regression through the Origin

Table 11.3 Anova in Building Model for Economic Resilience Dynamics Timespan 2

ANOVA[f,g]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.777	6	.630	10.440	.000[a]
	Residual	1.085	18	.060		
	Total	4.863[b]	24			
2	Regression	3.777	5	.755	13.222	.000[c]
	Residual	1.086	19	.057		
	Total	4.863[b]	24			
3	Regression	3.775	4	.944	17.361	.000[d]
	Residual	1.087	20	.054		
	Total	4.863[b]	24			
4	Regression	3.747	3	1.249	23.506	.000[e]
	Residual	1.116	21	.053		
	Total	4.863[b]	24			

a. Predictors: Non_Mine_02, Mining_02, New_Farm_02, Labour_02, Old_Farm_02, No_Irrig_02

b. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

c. Predictors: Non_Mine_02, Mining_02, New_Farm_02, Labour_02, No_Irrig_02

d. Predictors: Non_Mine_02, Mining_02, Labour_02, No_Irrig_02

e. Predictors: Non_Mine_02, Mining_02, No_Irrig_02

f. Dependent Variable: ER2

g. Linear Regression through the Origin

Table 11.4 Coefficients in Building Model for Economic Resilience Dynamics Timespan 2

Coefficients[a,b]

		Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
Model		B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	Labour_02	-.179	.294	-.081	-.609	.550	.227	-.142	-.068	.699	1.431
	No_Irrig_02	.341	.134	.464	2.537	.021	.671	.513	.282	.371	2.697
	Old_Farm_02	.005	.142	.006	.036	.972	.572	.008	.004	.430	2.325
	New_Farm_02	.049	.280	.022	.175	.863	.177	.041	.020	.769	1.300
	Mining_02	.338	.107	.406	3.161	.005	.552	.598	.352	.754	1.327
	Non_Mine_02	.462	.118	.468	3.912	.001	.539	.678	.436	.866	1.155
2	Labour_02	-.183	.266	-.083	-.687	.500	.227	-.156	-.074	.807	1.239
	No_Irrig_02	.344	.097	.468	3.567	.002	.671	.633	.387	.681	1.467
	New_Farm_02	.046	.258	.021	.178	.861	.177	.041	.019	.860	1.163
	Mining_02	.339	.103	.406	3.295	.004	.552	.603	.357	.773	1.293
	Non_Mine_02	.463	.109	.470	4.264	.000	.539	.699	.462	.968	1.033
3	Labour_02	-.187	.258	-.085	-.724	.478	.227	-.160	-.077	.814	1.229
	No_Irrig_02	.351	.087	.477	4.017	.001	.671	.668	.425	.793	1.262
	Mining_02	.336	.100	.404	3.380	.003	.552	.603	.357	.784	1.276
	Non_Mine_02	.462	.106	.468	4.369	.000	.539	.699	.462	.973	1.028
4	No_Irrig_02	.336	.084	.458	4.001	.001	.671	.658	.418	.835	1.198
	Mining_02	.316	.094	.379	3.350	.003	.552	.590	.350	.854	1.171
	Non_Mine_02	.465	.104	.471	4.449	.000	.539	.697	.465	.974	1.027

a. Dependent Variable: ER2

b. Linear Regression through the Origin

Table 11.5 Collinearity Diagnostics in Building Model for Economic Resilience Dynamics Timespan 2

Collinearity Diagnostics[a,b]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions					
				Labour_02	No_Irrig_02	Old_Farm_02	New_Farm_02	Mining_02	Non_Mine_02
1	1	2.139	1.000	.03	.06	.05	.01	.07	.02
	2	1.242	1.312	.19	.00	.06	.00	.10	.23
	3	1.083	1.405	.01	.02	.01	.56	.04	.05
	4	.777	1.659	.27	.01	.08	.04	.04	.51
	5	.556	1.961	.18	.08	.03	.09	.76	.11
	6	.202	3.255	.31	.83	.77	.30	.01	.07
2	1	1.788	1.000	.12	.14		.03	.13	.01
	2	1.121	1.263	.11	.04		.42	.09	.09
	3	1.000	1.337	.00	.00		.14	.00	.81
	4	.625	1.691	.72	.01		.01	.53	.00
	5	.466	1.958	.06	.81		.40	.26	.09
3	1	1.737	1.000	.15	.15			.15	.01
	2	1.030	1.299	.03	.03			.02	.84
	3	.643	1.644	.78	.31			.11	.07
	4	.591	1.714	.04	.51			.71	.08
4	1	1.406	1.000		.30			.26	.05
	2	1.000	1.186		.00			.11	.84
	3	.594	1.539		.70			.62	.11

a. Dependent Variable: ER2

b. Linear Regression through the Origin

Table 11.6 Excluded Variables in Building Model for Economic Resilience Dynamics Timespan 2

Excluded Variables[d,e]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
2	Old_Farm_02	.006[a]	.036	.972	.008	.430	2.325	.371
3	Old_Farm_02	-.004[b]	-.023	.982	-.005	.481	2.081	.481
	New_Farm_02	.021[b]	.178	.861	.041	.860	1.163	.681
4	Old_Farm_02	.031[c]	.211	.835	.047	.538	1.860	.538
	New_Farm_02	.028[c]	.244	.810	.054	.867	1.154	.724
	Labour_02	-.085[c]	-.724	.478	-.160	.814	1.229	.784

a. Predictors in the Model: Non_Mine_02, Mining_02, New_Farm_02, Labour_02, No_Irrig_02

b. Predictors in the Model: Non_Mine_02, Mining_02, Labour_02, No_Irrig_02

c. Predictors in the Model: Non_Mine_02, Mining_02, No_Irrig_02

d. Dependent Variable: ER2

e. Linear Regression through the Origin

12 Appendix 5

MODEL FOR ECONOMIC RESILIENCE DYNAMICS 3 (THIRD FOUR-MONTH PERIOD POST-DISASTER EVENT)

Warnings

For models with dependent variable ER3, the following variables are constants or have missing correlations: Labour_03. They will be deleted from the analysis.

Table 12.1 Variables Entered/Removed in Building Model For Economic Resilience Dynamics Timespan 3

Variables Entered/Removed[b,c]

Model	Variables Entered	Variables Removed	Method
1	Non_Mine_03, Mining_03, New_Farm_03, No_Irrig_03, Old_Farm_03[a]	.	Enter
2	.	Old_Farm_03	Backward (criterion: Probability of F-to-remove >= ,051).
3	.	New_Farm_03	Backward (criterion: Probability of F-to-remove >= ,051).
4	.	Mining_03	Backward (criterion: Probability of F-to-remove >= ,051).

a. All requested variables entered.

b. Dependent Variable: ER3

c. Linear Regression through the Origin

Table 12.2 Model Summary in Building Model for Economic Resilience Dynamics Timespan 3

Model Summary[f,g]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.883[a]	.780	.722	.29623	
2	.881[c]	.776	.731	.29137	
3	.859[d]	.738	.700	.30757	
4	.828[e]	.686	.658	.32865	1.977

a. Predictors: Non_Mine_03, Mining_03, New_Farm_03, No_Irrig_03, Old_Farm_03

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Predictors: Non_Mine_03, Mining_03, New_Farm_03, No_Irrig_03

d. Predictors: Non_Mine_03, Mining_03, No_Irrig_03

e. Predictors: Non_Mine_03, No_Irrig_03

f. Dependent Variable: ER3

g. Linear Regression through the Origin

Table 12.3 Anova in Building Model for Economic Resilience Dynamics Timespan 3

ANOVA[f,g]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.905	5	1.181	13.458	.000[a]
	Residual	1.667	19	.088		
	Total	7.572[b]	24			
2	Regression	5.874	4	1.469	17.298	.000[c]
	Residual	1.698	20	.085		
	Total	7.572[b]	24			
3	Regression	5.585	3	1.862	19.681	.000[d]
	Residual	1.987	21	.095		
	Total	7.572[b]	24			
4	Regression	5.196	2	2.598	24.052	.000[e]
	Residual	2.376	22	.108		
	Total	7.572[b]	24			

a. Predictors: Non_Mine_03, Mining_03, New_Farm_03, No_Irrig_03, Old_Farm_03

b. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

c. Predictors: Non_Mine_03, Mining_03, New_Farm_03, No_Irrig_03

d. Predictors: Non_Mine_03, Mining_03, No_Irrig_03

e. Predictors: Non_Mine_03, No_Irrig_03

f. Dependent Variable: ER3

g. Linear Regression through the Origin

Table 12.4 Coefficients in Building Model for Economic Resilience Dynamics Timespan 3

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	No_Irrig_03	.303	.112	.381	2.698	.014	.734	.526	.290	.580	1.724
	Old_Farm_03	.074	.125	.085	.592	.561	.583	.134	.064	.559	1.789
	New_Farm_03	.259	.163	.188	1.589	.129	.400	.343	.171	.825	1.213
	Mining_03	.294	.154	.261	1.905	.072	.485	.400	.205	.615	1.626
	Non_Mine_03	.409	.113	.421	3.626	.002	.590	.639	.390	.861	1.162
2	No_Irrig_03	.321	.106	.404	3.023	.007	.734	.560	.320	.627	1.594
	New_Farm_03	.285	.155	.207	1.844	.080	.400	.381	.195	.888	1.126
	Mining_03	.331	.138	.295	2.391	.027	.485	.471	.253	.738	1.354
	Non_Mine_03	.418	.110	.429	3.793	.001	.590	.647	.402	.875	1.143
3	No_Irrig_03	.378	.107	.475	3.517	.002	.734	.609	.393	.684	1.462
	Mining_03	.293	.145	.261	2.030	.055	.485	.405	.227	.755	1.325
	Non_Mine_03	.432	.116	.444	3.727	.001	.590	.631	.417	.879	1.137
4	No_Irrig_03	.485	.100	.611	4.871	.000	.734	.720	.582	.906	1.103
	Non_Mine_03	.392	.122	.403	3.209	.004	.590	.565	.383	.906	1.103

a. Dependent Variable: ER3

b. Linear Regression through the Origin

Table 12.5 Collinearity Diagnostics in Building Model for Economic Resilience Dynamics Timespan 3

Collinearity Diagnostics[a,b]

				Variance Proportions				
Model	Dimension	Eigenvalue	Condition Index	No_Irrig_03	Old_Farm_03	New_Farm_03	Mining_03	Non_Mine_03
1	1	2.243	1.000	.08	.08	.04	.05	.03
	2	1.113	1.420	.00	.01	.22	.19	.26
	3	.831	1.643	.01	.01	.48	.00	.51
	4	.444	2.247	.77	.47	.00	.01	.06
	5	.368	2.468	.15	.44	.26	.74	.14
2	1	1.679	1.000	.17		.08	.10	.09
	2	1.097	1.238	.01		.22	.31	.21
	3	.823	1.428	.00		.55	.00	.52
	4	.401	2.047	.82		.15	.60	.19
3	1	1.562	1.000	.22			.17	.08
	2	1.000	1.250	.00			.22	.62
	3	.438	1.889	.78			.61	.30
4	1	1.306	1.000	.35				.35
	2	.694	1.372	.65				.65

a. Dependent Variable: ER3

b. Linear Regression through the Origin

Table 12.6 Excluded Variables in Building Model For Economic Resilience Dynamics Timespan 3

Excluded Variables[d,e]

						Collinearity Statistics		
Model		Beta In	t	Sig.	Partial Correlation	Tolerance	VIF	Minimum Tolerance
2	Old_Farm_03	.085[a]	.592	.561	.134	.559	1.789	.559
3	Old_Farm_03	.146[b]	1.018	.321	.222	.602	1.661	.602
	New_Farm_03	.207[b]	1.844	.080	.381	.888	1.126	.627
4	Old_Farm_03	.227[c]	1.644	.115	.338	.697	1.436	.664
	New_Farm_03	.168[c]	1.363	.187	.285	.908	1.101	.849
	Mining_03	.261[c]	2.030	.055	.405	.755	1.325	.684

a. Predictors in the Model: Non_Mine_03, Mining_03, New_Farm_03, No_Irrig_03

b. Predictors in the Model: Non_Mine_03, Mining_03, No_Irrig_03

c. Predictors in the Model: Non_Mine_03, No_Irrig_03

d. Dependent Variable: ER3

e. Linear Regression through the Origin