Spatio-temporal Behaviour of Residents after the 2004 Chuetsu Earthquake: A Case Study of Kawaguchi Town, Japan

January 2011

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A Dissertation Submitted to
the Graduate School of Life and Environmental Sciences,
the University of Tsukuba
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy in Science
(Doctoral Program in Geoenvironmental Sciences)

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Abstract

Earthquakes are a global threat causing economical and human losses. The human reaction in the case of a seismic event is a complex process. However, its understanding is vital to the improvement of the awareness and preparation of people living in areas with high risk. In Japan, major attention has been focused to improve the safety of infrastructure and citizens in the last decade, with a constant introduction of policies raising the level of security nationwide. Despite this strong effort, major lacks still appear in the preparation and awareness of people, especially in rural areas where the technological advancement and the policy application are late to arrive. Therefore, Kawaguchi Town in Niigata Prefecture is selected in this study, reporting high damages during the 2004 Chuetsu Earthquake. This research aims to investigate the causes behind the regional differences in behaviour after the earthquake in the town using interviews and surveys to collect data for the social backgrounds of residents and incorporating elements of geovisualisation and space-time data exploration.

Three research areas are selected in Kawaguchi town, a central, a peripheral and an isolated area in order to understand the causes behind the differences in behaviour and how they affected the recovery process. The social network and the surrounding environment conditions are considered as the main factor explaining these differences, showing a stronger bond and better collaboration in the most isolated and aged areas, whereas a

weaker bond and difficulties in sharing resources appear in the more populated sections of the town. Furthermore, the organisation within each community is also affected by the type of working activity and the time shared in daily life. In fact, farmers and the elderly had a strict connection, as they shared part of their lives on the fields and often collaborated to support each other. Oppositely in the central area the residents are mostly working outside the town, passing most of their time outside of the community. Therefore, the weak relationships among residents is the main cause of the lack in collaboration during the recovery process.

The community resulted to be an important part of the daily life for the isolated and peripheral areas. Oppositely, the central area has an individualistic life style. Despite these differences the community had a capital role during the recovery process. The surrounding environment conditions such as working activity, social network, different age and size of the community are important factors in explaining the regional differences in behaviour and the different community organisation. Therefore, the Japanese community system could be more effectively used to raise the awareness and preparation among residents living in rural areas, increasing independence and the auto-sustainability in case of natural disaster.

Keywords: behaviour, community, vulnerability, space time cube, social geography, Chuetsu earthquake, Japan

Contents

List of Tables

List of Figures

List of Photos

Abbreviations

CDMC – Central Disaster Management Council

CIP – International Potato Centre

DEM – Digital Elevation Model

DEWS – Distant Early Warning System for Tsunamis

EERI – Earthquake Engineering Research Institute

EMC – Emergency Mapping Centre

ESRI – Environmental System Research Institute

FDMA – Fire and Disaster Management Agency

FEMA – Federal Emergency Management Agency

GIS – Geographical Information Systems

ISDR – International Strategy for Disaster Reduction

ITC – International Institute for Geo-Information Science and Earth Observation

JMA – Japan Meteorological Agency scale

OECD – Organisation for Economic Co-operation and Development

PAR – Pressure And Release model

RMS – Risk Management Solutions

ST – Space-Time

STC – Space Time Cube

UNISDR – United Nations International Strategy for Disaster Reduction

USGS – United States Geological Survey

WHO – World Health Organisation

Chapter One

Introduction

1.1 Background and problem statement

Natural disasters are a common occurrence worldwide. In the last three decades there has been considerable discussion on the definition of natural disasters and their characteristics (Hewitt, 1983; Dynes, 1993). A common definition of disasters within social science is given by Fritz (1961): "*An event, concentrated in time and space, in which a society undergoes severe danger and incurs such losses to its members and physical appurtenances that the social structure is disrupted*". The main causes of natural disasters are classified into four hazard types: floods, tropical cyclones, earthquakes and drought (Burton et al., 1993). Among those, an earthquake is an "event that can be prepared for in advance" (Turner, 1976). Hence in high risk areas preparations such as emergency provisions, emergency communication plans, community based planning are crucial (USGS, 2005; FEMA, 2006). Although earthquake engineering research and earthquake hazard mitigation has developed, the risk from earthquakes is rapidly growing worldwide in accordance with economic development and the increasing number of cities resulting in the world's population being more earthquake prone (Tucker et al, 1994).

Japan has experienced around 18 percent of the total number of earthquakes of magnitude 7 and above between 1997 and 2006 (OECD, 2009). The Japanese people have learnt to survive in a high seismic risk environment and have adapted measures to minimise the damage produced by seismic events and enhancing the recovery process (Usami, 1979). As Usami (1979) suggests, earthquakes in Japan have occurred cyclically, such as the 90 to 150 year cycle seen for the Nankai Trough (off the coastline from Tokyo, Nagoya and Osaka). Three earthquake cycles are upcoming in the next decade, including the Nankai and Tonankai earthquakes originating in the area delimited between the Kyushu and the south-eastern tip of Honshu, and the Tokai earthquake originating 200 km south-west of Tokyo (HERP, 2007).

The Japanese government has rectified several national scale policies within the last 50 years. The Disaster Relief Act in 1947 made local prefectures responsible for the provision of post earthquake relief services such as rescue, sheltering, hearth care and emergency repairs. In order to increase the integrated action of the central government, local governments and public corporations, the Countermeasures Basic Act was later stipulated in 1961. After the Great Hanshin-Awaji Earthquake in Kobe, the Earthquake Disaster Management Special Measure Act was elaborated (1995), which revealed the deficiencies in the existing risk management system. The Act mainly focused on establishing evacuation areas and promoted the anti-seismic retrofitting of schools. These policy frameworks all focused on decentralised and more localized operations in disaster situations. Recently, the Central Disaster Management Council established an Earthquake Disaster Management Reduction scheme (CDMC) establishing new disaster mitigation goals; refining policies on earthquake resistant housing and public facilities (Suganuma, 2006). However, despite the progressive and continuous improvement of the policy frameworks, the roles and responsibilities of organizations and individuals during and after natural disasters are still not clear, with the exchange of information between the different governmental levels still not sufficient (OECD, 2009).

Despite the effort done by the Japanese government, regional differences, appear between metropolitan and rural areas, further complicating the successful adoption of the policies previously described. The concepts of urban and rural are considered as one of the most significant sources of regional variation in this literature. In fact, as noted by many (Kagitçibasi, 1997; Kashima, 2001; Oyserman et al., 2002) individualism and collectivism are often considered as analogous to the modern (urban) and traditional (rural) social conditions. The regional differences between urban and rural areas are therefore symptomatic of a different life style and cultural traditions. Under a modern and urbanised social order, an individualistic life style approach appears, reducing the levels of collectivism (Triandis, 1995). On the other hand, under a traditional and rural social order, people are more prone to a collective life style. In fact in rural areas, aspects such as the social roles, the type of occupation and the local community are necessary to maintain a collective life style (Baumeister, 1986 and 1987). Therefore, the differences in life styles could affect the residents' behaviour in case of a seismic event especially in areas in which urban and rural life style coexist. Because of the economic and political interests, urban areas are often object of policies and technological improvements against earthquakes, however rural areas are still disadvantaged due to the lack of awareness, policies, earthquake resistant construction and anti seismic evaluations (Matsushita et al., 2008). The lack of the economic development in rural areas is globally also the main cause of the migration of younger generations to urban centres (Gismondi M., 2010a). Moreover rural areas are often affected by post earthquake isolation due to the lack of accessibility, especially in mountainous areas (Olshansky et al., 2006).

This study will focus on rural areas where the presence of a collective life style is believed to be important to provide support during the recovery process and overcome the lack in technological development and policies. In this paper the community is defined as a group of people (a neighbourhood or a group of neighbourhoods) living in the same locality, sharing and participating in daily life. Despite the similar environment conditions in which members of the same community live in, discrepancies and issues can eventually emerge during emergency situations. Acquiring awareness and preparation to face an earthquake is the first step towards the independence of a community (Coburn and Spence, 2002). However, maintaining the community awareness and organization is an arduous task and requires constant effort (Smith, 1961; Yoshida, 1964; Coburn and Spence 2002). In fact, The Japanese Cabinet Office's Survey on disaster preparedness confirms the progressive decrease of risk awareness after a major earthquake (Suganuma, 2006). The actual policy system appears not to be sufficiently efficient to provide the preparation required to face a seismic event (OECD, 2009). For this reason it is important to understand the difference in community response after an earthquake in rural areas and the type of interaction that exists among community members. Therefore, an integration of multiple fieldworks, GIS and STC techniques is proposed to summarize and interpret the regional differences during the recovery process, the spatio-temporal evacuation patterns and the driving factors causing the behavioural changes in different communities.

1.2 Research objective

The main purpose of this research is to examine the causes behind the regional differences in behavioural response to an earthquake within a rural area in Japan. This objective will be accomplished by analysing the differences in behaviour and investigating its causes after an earthquake by incorporating elements of geovisualisation and data exploration. In particular, the research aims to use surveys to collect data regarding the daily activities and preparation prior to the earthquake, investigate the reactions after the seismic event and evaluate the temporal movement paths during the recovery process. Kawaguchi town, located inland in the centre of Niigata Prefecture, is a case study representative of the typical Japanese rural settlement with a community based life style. The dispersed geographical distribution of the rural tissue allows to consider the town as a union of hamlets composed by different communities. The lack of commuting roads and the significant number of landslides in the area are responsible for the high risk of isolation in case of the natural disaster such as in the 2004 Chuetsu earthquake. Furthermore, the progressive abandonment of rural areas results in a higher average age, leaving the elderly in the rural (Gee, 2000). These elements explain the need of major attention in disaster preparedness in rural areas and the importance of this study. To understand the reason behind the differences in behaviour, it is necessary to clarify the weaknesses of the actual community system. By increasing the residents' knowledge and awareness for self protection, the number of casualties due to a seismic event can be reduced (Akason et al., 2006).

1.3 Literature review

Vulnerability and preparation. Vulnerability can be defined as "the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard" (Wisner et al., 2004). Another definition includes the concept of "capacity" as the ability of a group or household to succeed in resisting the violence of a hazard and easily start the recovery process (Anderson and Woodrow, 1998; Eade 1998; IFRC, 1999b; Wisner 2003a). In this definition of vulnerability, time also plays an important role, during the recovery process.

According to Wisner et al. (2004) the earthquake vulnerability can be explained through four determinants. The location and damages of the earthquake give the preliminary information about the seismic susceptibility of a location. The temporal characteristics of earthquakes produce extensive information about the frequency of earthquake events and can condition the level of risk awareness. An earthquake occurring at night would produce higher casualties because people are more exposed to injuries (Alexander, 1985). The characteristics of building such as the safety level and anti-seismic constructions are also considered having strong influence on vulnerability (Cuny, 1983; Coburn and Spence, 2002). As Alexander (1985) explains, over 95 percent of all deaths in earthquakes are caused by buildings collapsing. The protective measures includes the structural and non-structural regulations, and policies that should be taken before the occurrence of the earthquake. After the earthquake, the relief measures such as provision and medical accessibility are considered critical factors in the vulnerability of people (WHO, 1997).

Understanding the vulnerability of people living in an earthquake risk area is the first step to providing preparation (Tierney, 2001). Moreover, the advancement in technology allowed to introduce GIS as a supporting tool to acquire major information about seismic hazard risks (King and Kiremidjan, 1994; FEMA, 2001; McGuire, 2004), disaster management (Mansourian, 2005; Saadarseresht, 2006) and post earthquake support (ESRI, 2007; EMC, 2007). Although a wide range of researches are available, the responsibility for successful organisation to minimise the impact of a natural hazard remains to the different governmental levels (Tierney, 2001). Despite the progressive advancements in understanding the vulnerability, producing awareness, preparation and general resources to invest in preventive actions are largely latent in social institutions (Adger, 2006). In order to improve the current situation in the matter of earthquake safety, several global initiatives have been developed in the last decade. Initiatives such as the Community Emergency Preparedness (WHO, 1999) and the Global Earthquake Safety Initiative (GeoHazard International United Nations Centre fro Regional Development, 2001) are the most prominent in this movement. The priority of these studies are to reduce the earthquake risk by providing short and long therm emergency preparedness programs, combining the natural hazards and scientific research findings with governmental policy planning (WHO, 1999; GeoHazard International United Nations Centre fro Regional Development, 2001).

Household preparedness. A seismic event cannot be prevented, but the impact of an earthquake can be minimised by adopting preparedness measures (Mileti, 1999; Tierney et al., 2001). Considering the individual or household level, the preparation consists of acquiring a certain knowledge about possible risks within the living area and making safer housing. (Palm, 1990; Turner et al., 1986). Pre-impact actions such as insurance purchase, is also a determinant (Kunreuther et al., 1978). Despite the level of awareness and knowledge about seismic events, constraints often appear from economic availability, indecision and other impediments (Palm and Hodgson, 1993). The perception of the earthquake risk is the main factor influencing the human reaction in pre-earthquake arrangements and responses to a hazard (Asgary and Willis, 1997). Therefore, "an understanding of how and why households prepare for disasters must be based first on an understanding of how the public perceives and acts on risk information" (Tierney et al. 2001).

There are several examples of researches aiming to clarify the connection between hazard perception and the preparedness behaviour. Nigg (1982) in his research conceives three stages, first the information is heard, secondly understood and finally the importance is perceived. Another interpretation focuses on the importance of the communication process to enhance the emergency preparedness. Five stages are conceived: attention, comprehension, acceptance, retention and action (Lindell and Barnes, 1986; Lindell and Perry, 1992; Lindell and Perry, 2003). From these two examples, the importance of the risk communication process to produce the sufficient preparation to face an earthquake becomes evident (Mileti and Fitzpatrick, 1992; Lindell and Perry, 2000). Suganuma (2006) observed the progressive decrease of risk awareness after a major earthquake, highlighting the importance of an effective and persistent in time risk communication process, as in the case of Tierney et al. (2001).

Community role in disaster management. Several researches underlined as the main reason of local disaster vulnerability the preexisting patterns inside the community members (Anderson, 1994; Varley 1994; Pulwarty and Riebsame 1997; Pielke and Pielke, 1997, Cutter et al., 2008). Factors such as geographical location, everyday relations, social interaction and organisation are responsible to how resources and organisation can be produced (Blaikie et al., 1994; Bolin and Stanford, 1998). These factors are not always the same within the same community or even within the same neighbourhood. The differences in the socio-economic system are responsible of the unequal exposure to risk. This is the reason why the study of the human systems and relations to the environment are considered much more important than the interpretation of the natural event itself (Cannon, 1994).

Recently, strong attention is given to national programs sponsored by governmental agencies such as the Natural Disasters Action Plan and the Federal Emergency Management Agency with numerous activities aiming to prepare communities to face natural disasters in the United States (FEMA, 1997 ; Wachtendorf and Tierney, 2001). At a global level, programs such as the ISDR (International Strategy for Disaster Reduction) aim to build disaster resilient communities and involving community members to disaster reduction goals (UNISDR, 2009). This trend highlights the global effort in minimising the natural disaster damage and provides awareness among people.

Also in Japan, the community participation in disaster management is an actual topic of discussion at local and national levels (Government of Japan, 2005). The geographical location exposed to frequent earthquakes had made the Japanese government very active in disaster management. At a community level the autonomous organization for disaster reduction has a very important role during the recovery process: guiding the refugees to a shelter, rescuing residents, providing initial first aid and necessary supplies (Bajek et al., 2008). Moreover, after the Basic Act on Natural Disasters, the central and local governments have the duty to foster autonomous organizations for disaster reduction (FDMA, 2004). Progressively, this practice is incrementing in the number of groups present in the country with a total number of registered organisation of 104,539 (FDMA, 2003). The positive increase of autonomous organizations for disaster reduction represents a favourable increment of interest among households and community members in actively participating in the disaster preparation process (Bajek et al., 2008). However, strong lacks in emergency planning and governmental inter-level communication still appear, with the community system awareness and preparation also weakening (OECD, 2009).

Recent trends in earthquake disaster management in Japan. The Great Hanshin-Awaji Earthquake in 1995 is considered the most compelling seismological event in Japan after the 1923 Great Kanto Earthquake, causing a significant amount of human losses and structural damages (Suganuma, 2006). As a result, after the event, the number of research programs in disaster management and other disciplines rapidly increased (RMS, 2005). At the governmental level subsequently after the seismic event, the Headquartes of Earthquake Research Promotion composed by the Policy Committee and Earthquake Research Committee was established with the objective to better understand the Japanese seismic activity (Shimazaki, 2002). Another subcommittee for Survey and Observation Planning was also conceived. As result of the creation of the subcommittee, the Interim Report Regarding Earthquake Observation and Surveys in 1996 focusing on nation-wide surveys and observation was produced (Koide, 1997).

In the last two decades, the idea of how the risk is conceived endured considerable changes. In fact, social, psychological and economic approaches are progressively taking over the pure scientific technical approaches. Despite the usefulness of technical research and devices, in the case of extreme conditions, the human factor plays an important role in disaster management and mitigation (Menoni, 2001). For this reason after the Kobe Earthquake, there are examples of attempts to increase the risk awareness and tighten the relationship between people and the local government. The objective is to have a collective risk idea making easier the share of responsibilities not only between communities but also among different governmental levels (Huber, 1995).

The use of fieldworks and questionnaires are a common practice in understanding the human, social and economical side of disaster management. In the 1995 Great Hanshin-Awaji Earthquake in Kobe and 2004 Chuetsu Earthquake in Niigata Prefecture, fieldwork was largely used in a number of research to collect information directly from the residents who experienced the extreme event; such as Kimura et al., 1999; Kimura et al., 2001; Tamura et al., 2002; Tamura et al., 2005; Kimura et al., 2006; Kimura et al., 2007. As Slovic (2002) suggests, the risk perception differs according to people. In this sense, being able to collect information from multiple respondents is an important step to understand the differences in behaviour and in risk perception during and after a seismic event. Hence, to understand the importance of earthquake preparation, risk perception and awareness, the level of education is also considered as a determinant factor (Shaw et al., 2004). In both aspects, earthquake preparation and education should be considered in order to provide a comprehensive information about changes in spatial behavioural patterns during the recovery process.

Introduction to time geography. Geovisualisation and data exploration analysis give an important contribution in facilitating the translation of raw data into meaningful information (Andrienko et al., 2003). When dealing with temporal data visualisation, it is important to understand the properties of each individual, the location, the time and the correlation among individual actions. Three main questions are relevant for a user of spatio-temporal data: what, where and when (Peuquet, 1994). There are several ways of graphically represent these three questions. The narrative static single graphics includes all the information in one frame. It consists of a bi-dimensional graph in which the temporal aspect is represented using text or symbols such as the Minard 1812 Napoleon's march to Moskow (Tufte, 1982). Another techniques explained by Tufte (1982) consists of using small multiple graphs in which a specific temporal information is recorded. The first attempt of devising an alternative way of incorporating time in visualisation occurred in the 1970s by the hand of Hägerstrand (1970). The method started from the bi-dimensional representation of the geographic spatial dimension (x,y) adding a third dimension (z) used to indicate the time. Often, the name of Hagerstrand is associated with the development of time-geography studies and applications (Kraak and Ormeling, 2003).

Time geography uses visual tools to study human behaviour in space and time, observing the path of individuals throughout space and time and considering their interactions (Moore et al., 2003). Following Figure 1 introduced by Moore et al. (2003), five main elements are representative in the time geography, lifelines, stations, bundles, domains and prisms. The lifeline represent the path resulting from the movement of a person or object. The vertical line in Figure 1-1 correspond to the immobility of an object or person for a determined amount of time (z). The different angles of trajectory explain the change in speed from one station to the other. To the increment of steepness is associated a slower movement and vice-versa. Considering the previously cited concept by Peuquet (1994), the identity of the object shows "what" , the domain answers "where" and the temporal position (z) explains "when". Situation of bundle can occur where situation of co-location appear in space and time. Finally, the prism is the visual representation of the total area of space reachable by an individual in the available time.

The development of GIS science tools such as geovisual analytics incorporating elements of visualisation, knowledge creation and decision-support, successfully improved the visualisation of temporal data (Andrienko et al., 2007). The space-time cube (STC) is an example of a concept refined from the time geography aquarium, evolving from the limited manual methods to the digitalized GIS. The STC presents a similar way to represent data to the aquarium showed in Figure 1-1. A three dimensional orthogonal viewpoint is used to represent the data, horizontal axes are used to geographically point the location of an object or person whether the vertical axis presents the position of specific events occurred throughout the lifespan of each individual (Abrahart and Bradshaw, 2004). The STC facilitates the investigation of the co-location of objects and events in space and time, and recently has been used in a range of geo-visual and analytical studies (Kwan, 1999; Forer and Huisman, 2000; Kraak and Kousoulakou, 2004; Sinha and Mark, 2005). Despite still presenting a lack in software development, the STC is progressively growing in popularity as providing both visual and analytical basis for linking objects and phenomena in space and time (Kraak and Huisman, 2009).

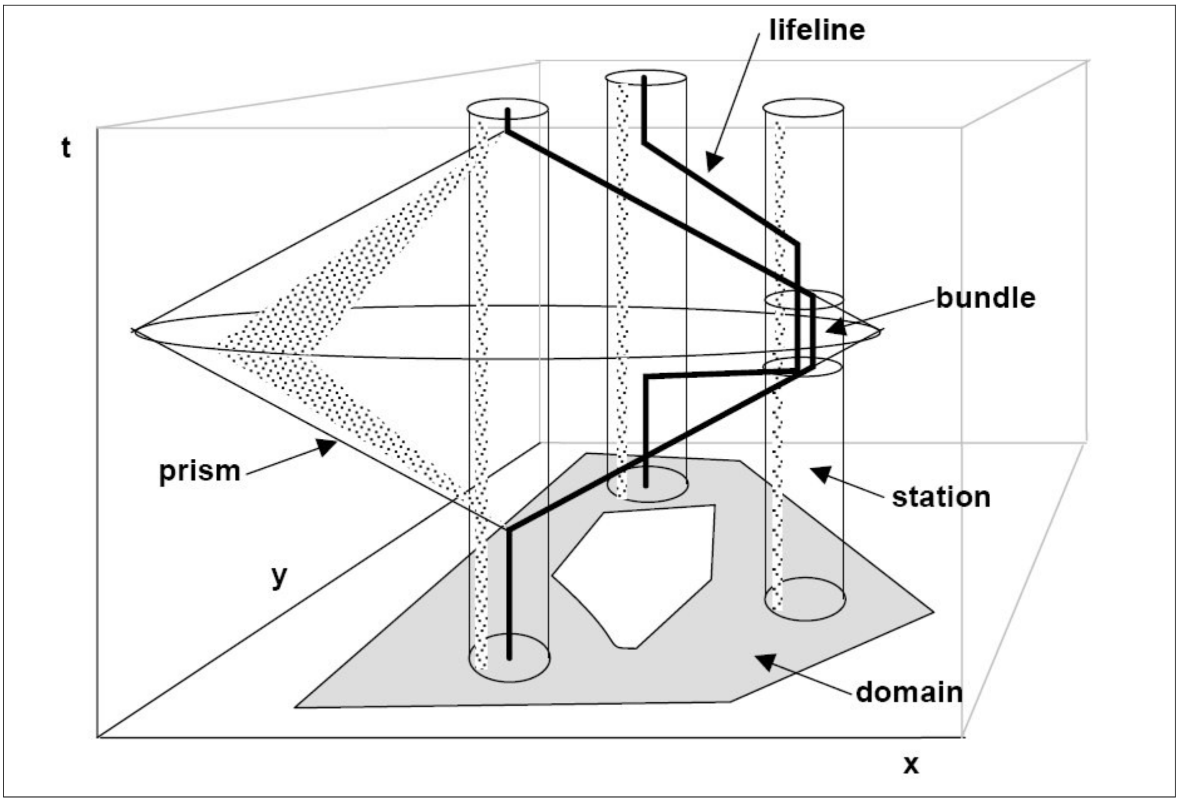


Figure 1-1: Aquarium.

Source: Moore et al, 2003

1.4 Outline of the study area

The following sub-chapters propose an overview over the area covered in this study and provide an outline of the 2004 Chuetsu Earthquake in Kawaguchi town.

1.4.1 Geographical setting

Niigata Prefecture is located on the Honshu Island on the coasts of the Sea of Japan between 36°34'32” to 39°01'27” North and 137°07'18” to 139°21'32” East. The coastal area stretches from the south-west to north-east for about 240 km, with a wide coastal plain between the mountainous inland areas and the coastal zone. The area is divided into four geographical areas: Joetsu in the south, Chuetsu in the centre, Kaetsu in the north, the Sado Island and consist of 10 districts and 35 municipalities. 20 cities are present in the prefecture with several town and villages. Niigata Prefecture is the second biggest producer of rice after Hokkaido, making agriculture the primary economic activity (Niigata Prefecture, 2010).

Kawaguchi town is located inland of the Niigata Prefecture in the Chuetsu area, 25km apart from the prefecture main city (Nagaoka). The study area is situated between 37°10'12” to 37°18'58” North and 138°49'57” to 138°51'44” East (Figure 1-2). Since March 31st 2010 the Kawaguchi town was absorbed into the city of Nagaoka, dissolving the Kitauonuma district as Kawaguchi was the only town remained. The town is located at the bottom of a wide valley in a hilly area surrounded by mountains and divided by the Uono river and Shinano river, the longest river in Japan.

Eleven sections compose of the Kawaguchi area. Higashi Kawaguchi represents the centre of the town. Nishi Kawaguchi, Nawadu, Nakayama and Ushigashima occupy the plane areas used for rice cultivation. Aikawa, Araya, Touge, Budoukubo, Kizawa and

Yamugiyama are located on the fringe of the hilly/mountainous areas. The town population before the earthquake (2004) was 5572 people with a density of 111 persons per km^2 (Research Group on Damage of Mid Niigata Earthquake, 2005). Like most of the rural areas in Japan, since the end of the Second World War, the population is progressively decreasing due to migration with a consequent increase of the elderly population (Gee, 2000). The economy is mainly based on local small businesses and agricultural activities predominant in the hinterland consisting of mainly rural farming communities. The satellite image proposed in photo 1-1 shows the large amount of land dedicated to rice cultivation.

Concerning natural risks, the area is subject to heavy snow during the winter period and landslide hazard in spring because of the geological conditions of differential denudation (Konagai, 2004). Japanese style wooden houses are the main construction of residence in the area. Because of the high risk of heavy snow in winter time, the structures were built with special care to be resistant to the weight of the snow. Hence, no special attention was dedicated to the earthquake resistant construction.

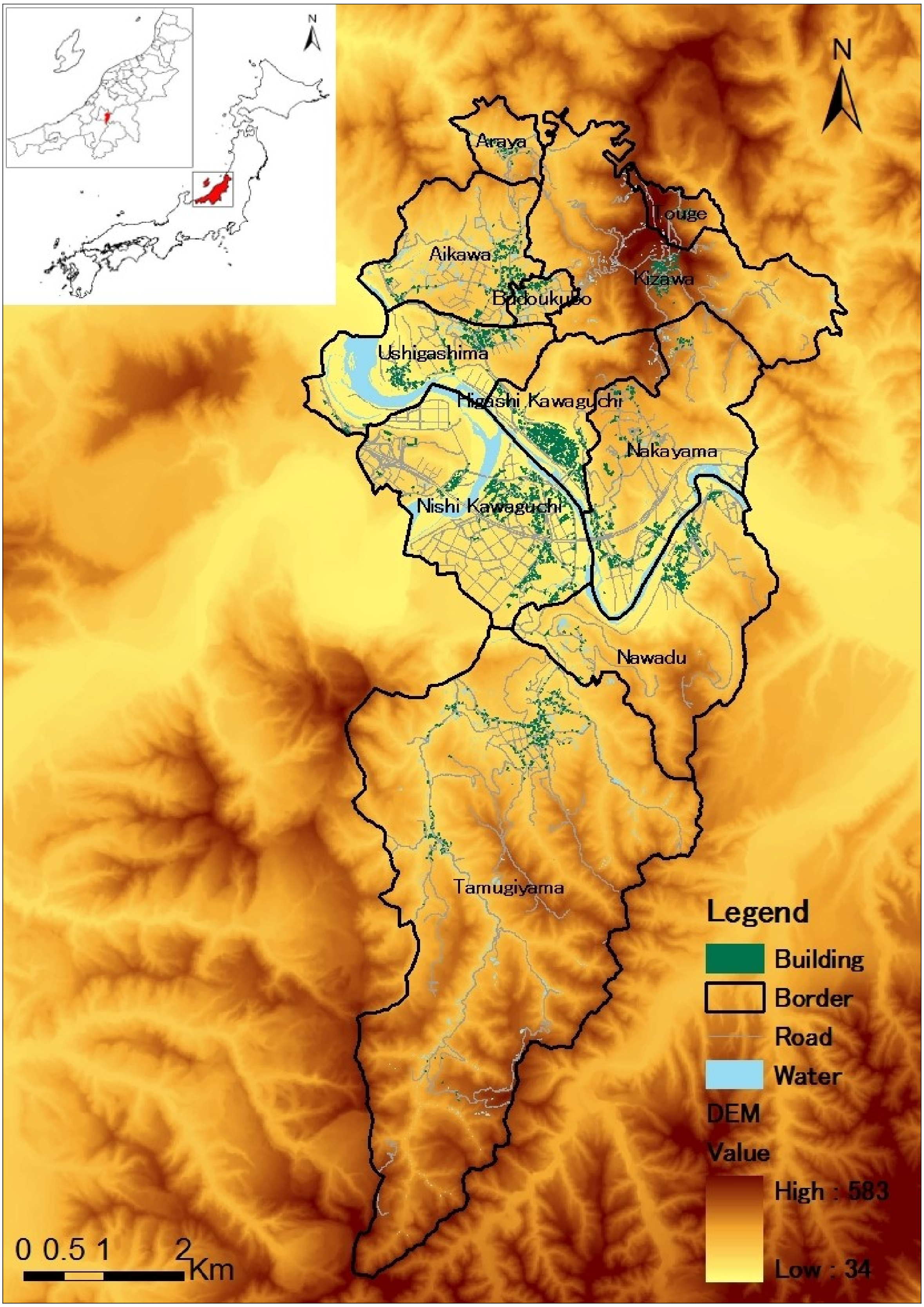


Figure 1-2: Kawaguchi town: geographical location and section division.

Data source: Zenrin and Hokkaido-Chizu data

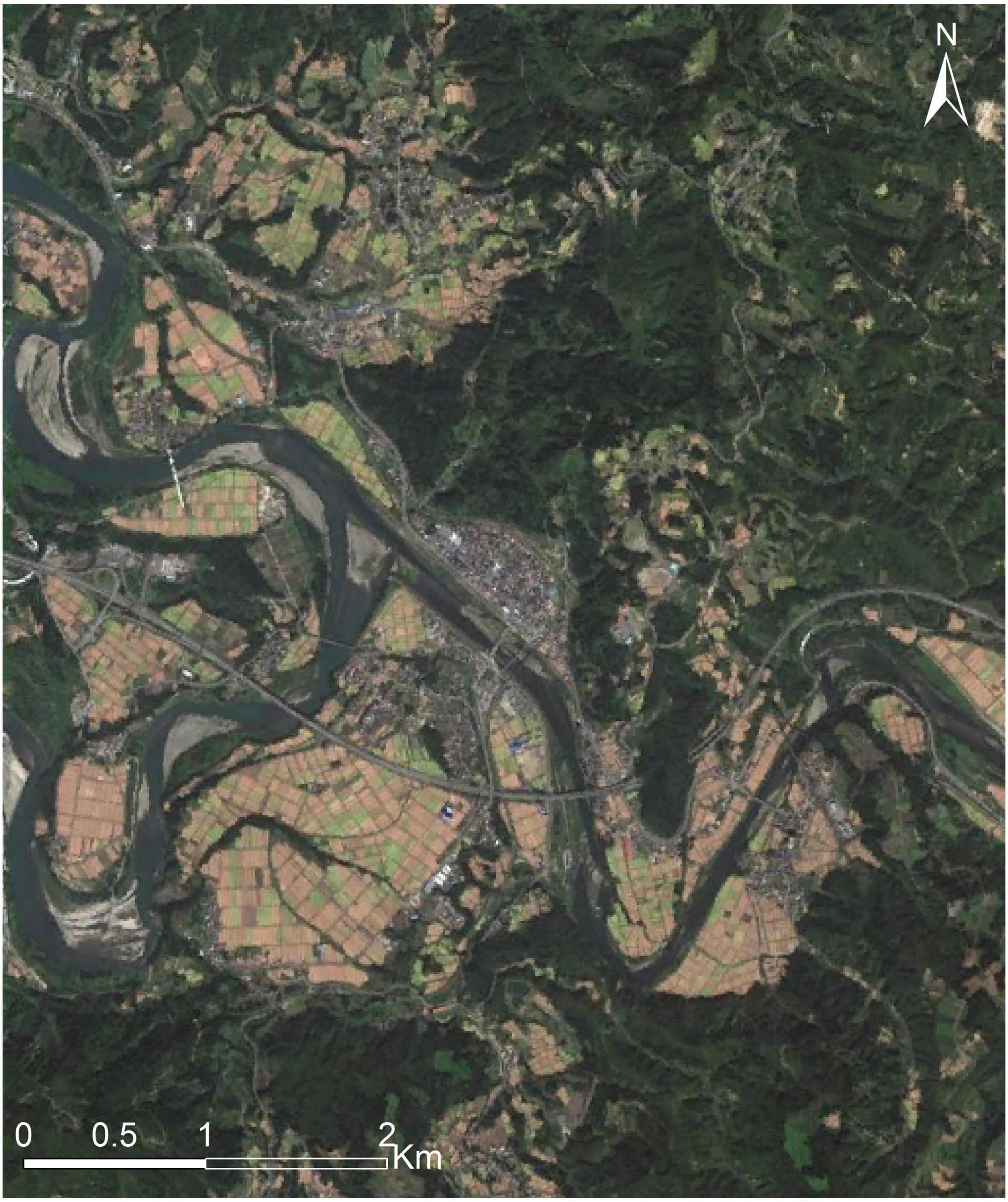


Photo 1-1: Satellite view over the rice field landscape in Kawaguchi town.

Data source: Google Earth Map – Aerial photo by GSI, 2007

Note: The photograph shows the typical landscape of Kawaguchi town, presenting a mixture of cultivated areas and natural forests

1.4.2 The 2004 Chuetsu Earthquake

The Chuetsu Earthquake occurred in Niigata Prefecture on Saturday, 23rd October 2004. The event is considered as the most costly earthquake after Kobe (1995), and produced a surface wave magnitude of 6.6, JMA scale (Japanese Meteorological Agency seismic intensity scale) of 7 and an estimated economic costs of USD 30 billion (Munich Re, 2005). Due to the damage, 100,000 persons evacuated to temporal shelters and 10,000 were obliged to life in temporary housing for several years (EERI, 2005). Niigata Prefecture has a long historical record of earthquakes, confirming the high seismic risk. Especially in the last 50 years, multiple earthquakes of different intensity were recorded, such as the 1964 Great Niigata Earthquake. The Chuetsu Earthquake caused large damage on the infrastructure, including building, roads, bridges and railway lines, making the Shinkansen derail for the first time. Photo 1-2 shows an example of the severity of the damage produced by the seismic event in two areas in Kawaguchi town. Images a) and c) represent two damaged areas after the 2004 earthquake and images b) and d) show the same areas after reconstruction. Several reasons can be reported on explaining the severity of damages. First, the ground acceleration of 1.7g was double the strength of the figures recorded in Kobe in 1995 and far over the structural resistance parameters of the existing construction. Second, the Tokage typhoon had just passed over the area producing a destabilisation of the ground due to the heavy rainfall. This typhoon is considered as the main component in affecting a large number of landslides registered in the Niigata Prefecture (EERI, 2005). The earthquake itself occurred in an earthquake-prone rural area, mainly damaging Ojiya city, Yamakoshi village and Kawaguchi town. The first shock occurred within the border of town. Figure 1-3 shows the location of the main shock recorded by the JMA (level 7) and the other aftershocks. In fact, after the main shock, major aftershocks with a JMA level of more than 5 were observed within two weeks (Japan Meteorological Agency, 2004).

Kawaguchi town reported 6 people killed, 62 injured, 605 houses destroyed, 145 houses seriously damaged, 643 houses partially damaged and 1460 public buildings also damaged (Research Group on Damage of Mid Niigata Earthquake, 2005). The geomorphology around Kawaguchi town allowed the construction of only two commuting roads passing through the town. Those roads reported severe damages during the earthquake delaying the arrival of rescuers, leaving the town completely isolated for the first 72 hours after the seismic activity. Table 1-1 shows the time, deepness, magnitude and JMA levels of the shocks that had occurred since the first earthquake. Within the first 2 hours, three major aftershocks with a JMA level 6 are observed. In-between the major aftershocks, other seismic activity of smaller intensity were also recorded. The prominent aftershocks recorded are the main cause of further damages and the hindering of the rescue activities (Hirata et al., 2005).

Higashi Kawaguchi section

a)

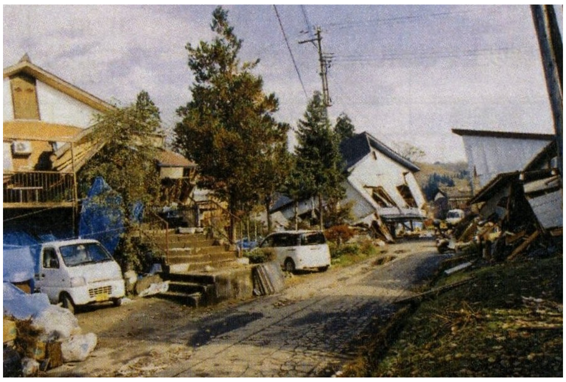
After the earthquake

b)

At the end of the restoration process

Tamujiyama section

c)



After the earthquake

d)

At the end of the restoration process

Photo 1-2: The structural damage provoked by the Chuetsu earthquake.

Data source: Niigata Prefecture, Kawaguchi town city office

Note: Photos were taken by an officer of Kawaguchi town a week after the Chuetsu earthquake occurred and after the reconstruction was completed (Summer, 2005)

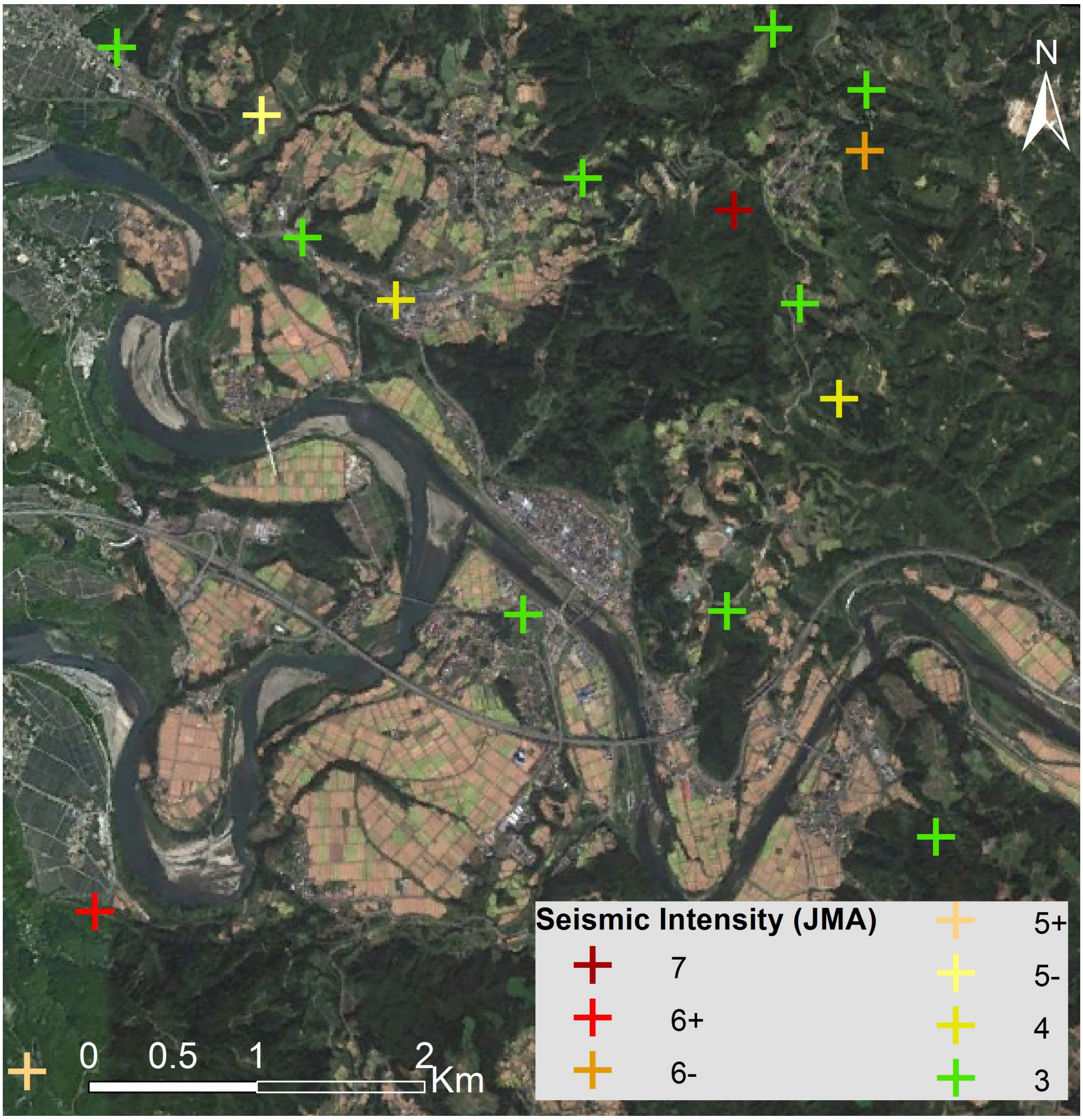


Figure 1-3: Location of the main earthquakes in proximity to Kawaguchi town.

Data source: Niigata Chuetsu Earthquake GIS project website

Table 1-1: Aftershocks perceived around Kawaguchi town with a JMA level superior to 5.

Earthquake		Magnitude	Deepness(km)	JMA
Date	Time			
2004/10/23	17:56	6,8	13	7
2004/10/23	17:59	5,3	16	5
2004/10/23	18:03	6,3	9	5
2004/10/23	18:07	5,7	15	5
2004/10/23	18:11	6	12	6
2004/10/23	18:34	6,5	14	6
2004/10/23	18:36	5,1	7	5
2004/10/23	18:57	5,3	8	5
2004/10/23	19:36	5,3	11	5
2004/10/23	19:45	5,7	12	6
2004/10/23	19:48	4,4	14	5
2004/10/24	14:21	5	11	5
2004/10/25	00:28	5,3	10	5
2004/10/25	06:04	5,8	15	5
2004/10/27	10:40	6,1	12	6

Data source: Niigata Prefecture, Kawaguchi town city office

Chapter Two

Research Procedures

2.1 Data collection methods

This study primarily focuses on the social and spatio-temporal aspects of the post earthquake behaviour. The level of the social tissue brings changes in the spatio-temporal paths provoking a different type of behaviour among individuals living in the same area. Therefore, the research relied on heavy fieldwork activities to summarize the different aspects of the behaviour directly from the residents of Kawaguchi village, using interviews and questionnaire surveys, common practice in social geography (Cook, 1998; Babbie, 2001). Furthermore, geovisualisation with STC (Space Time Cube) is used to provide the temporal path distribution during the recovery process. Due to the nature of the research, the data used can be divided into two types: digital data and interview based data. Table 2-1 shows the data used in this research.

The digital data has a supportive role and are mainly used as a base to display the information issued from the interviews. The digital data consists in layers containing the main features of the Kawaguchi town. Elements such as building footprints, roads, rivers, DEM (Digital Elevation Model), etc. were collected from the Zenrin Zmap II and Hokkaido Chizu, kindly provided by the temporal access to the Center of Spatial Information Science (University of Tokyo) databases. The location of the shelters inside the town was instead produced by digitalising the paper maps collected from the Kawaguchi town governmental office (Appendix I). Additional fieldwork was performed to verify the effective presence of the shelter before the 2004 earthquake and its location.

The behavioural and temporal data used in this study were collected using four main fieldwork sessions (from 2008 to 2010) as summarized in Table 2-2. The first fieldwork had the aim of collecting information about the town structure and organisation, highlighting the differences in community organisation within Kawaguchi town. The second and the third were conceived as in-depth interviews to the local residents to extract the social behaviour data after the 2004 earthquake. The interview was composed by two parts; in-depth interview in which the reactions, preparation and behaviour of the respondent was recorded and a short questionnaire in order to be able to produce quantitative evaluation (Appendices II and III). Particular attention was dedicated to the temporal side of the movement behaviour, collecting the physical move of the respondent after the first seismic activity, used with the STC analysis. The fourth fieldwork was performed to investigate the daily community activities and management in the town to understand the importance of the community in everyday life. The following sections of this chapter are proposed to explain the methods used during the fieldworks, focusing on the comparative analysis and the time geography application used.

Table 2-1: List of data used in this study.

Data types	Year	Sources
Physical features		
Road network (vector layer)	2004	Zenrin Zmap II (CSIS)
Building footprint (vector layer)	2004	Zenrin Zmap II (CSIS)
Water network (vector layer)	2004	Zenrin Zmap II (CSIS)
Jurisdictional borders (vector layer)	2004	Zenrin Zmap II (CSIS)
DEM (raster layer)	2005	Hokkaido-Chizu (CSIS)
Shelters location (vector layer)	2008	Fieldwork
Paper maps		
Chuetsu earthquake damage maps	2004	Kawaguchi town local government office
Chuetsu earthquake landslide maps	2005	Kawaguchi town local government office
Chuetsu earthquake inundation risk map	2005	Kawaguchi town local government office
Social features		
Respondents house location	2008-2010	Fieldwork
Questionnaire digitalised answers	2008-2010	Fieldwork
ST movement paths	2008-2010	Fieldwork

Table 2-2: Surveys overview.

	Kawaguchi town general fieldwork	Kawaguchi town area fieldwork 1	Kawaguchi town area fieldwork 2	Kawaguchi town general fieldwork
Survey objective	Collect information about the structure and organisation of the town and its communities	Retrieve the experience of residents during and after the 2004 Chuetsu earthquake in specific location of the town according to the community characteristics.		Collect information about the daily life community organisation and activities
Survey date	Winter 2008/09	Summer 2009	Winter 2009/10	Summer 2010
Survey target areas	Kawaguchi town	Nishi and Higashi Kawaguchi	Kizawa	Kawaguchi town
Survey method	Door-to-door interviews	Door-to-door interviews and questionnaire		Door-to-door interviews

Note: The table proposes the four main fieldworks done with their respective objectives. The length of each fieldwork was approximatively one week

2.2 Research areas

Kawaguchi town is composed of 11 sections and 39 communities as show in Table 2-3. Each community and section varies by size and population density according to the geographical location. Therefore, to succeed in comparing the behaviour that had occurred during the recovery process, three research areas are proposed in Kawaguchi town. First using the local government officers support the town is divided in central, peripheral and fringe areas according to the different characteristics of each community. This type of division is often used by urban planners to define different areas of a city (Lynch, 1960). Using the same way to divide the city is useful to highlight the difference in residents' behaviour according to the geographical location. In a second moment, three research areas are selected as follows (Figure 2-1). Kawaguchi 1 to 6 represents the central area. Offices, shops and the main communication ways are in this area, representing the centre of the town. Despite the presence of six communities, during the recovery process the lack of pre-arranged organisation provoked a mixture between members from different communities. Therefore the central area is considered as a unique group in this study. Concerning the peripheral area, Araya and Nishiki are selected. The two communities are at only 500m from the city centre, however different characteristics of the community and a divergent behaviour from the central area emerged during the recovery process. A third research area was selected among the isolated hamlets, because of the unique community features: extremely low accessibility to the main road network, high percentage aged residents and low access to information during the recovery process. Kizawa is located 8km from the city centre and is considered as an isolated area as it was the last location reached by the rescuers after the seismic activity.

Table 2-3: Kawaguchi town sections and community division in 2000.

Section	Community	Population	Household
Wanadu (和南津)	Hachirouba (八郎場)	56	13
	Vegahara (上河原)	172	39
	Nagasaka (長坂)	101	26
	Shimomura (下村)	127	31
	Owakita (小和北)	16	4
Nakayama (中山)	Nakayama (中山)	201	58
	Noda (野田)	136	32
	Takeda (竹田)	30	10
	Ushigakubi (牛ヶ首)	16	6
Kawaguchi (川口)	Kawaguchi 1 (川口1)	351	96
	Kawaguchi 2 (川口2)	165	53
	Kawaguchi 3 (川口3)	200	54
	Kawaguchi 4 (川口4)	259	101
	Kawaguchi 5 (川口5)	241	66
	Kawaguchi 6 (川口6)	187	62
	Kawaguchi 7 (川口7)	148	50
Nishi-Kawaguchi (西川口)	Kawagishimachi (川岸町)	252	125
	Aikawaguchi (相川口)	88	21
	Iwadehara (岩出原)	160	37
	Yamanoaikawadanchi (山ノ相川団地)	63	16
	Araya (荒屋)	171	44
	Nishiki (新敷)	151	36
	Harashinden (原新田)	180	44
	Nakashinden (中新田)	160	38
	Nishikura (西倉)	142	30
Tamugiyama (田麦山)	Maehara (前原)	182	45
	Ogata (大形)	234	55
	Tanaka (田中)	100	24
	Oyauchi (大谷内)	87	18
	Odaka (小高)	106	25
Ushigashima (牛ヶ島)	Ushigashima (牛ヶ島)	230	62
	Kainosawa (貝ノ沢)	198	55
Budokubo (武道窪)	Budokubo (武道窪)	183	47
Aikawa (相川)	Aikawa 1 (相川1)	164	43
	Aikawa 2 (相川2)	139	34
	Aikawa 3 (相川3)	63	18
Araya (荒谷)	Araya (荒谷)	83	21
Kizawa (木沢)	Kizawa (木沢)	138	52
Touge (峠)	Touge (峠)	12	4
11	39	5.692	1.595

Data source: Niigata Prefecture, Kawaguchi town city office

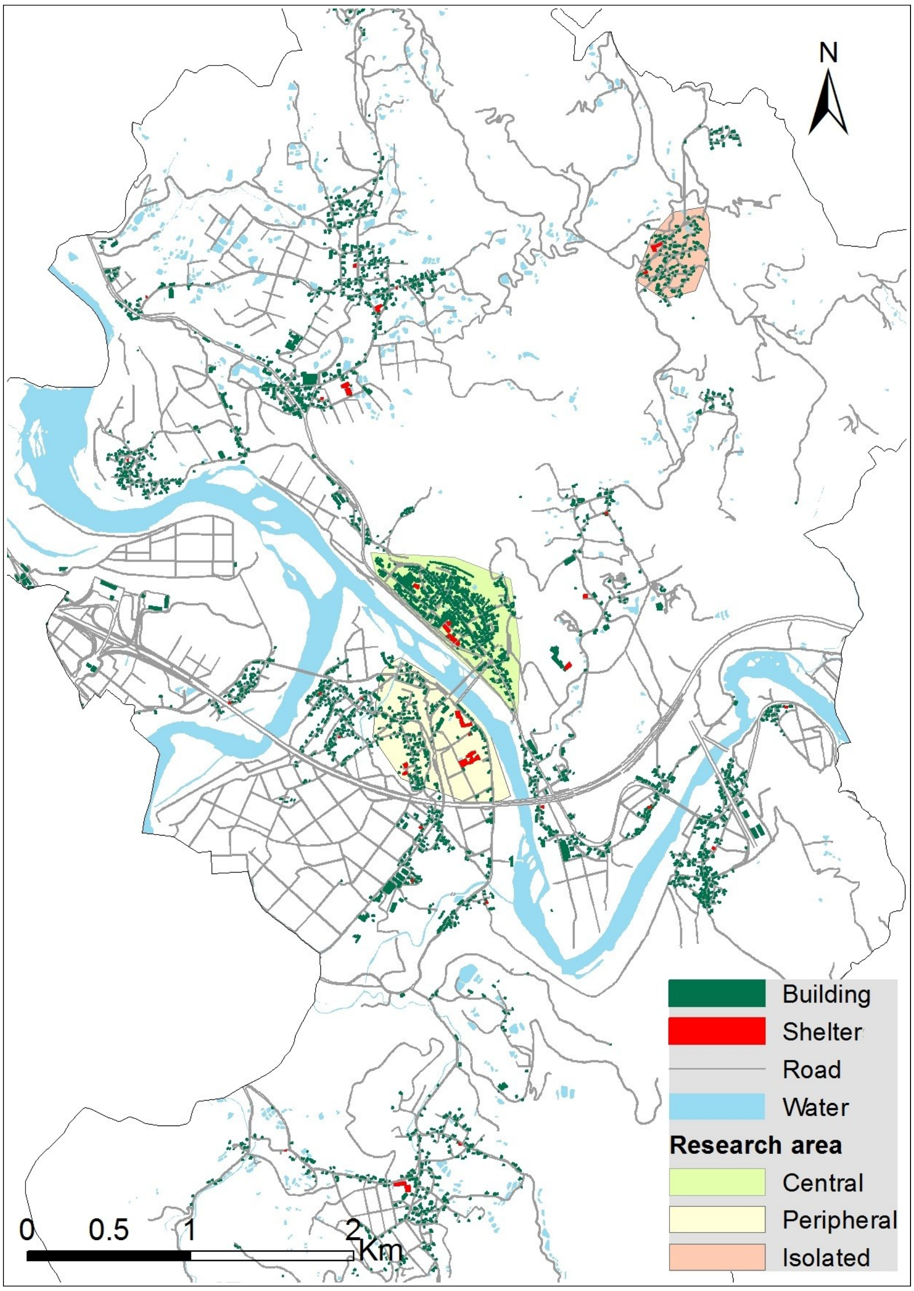


Figure 2-1: The three research areas within Kawaguchi town.

2.3 Investigating the residents' behaviour

Interview structure. Collecting information using survey is a common practice in investigating the behaviour of people. In most cases such as in Kimura et al. (1999 and 2001) a questionnaire is submitted to a selected number of people in a specific area through post and answers are submitted directly back to the senders. Although this method is easy to plan, it collects only generic answers without knowing any further information about the respondent background and behaviour. For this reason, a different survey technique was used in this study, using door-to-door interviews with the questionnaire. The fieldwork composed by face to face interview and questionnaires collected more detailed information about the behaviour of the households and local communities. Deeper discussion revealed to be more efficient in data collecting and information sharing despite the low response rate. In this study, the household was considered as unit of reference for the interviews. This study concentrates on the first 4 weeks after the earthquake, especially focusing on the first few days. As the town was completely isolated for a time span from 3 to 5 days, collecting information of these moments is considered a priority to understand the community organisation, behaviour during the recovery process and preparation.

Fieldworks produced 50 complete interviews: 21 in the central area, 16 in the peripheral area and 13 in the isolated area. Additional 8 complete interviews are retrieved outside from the three research areas to validate the representation of the three areas chosen. Moreover, the respondents often shared information concerning their neighbourhood and other households. Due to the high quality of information shared during the survey, each household can be considered as representative of the neighbourhood in which it is located, which gave a wider overview over the community behaviour in Kawaguchi.

The steps of the interview process were as follows. The questions were divided as geographical location of the house, details about the daily life activities before the earthquake within the household and with the community members, community activities and the participation of the respondents, preparation and awareness before the earthquake, reason of the behaviour after the earthquake. At the end of the interview a short questionnaire was distributed to collect quantitative information such as damage received, behaviour during the evacuation, support given or received. As the house location was recorded for each respondent, a geographical location of the questionnaire respondents' answer was possible. Figure 2-2 represents the distribution of the respondent within Kawaguchi town. Using the information collected through the interviews and questionnaires, the three study areas were compared. The main focus was given on structural damage caused by the earthquake, the community support and the communication during the recovery process as important aspects in vulnerability reduction and risk analysis (Kimura et al., 1999 and 2007). Understanding the regional differences in community organisation and behaviour inside the town is the first step to improve the awareness and preparation in earthquake safety.

Vulnerability in Kawaguchi. Vulnerability is a very broad fast evolving research field with different trends and strategies offering tools and methods for resource management (Bankoff et al., 2004; Pelling, 2003; Fussel and Klein, 2006; Cutter, 2003). To summarize the processes by which vulnerability was generated in Kawaguchi, the main headers of the Pressure And Release (PAR) model are used: root causes, dynamic pressures and unsafe conditions. Root causes are defined by economic, demographic and political factors; dynamic pressures are the processes that made the root causes generating unsafe conditions both temporally and spatially. The social production of vulnerability is an important step in evaluating the disaster risk. The risk of disaster is a “compound function of the natural hazard and the number of people, characterised by their varying degrees of vulnerability to that specific hazard, who occupy the space and time of exposure during the hazard event" (Wisner et al., 2004). Therefore, the PAR is defined as a combination of two opposing forces: the processing creating the vulnerability, and the natural event. The model can be represented by the following pseudo-equation:

$$R = H \times V$$

These variables correspond to the effective risk (R) on one side of the pseudo-equation and the relation between the hazard (H) and the vulnerability (V). In this study, the data collected from surveys and literature reviews are used to define these three variables and developing a PAR model that summarize the different aspects of the earthquake and vulnerability in order to define the risk level produced by the seismic event. The PAR model is then used to better understand the causes behind the behaviour after the Chuetsu Earthquake.

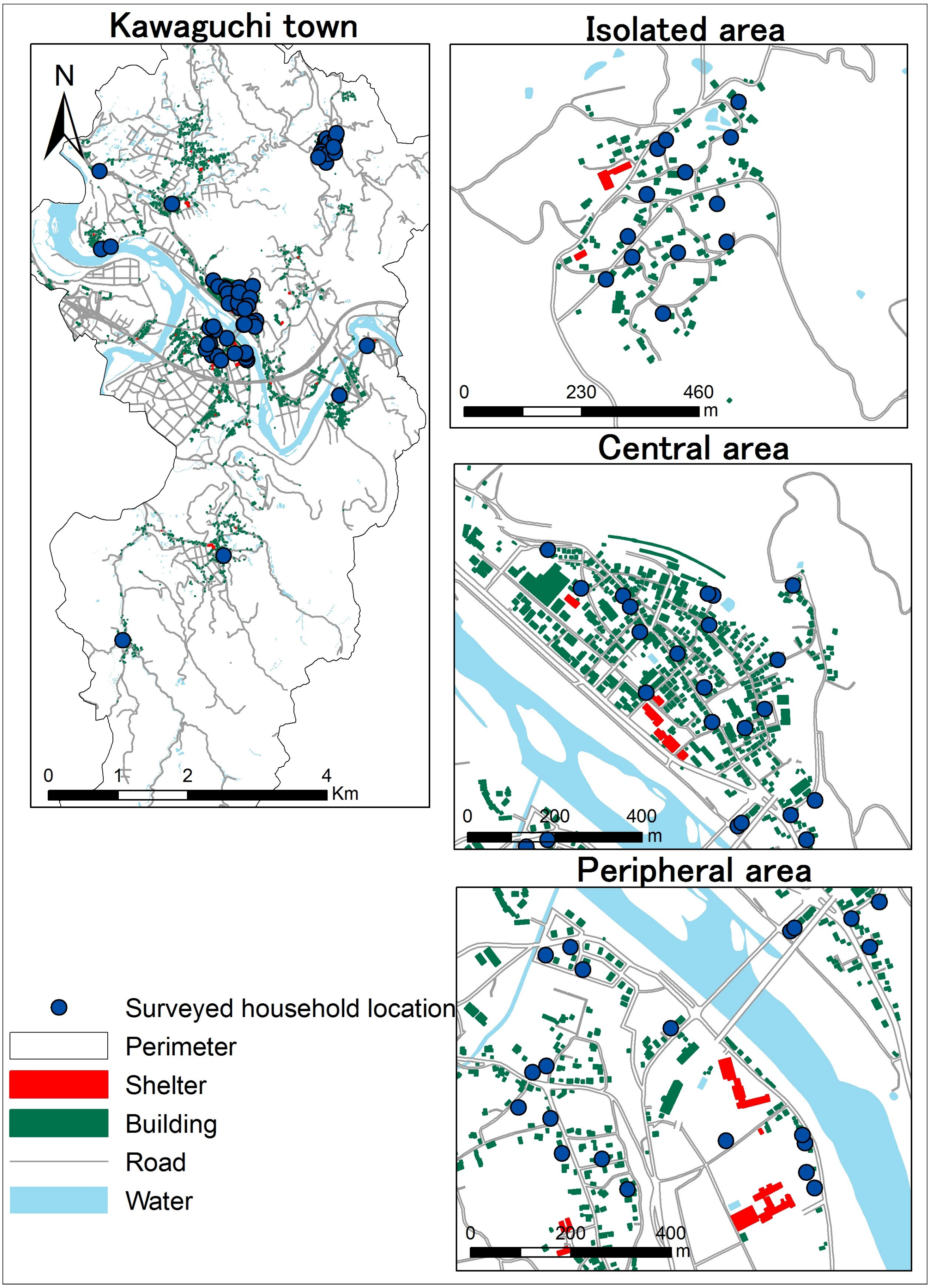


Figure 2-2: Respondents distribution in Kawaguchi town.

Data source: fieldwork 2008-2010

2.4 Time geography applications

The time geography is used in this study to temporally track the movement of residents in Kawguchi town after the Chuetsu Earthquake. This information is added to the qualitative data collected through surveys to better understand the differences in behaviour in the three research areas. Commercial GIS mainly focus on static spatial feature representation based on cartographic approach (Peuquet, 2002). The actual GIS development still lacks of proper tools to represent time as an internal dimension and lack in ST paths representation. An example of the application with ArcGIS is given by Yu (2004). In this study, an open- source GIS software called UDig is chosen. The open source nature of UDig allowed developing several plug-ins to be used in specific field of analysis such as JGrass – Hydrological Modelling (Hydrological and geomorphological analysis), DEWS – Distant Early Warning System for Tsunamis, Eurobios – Route Planning and Logistics, Arbonaut – Forest Management Applications and DIVA GIS – International Potato Centre (CIP). In this research, the STC analyst plug-in, currently in development at the University of Twente, International Institute for Geo-Information Science and Earth Observation (ITC) is used. The collaboration with ITC members allowed using the plug-in to spatially represent the time and the ST paths in a GIS software environment.

Three components are required to represent a spatio-temporal point feature of the coordinates "x, y" and the time "t". Following this concept, in order to represent a spatio-temporal line feature sequesce of triplets "x, y, t" are required ({<x0, y0, t0>, <x1, y1, t1>, ... , <xn, yn, tn>}, where t0< t1<...< tn) (Yu, 2004). Therefore additional data is collected during the surveys. Each respondent was asked to trace their movements after the first seismic event on a map. The result is a collection of point data summarizing the movement of each respondent for the first 30 days of the recovery process. Once the data was collected, the digitalisation process started, creating a database to contain the time referred point data. After the creation of the database, the data was uploaded inside UDig and the STC could start to process the information. The results issued from the process can be visualised through the 3D STC visualisation plug-in in UDig. As Andrienko et al. (2003) suggested, the geovisualisation is used in this study to better understand the raw data collected during the survey and characterizes the properties of the temporal paths.

Spatio-temporal relationships are used to evaluate the relationships among the residents' spatio-temporal paths as proposed in Figure 2-3. The movement from point A to point B represent a ST path. Each ST path is the visual representation of an object trajectory in both space and time as illustrated in Figure 2-3a. The object position in relation to space and time is represented by the dotted lines. This function allows tracing a resident's movement in both time and space. Usually, the ST path is used to visualise the movement of a person over time, hence in cases in which the possible movement location reachable from a person is to be highlighted, the space time prism is used (Figure 2-3b). When the three-dimensional representation of the space time prism is projected onto a two-dimensional space, a specific area called the potential path area is created. In this case study, the potential path area represents the possible accessible location on foot after the seismic event.

Considering the spatio-temporal relationships among the various human reaction recorded during the evacuation and recovery process, different interactions can be recorded (Figure 2-3c,d,e,f). Figure 2-3c shows the interaction between two subjects A and B in a specific location (L) for a determined amount of time T_1 until T_2. For the time span (T_1,T_2) the two ST paths are overlapping in the same location. This occurrence is defined as the co-location in space and time. In cases an asynchronous physical presence in a location (L) occurs the two subjects A and B would be represented in L but in a different time span, leading to co-location in space (Figure 2-3d). Therefore, a situation in which different locations are occupied in the same time period by the two subjects A and B will suggest the occurrence of time co-location (Figure 2-3e). In this situation, although the lack of physical contact in the same location is observed, the communication between subjects through telephone or visual contact is still possible. The Figure 2-3f represents the case in which both co-location in space and time are not occurring showing lack of interaction between the ST paths. Interactions between the subjects produce a different type of relationship between their respective ST paths (Yu, 2004). Therefore, these interaction types are used in this study to explore the spatio-temporal relationships of human activities and interactions. Starting from the 3D visualisation of the temporal behaviour in each research area is possible to observe the ST paths and their interaction among lifelines, defining a certain spatio-temporal relationship. Each lifeline according to the movements done during the time studied will experience situation of bundle with other lifelines, determining situation of co-location in time or in space or both, whereas in case no bundle will appear also no co-location will be observed. These relationships can be constant in time showing a similar SP path pattern or variate including different type of spatio-temporal relationships throughout time. Understand how residents behaved through the time and how they grouped and worked together is essential to understand the regional differences in behaviour in the town.

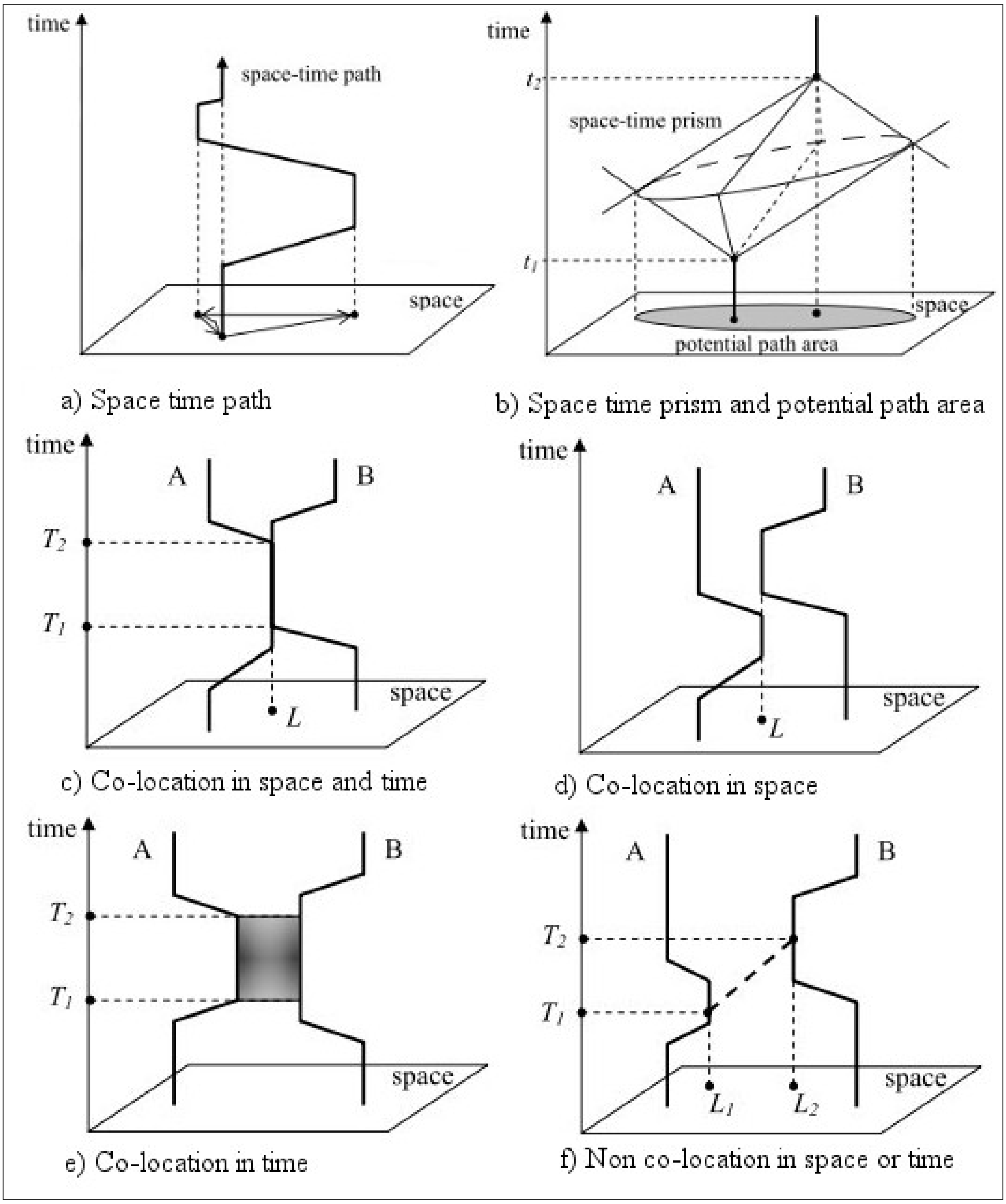


Figure 2-3: Spatio-temporal relationships.

Data source: Yu, 2004

Chapter Three

Exploring Kawaguchi town Recovery Process

3.1 Characteristics of the research areas

The following information derives from surveys done in Kawaguchi town, provides the main characteristics and differences of the central, peripheral and isolated areas. (For further information about the questionnaire answer data see Appendix IV).

The central area. Composed by 6 communities with a total of 432 households, is the core of the town. The inhabitants are mainly working in the local area. Public transportation such as trains and buses are available only in this research area all main shops, restaurants and governmental buildings are located here. The dense urban tissue and the employment characteristics of the residents are considered as the main factors explaining the loose relationships between the neighbourhood and community members. Moreover, the characteristics of the residents' employment are also relevant to the reduced amount of food provision in the area. Landslides occurred after the first seismic event isolated the central area. However, as most of the people were in this area, it was relatively easier to re-establish the communication ways in the bottom of the valley. Hence, the city centre was the first area reached by rescuers after the earthquake. Despite the high number of households, the local communities did not prepare any preventive emergency evacuation plan, or a prefixed shelter assignation. In the central area large families counting up to eight family members are observed. This event can be explained because two or three generations are living in the same house (Figure 3-2b). Furthermore, the average age (Figures 3-1 and 3-2a) is lower in the central area compared with the others, explaining the trend of younger generations migrating to the more populated areas. The sex balance in all areas is shown in Figure 3-2c.

The peripheral area. Smaller in size, it comprises of 80 households and two communities. Despite being less than 1km away from the central area, agricultural activities are becoming progressively predominant. The urban tissue is more dispersed leaving more free space between households. These factors deeply influence the residents' life style, the communication between neighbourhood and community members. A stronger bond connecting the residents is observed during the surveys. Hence, the physical space occurring between households favours the neighbourhood community and favours less of the whole community. The only bridge connecting the peripheral area to the central zone was damaged during the earthquake, increasing the isolation time to over 3 days. As observed in the central area in Figure 3-2b, a similar family member structure is recorded. In fact, despite the different structure and organisation at community and neighbourhood levels, the area is relatively close to the city centre but is located on the other side of the river. Considering the age (Figure 3-2a), differences from the central area can be observed. Most of the interviewed residents had an age of over 45 years at the time of the earthquake. Most of the respondents are engaged in agricultural activities whereas the new generation are often migrating to bigger urban centre for office work employment.

The isolated area. The area consists of a single community of 52 households located on the hills, 8km north-east from the city centre. The main working activity recorded is the field cultivation of rice and vegetables. No public transportation is available in this area and also the local school is unused as no children populate the area. However, the local school is often used for local events and as a shelter in case of natural disasters or emergency. The relatively low number of community members and the agricultural working activity positively influence the relationships between members. The average age issued from the interview is 64 years old. Figures 3-1 and 3-2a confirm this trend, showing the age proportionally increasing with more distance from the city centre. Following the same path, the household number considerably reduces (Figure 3-2b). Additional attributes of the three research areas are proposed in Table 3-1. Because of the distance from the central area and the damage received during the earthquake, this community experienced the longest isolation period (5 days). The position of the hamlet on the side of the hill induced a large number of landslides explaining the longer isolation time requiring further effort by the rescuers to re-establish the main commuting road.

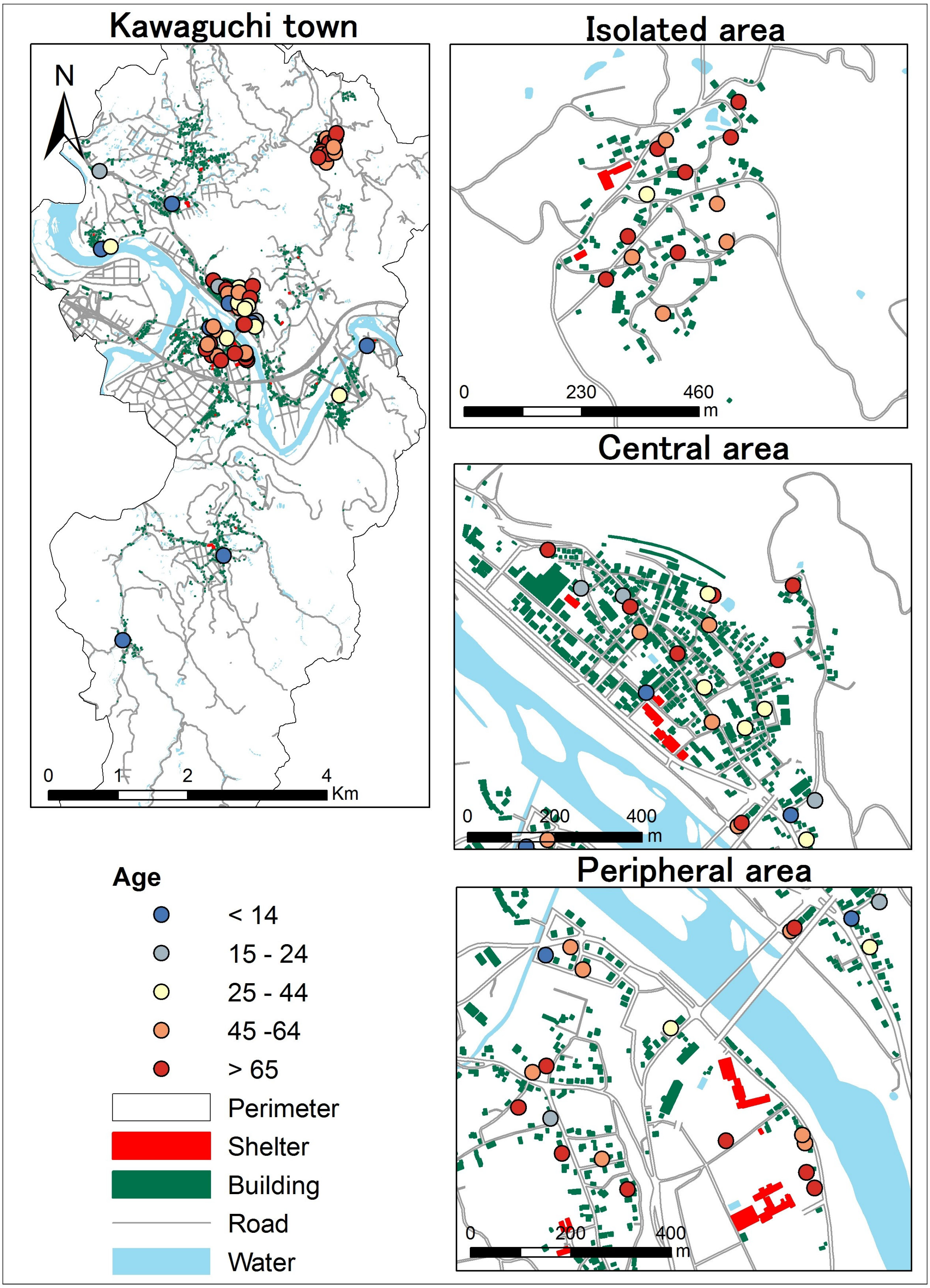
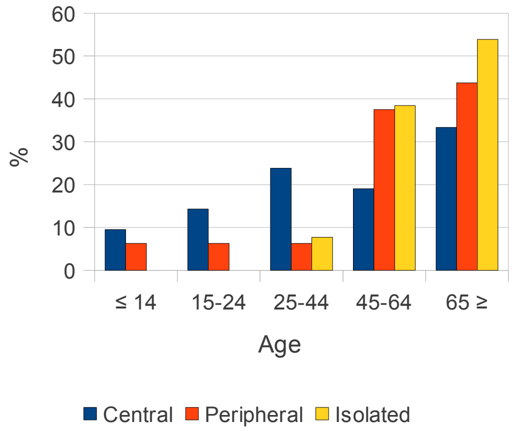


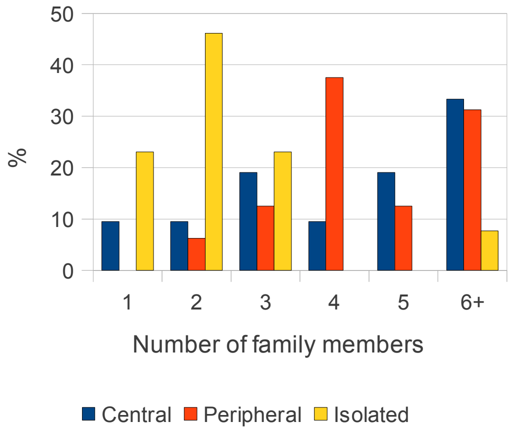
Figure 3-1: Respondents' age distribution.

Data source: fieldwork 2008-2010

a) Proportion of residents by age



b) Proportion of residents by family size



c) Gender ratio

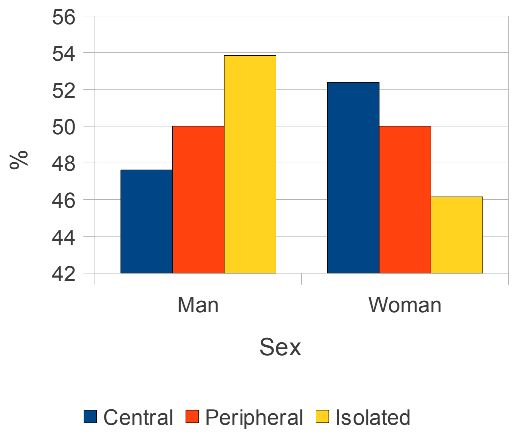


Figure 3-2: Respondents' characteristics.

Data source: fieldwork 2008-2010

Table 3-1: Relevant attributes in the three research areas.

	Central	Peripheral	Isolated
Number of residents	1403	322	138
Number of household	432	80	52
Average of residents each house	3.2	4	2.6
Number of residents engaged in farming	134	173	116
Number of household engaged in farming	29	39	35
Number of communities	6	2	1
Age average	45	57	64
Number of annual activities	8	3	6
Time isolated (number of days)	3	3	5
Distance from the city centre (in Km)	0 – 0.5	1 – 2	8 – 8.5

Data source: Population census, 2000; Agricultural census, 2000; Kawaguchi town local governmental office, 2000

Note: The table shows the main differences in attributes characterizing the three research areas

3.2 Damage received and evacuation methods

Damage received. The 2004 Chuetsu Earthquake produced strong ground motions eventually resulting in considerable damages to the town buildings (Appendix V). Figure 3-3 show the house damage distribution recorded during the survey. After the arrival of the rescuers in Kawaguchi, an exhaustive control of the property's safety and security was performed within the first 15 days after the seismic event. A damage scale was used by the rescuers to indicate the severity of the damage, starting from level 1 (no damage) to level 6 (completely destroyed). In most cases, houses with a damage level defined as "half destroyed" or more were defined as dangerous, requiring major reconstruction before residents can move in.

The respondents reported the severity of the earthquake damage, classifying the central area as the highest damage. 42% of the respondents had their own house completely destroyed and 27% had half destroyed after the first shock. The compact urban structure with nucleated housing had a negative impact during the earthquake. In fact, the houses first damaged also affected the surrounding buildings. Buildings with earthquake resistance reported minor damages, with exception of the gym of one of the schools collapsed during the recovery process. However, earthquake resistant buildings were mainly public buildings and in most cases, private housings were built before 1989 with a wooden framework.

Despite the proximity to the city centre, minor damage to households was recorded by the local governmental office in the peripheral area. Figure 3-3 confirms this situation, showing a lower number of completely destroyed houses and the predominance of minor damaged houses. The reduced damage explains why during the fieldwork in the peripheral study area, the houses were mainly reinforced and refurbished, while in the central area, most of the households were completely rebuild. According to the respondents, the peripheral area located on the southern part of the town and the larger space occurring between houses contributed to attenuate the damage. The reduced damage also positively influenced the recovery process allowing a faster rehabilitation and reconstruction after the earthquake.

The isolated area presents similar damage distribution to the central area. 24% of the respondents reported completely destroyed housing, with 38% reporting big damage and 24% half destroyed. The old building construction contributed to amplify the damage. In addition, road deterioration and landslides were reported all around the hills where the isolated area is located. Despite the larger damage, refurbishment and consolidation of the houses were also considered in this area rather than complete reconstruction. This choice is due to the residents preferring to refurbish rather than completely re-build from scratch.

Evacuation methods. According to the local government of Kawaguchi town, no preparation in disaster management reduction and evacuation procedures were performed before the 2004 earthquake. When the natural disaster occurred, panic was observed over the whole town. In the central area, fear and panic of the residents can be seen from the histogram (Figure 3-4b) as 52% of the respondents did not move, passively waiting for the end of the earthquake. Only 28% tried to reach a safe spot inside the building where they were situated during the seismic event as shown in Figure 3-4a. After the shock, the evacuation pattern was heterogeneous. However, the dense urban tissue, combined with the lack of pre-organisation induced members from different communities to be mixed together and group in the few open spots available in the zone such as parking areas and temple courtyards. Due to the large damage received and the fear of profiteering, more than 60% of the interviewees preferred their own cars as provisional shelter for the first days of the recovery process (Figure 3-5). This allowed to overlook over their houses and to start the organisation of groups inside the community. Another factor explaining the difficulties in organising the community in the first moment is represented by the lack of knowledge of the town shelters (Figure 3-6). Therefore, residents generally moved to the closest shelter or shelters closest to the local governmental building. Although a portion of the population started to move to the official pre-fixed shelters, the local government confirmed the total absence of household sheltering.

Similar evacuation patterns to the central area were also observed in the peripheral area. However, 43% of the respondents stayed inside the buildings, trying to reach a safe spot and only 38% did not move because they were scared or blocked in during the earthquake (Figure 3-4a). Also, the reason of the first reactions proposed in Figure 3-4b highlights the residents' self-awareness with over 30% recorded. Protection of their own family inside the house is generally observed over the thematic area. The lower density of housing provoked a scattered evacuation pattern of the residents, contrary to the compact evacuation observed in the central area. The car is also the preferred provisional shelter for the first night with 88% recorded, showing once again the attachment of respondents to their own house and the fear for crime (Figure 3-5). After the first shock, a poorly organised evacuation is observed. The peripheral area contains two schools used as shelters in case of emergency. Despite the large space available in the shelters, most residents preferred to stay close to their own household and spend the first moments of the rehabilitation process divided in small groups.

The isolated areas show a different evacuation pattern compared to the other research areas. Similarities appear in the first reactions as seen in Figure 3-4a. Despite the similarities in the first reaction, a different trend occurs in the reason of the behaviour of residents (Figure 3-4b), resulting to be uniquely different afterwards. In fact, after the first earthquake, residents moved directly to the local shelter (a closed school) which was considered as a secure location (Figure 3-5). This location was maintained as a reference point during the whole recovery process to the mutual efforts done by community members in organising their own reconstruction of the hamlet and the restoration of daily activities.

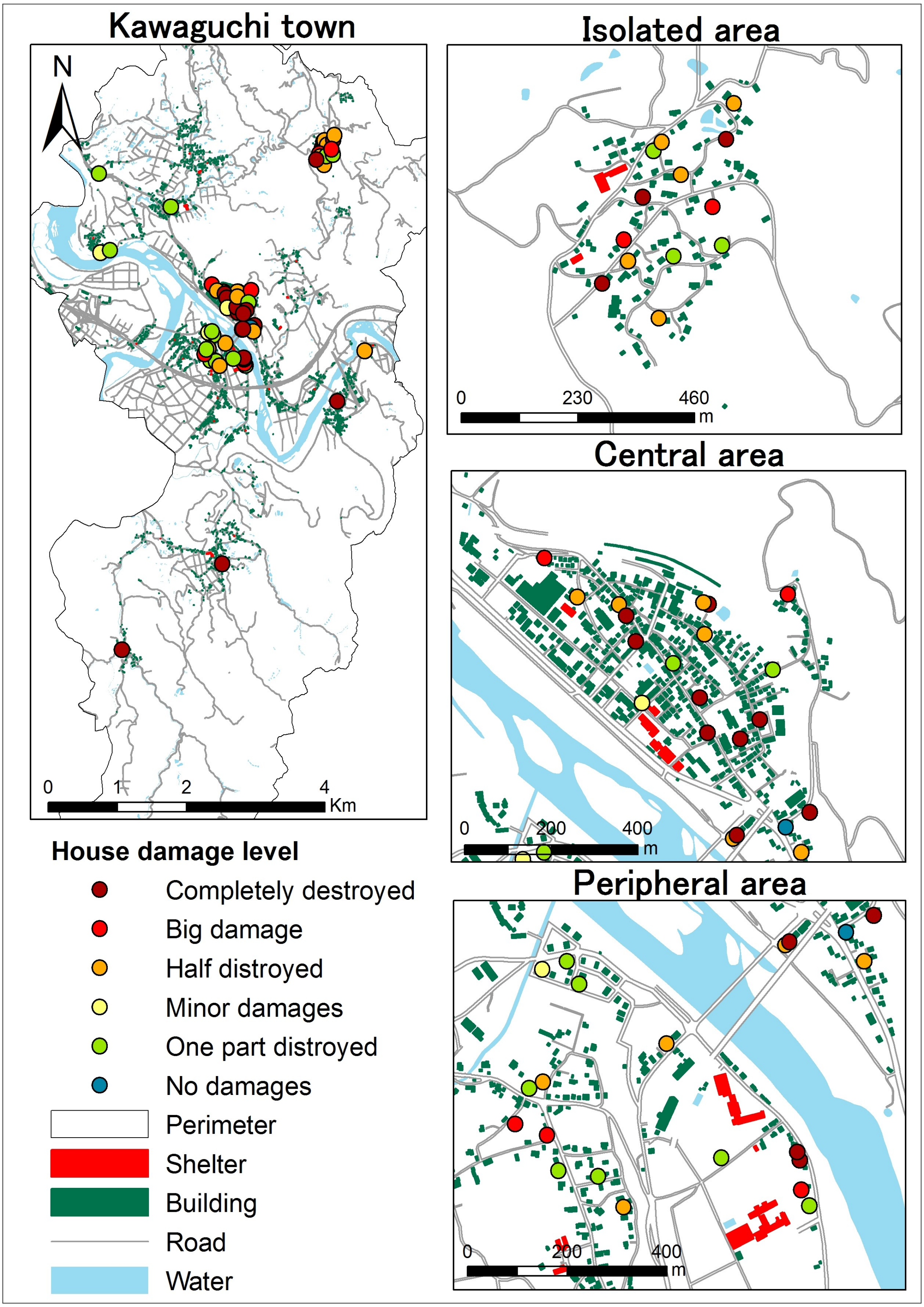
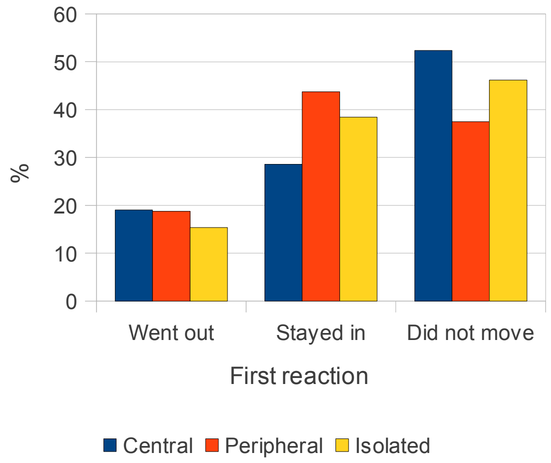


Figure 3-3: Distribution of house damages in Kawaguchi town.

Data source: fieldwork 2008-2010

a) Proportion of residents by type of reaction



b) Reason explaining the reaction

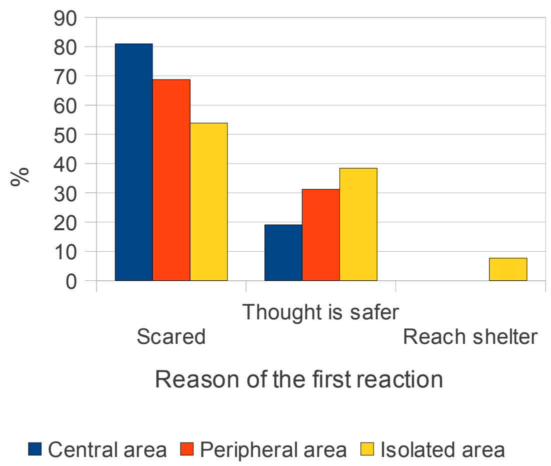


Figure 3-4: Respondents' reactions to the earthquake.

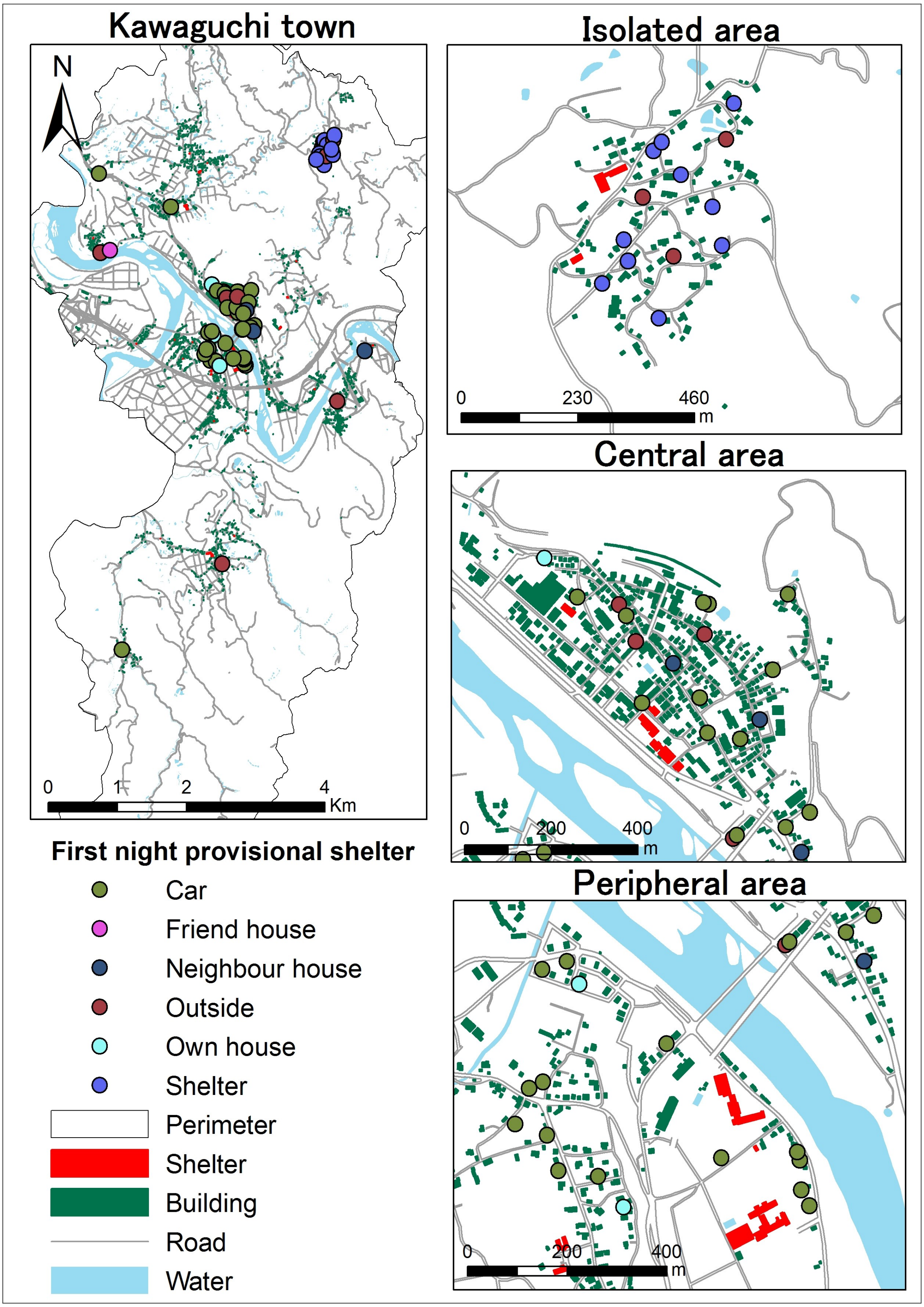


Figure 3-5: First night provisional shelter.

Data source: fieldwork 2008-2010

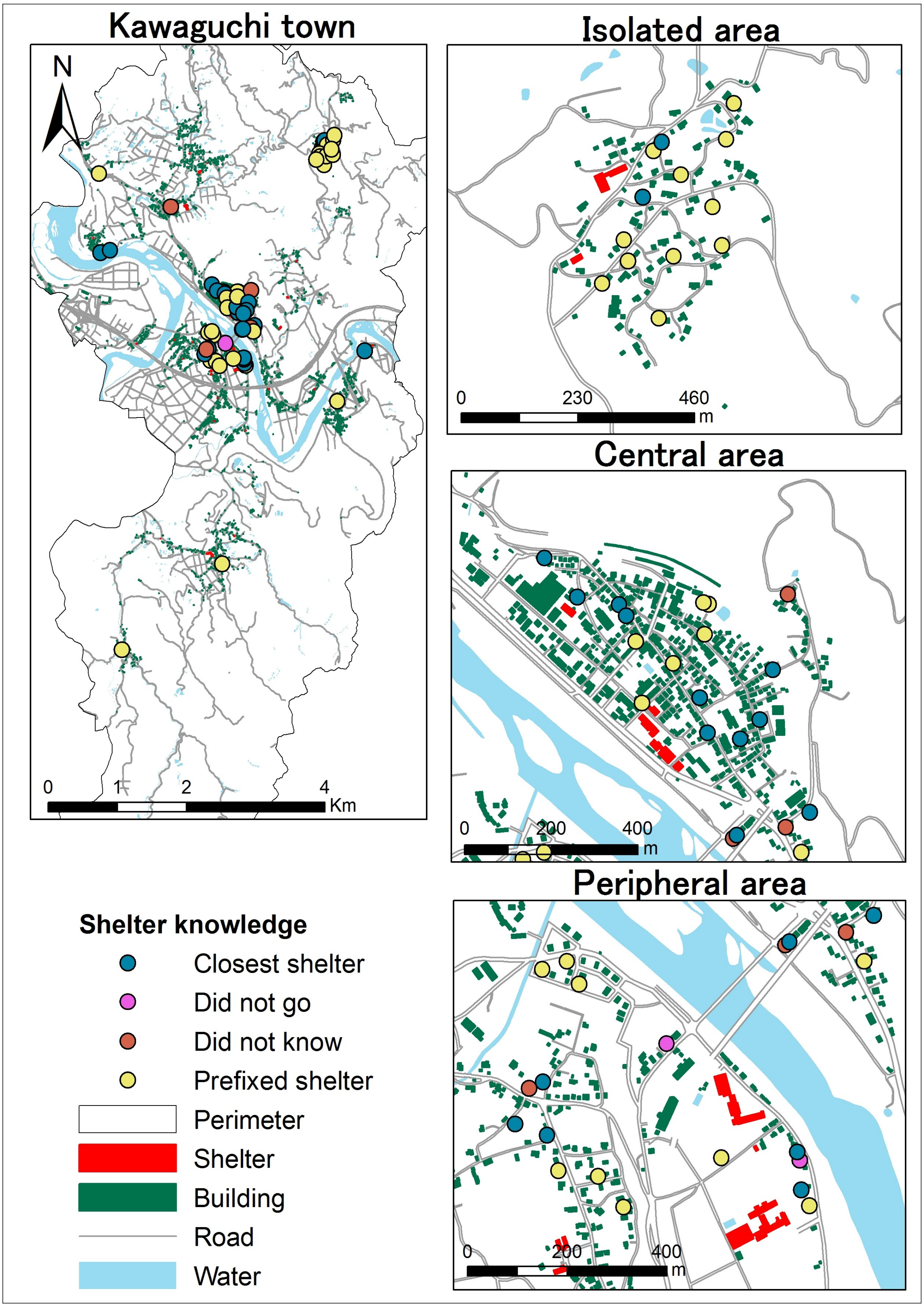


Figure 3-6: Respondents' knowledge about sheltering.

Data source: fieldwork 2008-2010

3.3 Support during the recovery process

The community has an important role in minimising the vulnerability of a natural disaster such as an earthquake. However, the lack in preventive organisation within community members can considerably reduce the efficiency of the community support. In Kawaguchi town, different types of behaviour are observed according to the area considered. In the central area, despite the larger number of inhabitants, the recovery process was more family focused, at least during the first period of the recovery process. The peripheral area instead considered the collaboration among neighbourhood members as important with those physical closer to each other gave their support during the whole recovery process. The isolated area adopted a centralised community based support system for all members. The social structure and geographical location are considered as a complementary reasons explaining the differences as previously mentioned.

Figure 3-7 shows the importance of giving support during the recovery process. In the central area, 68% actively gave their support during the recovery process. The high percentage highlights the presence of a bond among the residents, providing support to each other when needed. However, only 32% admitted to concretely know how to give proper support (Figure 3-8). The lack of preparation in the case of emergency appears as the main issue during the recovery process. Considering the sources of support and the time isolated, the interviewees judged their own family and the community as important rather than support from the rescuers (Figure 3-9). The first days were in fact the one most needing external support to find survivors. For this reason, residents started to search for survivors although lacking in external support in the areas during the first isolation period. Moreover, the local government support was considered essential in the sheltering and tent camp organisation process. With the arrival of rescuers, organisation was provided allowing the reconstruction and consolidation of damaged structures and roads. Figure 3-10 proposes a thematic map of the location of residents needing support to evacuate and during needing support during the recovery process. Concerning the central area, young children and particularly the elderly are recognised as those requiring further assistance.

In the peripheral area, despite the lack of connection with the central area, households succeeded grouping in small units. With the connection of the local government interrupted, the residents did not benefit from the local government support in the first few days. However, a better collaboration appears between households with resource sharing and mutual support. The agricultural activity predominant in the area positively influenced the food sharing among community members. Although most of the residents were organized in groups, the choice of local sheltering was also considered in case of highly damaged building or elderly needing assistance. A similar situation with the central area is recorded, concerning the relatively high percentage of respondents giving support. In this case, the positive auto-evaluation increased from 32% in the central area to 42% in the peripheral area, showing an improvement in self-consciousness and preparation in case of emergency. Similarities with the central area also appear when considering the importance of the support received from family members, neighbourhood and community (Figure 3-9). Considering the residents needing support, the general trend shows an increment of the elderly and invalid or very old people moving from the city centre to the fringe areas. The abandonment of the rural area is the first reason explaining the results from the interview.

A different approach can be identified in the isolated area. Despite the lack of emergency planning, preparation was conceived and household members succeeded in a rapid organisation making one group extensively sharing resource, independent from the local government. Furthermore, the reconstruction of local buildings and the only commuting road was provided by the local residents, allowing an easier accessibility when the rescuers were able to reach the area. Figures 3-7 and 3-8 confirm the trend of cooperation between members s previously highlighted, a better ability to adapt and to give support during the recovery process. Because of the higher average age of the hamlet, parts of the population required additional assistance, especially during the evacuation process. Being isolated and without possibility to access the local governmental office, the community members supported those needing assistance. By using only one shelter as the core of the recovery process, an easier organisation and control was performed to overcome the lack of external support.

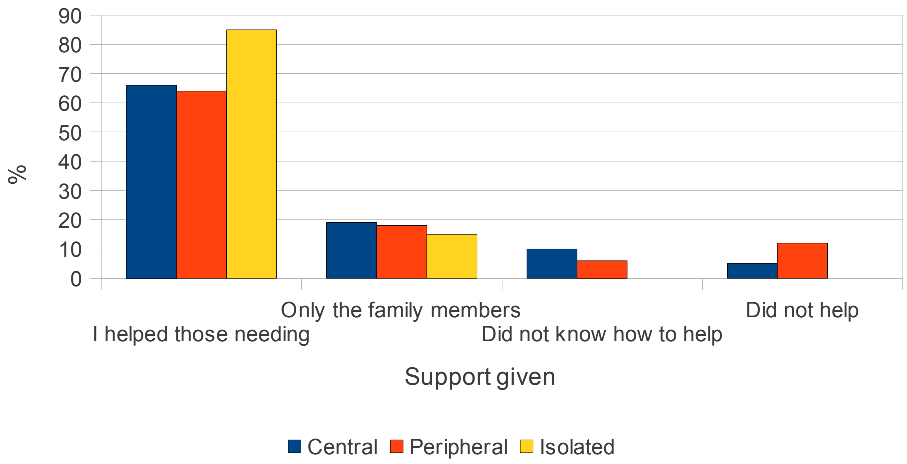


Figure 3-7: Support given during the recovery process.

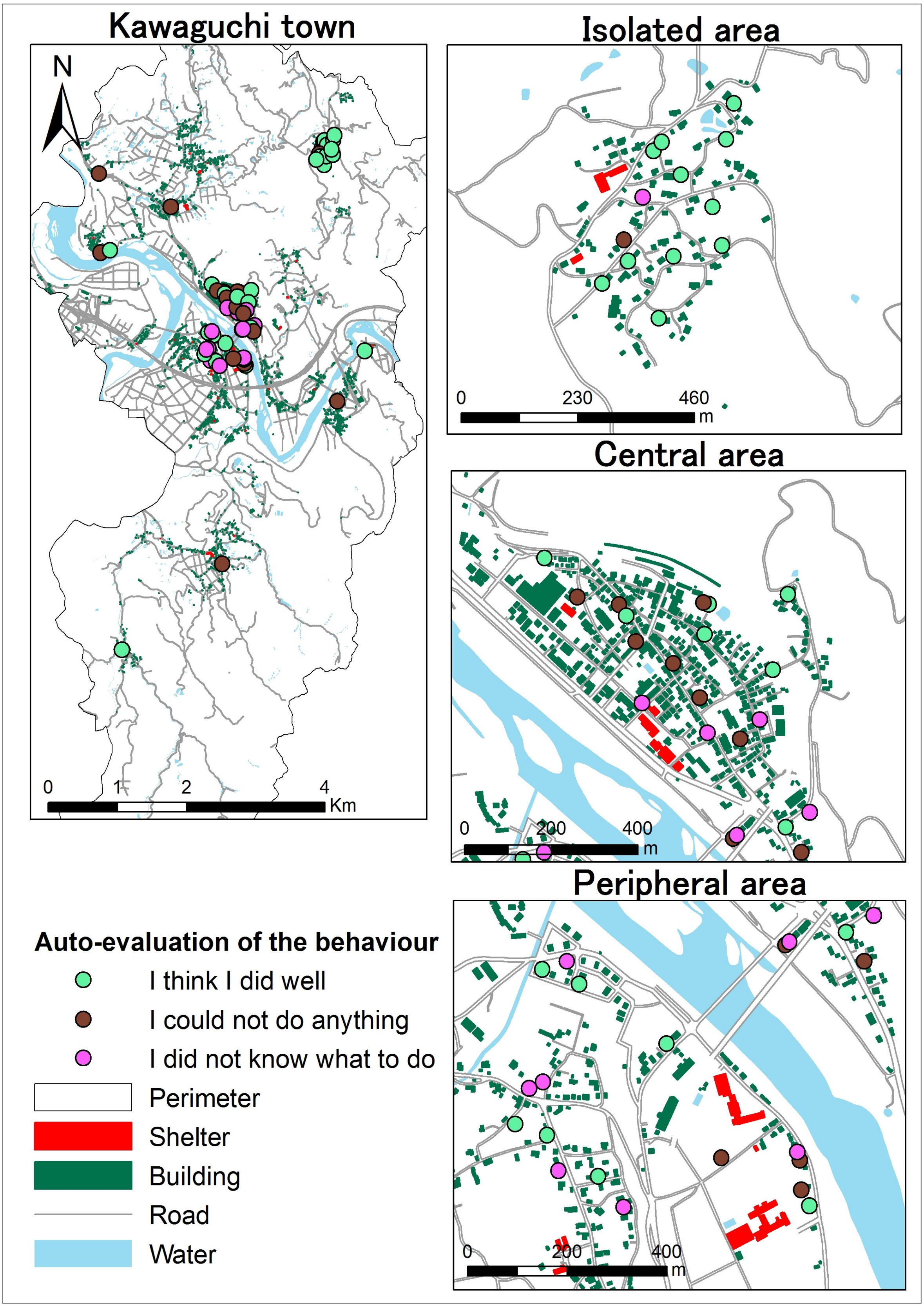


Figure 3-8: Respondents' auto-evaluation of the behaviour.

Data source: fieldwork 2008-2010

Figure 3-9: Importance of support during the recovery process.

Note: One cube represents two respondents choosing the category as relevant in providing support during the recovery process

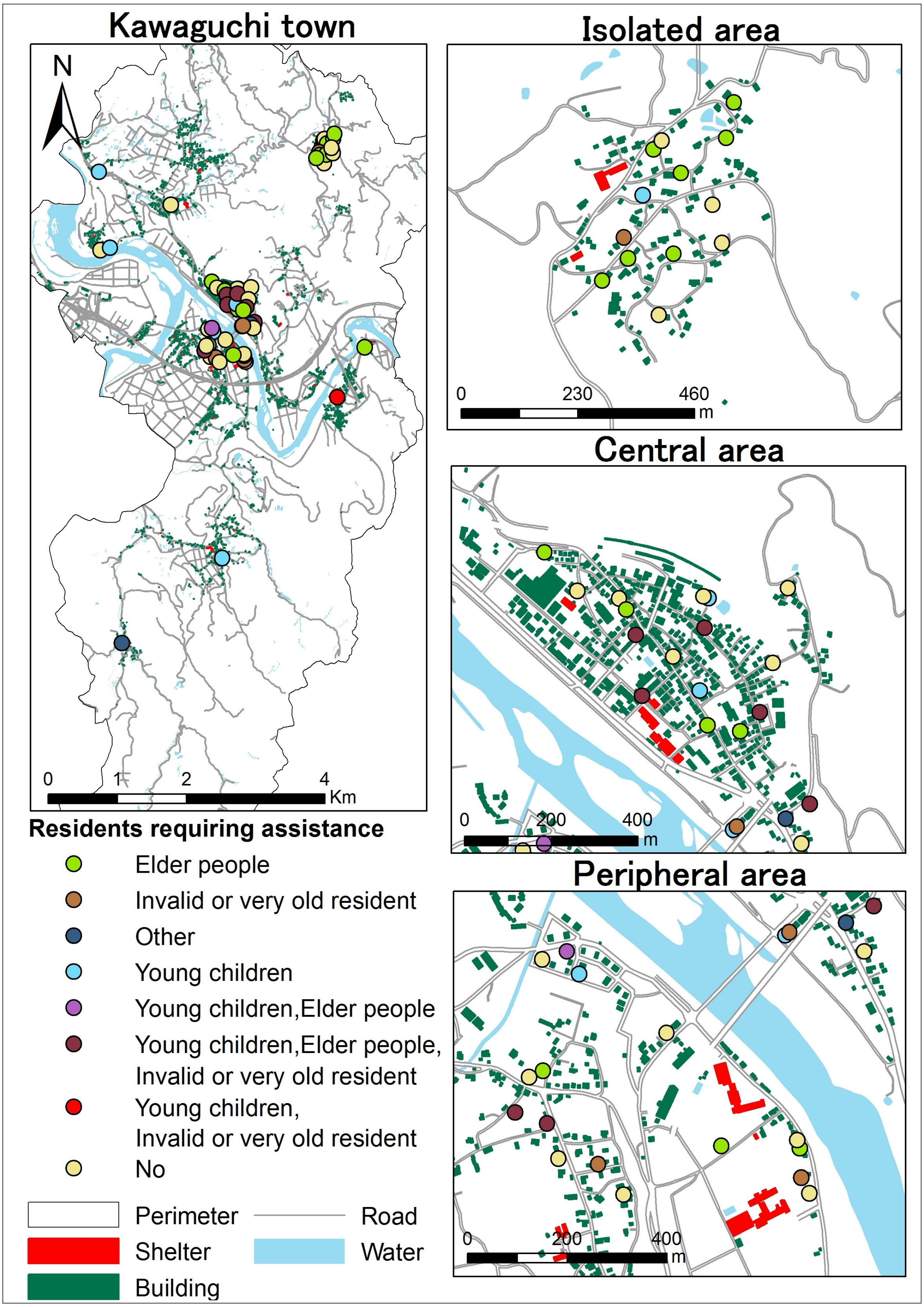


Figure 3-10: Respondents requiring assistance.

Data source: fieldwork 2008-2010

3.4 Communication methods

Lack in communication planning had a strong impact in the rehabilitation process. At family level, the lack of an emergency communication plan caused difficulties in contacting the other members. At community level, did not allow to announce information about the rehabilitation procedures. Most of the respondents considered their own house as the meeting point to regroup the family members. However, no effective inter-familiar evacuation plan was conceived in case of emergency. This episode is a side effect that had occurred since the local government did not provide sufficient awareness and knowledge in disaster mitigation at family level. A different type of communication appears according to the geographical location. A family oriented communication immediately after the earthquake is observed in the central area. Also in the peripheral area, a similar communication strategy is observed at least in the first moments. Hence, the isolated area showed a community centric communication with a rapid exchange of information in order to provide immediate support in the hamlet since the first moment.

Figure 3-11 highlights how the different research areas established their first communication with their household, the family members and the neighbourhood. In the central area, the telephone was considered as the main alternative communication way used to contact family members, as telephone lines were also damaged from the earthquake. For this reason, despite their efforts, families were not able to verify the safety of all members immediately after the earthquake had occurred, especially for those being outside of town. The earthquake positively influenced the reunion of family members. In fact as the event took place on the 23rd October, a holiday, most residents were already within the town borders. The family members outside of Kawaguchi at the moment of the seismic event, cases appeared of families being separated for 24hours or more because of the inaccessibility of the commuting roads.

In the peripheral area, the information about the own family members were collected mainly from the own household after the earthquake. Also in this case, the telephone was used but with the same issue of disruption similar to the central area. Despite the lack of communication methods, the smaller community size and the lower urban tissue density positively contributed in creating better interaction among groups within each neighbourhood. 50% of the interviewees received information about the situation of community members, showing a stronger bond compared with the 30% reported in the central area.

In the isolated area, a different communication method is observed. The size of the community allowed an easier sharing of information among residents, although no emergency communication was previewed similar to the other two cases. The members grouped all in one shelter thanks to the efficient sharing of information. Considering Figure 3-11, all the values have increased compared with the other two areas showing better attention and communication not only within the own household and family but also within the members of the community. Despite the successful communication between community members, the hamlet was isolated for the first week and did not establish any communication with the local governmental and the rescue teams who arrived in the central area 3 day afterword.

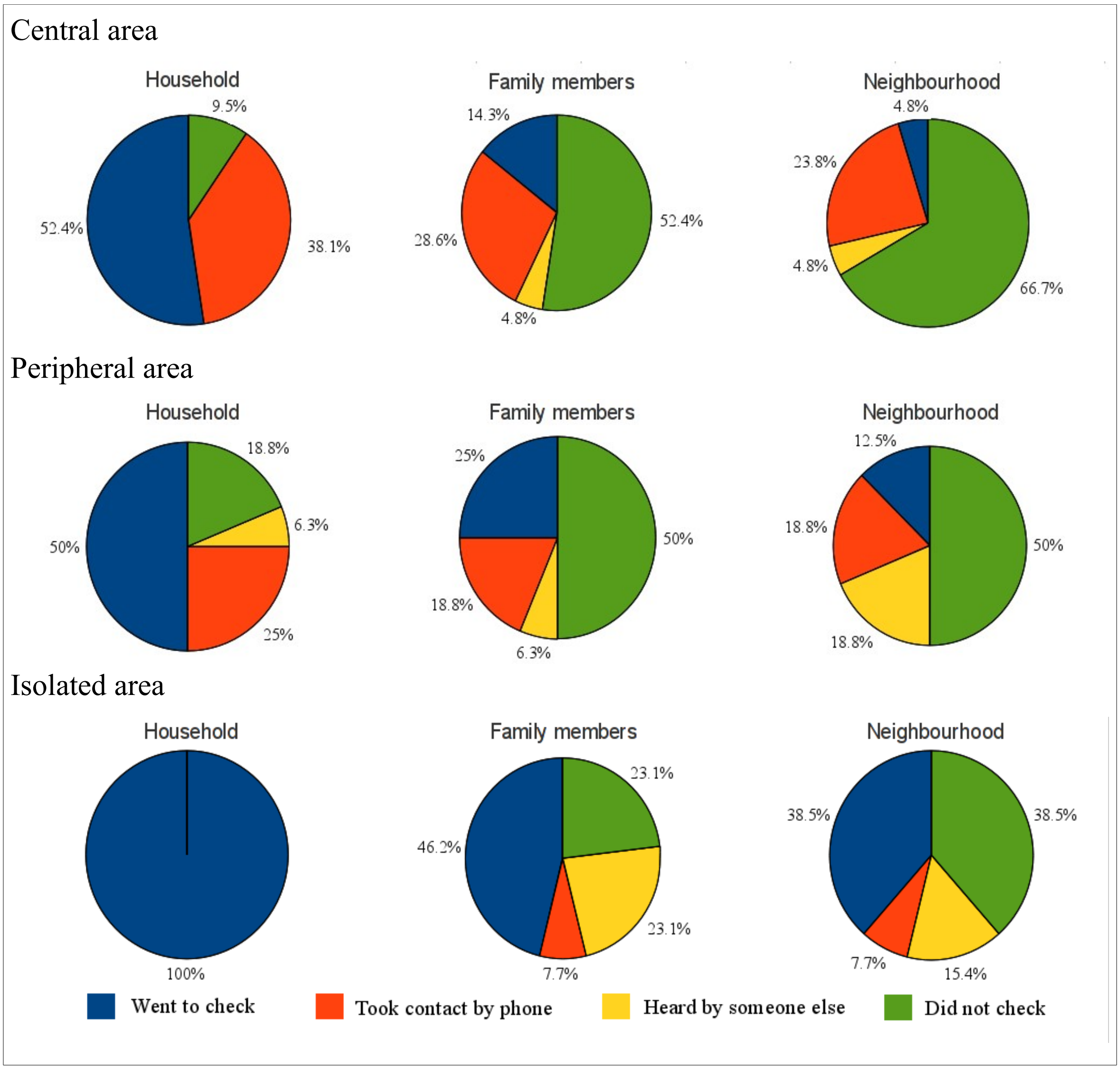


Figure 3-11: Respondents' main communication methods.

Data source: fieldwork 2008-2010

3.5 Factors affecting the behaviour

A diverse behaviour is observed in Kawaguchi town after the Chuetsu Earthquake according to the geographical location. In order to clarify the factors affecting this behaviour, the community daily activities prior 2004 have been investigated. Table 3-2 reports the main community activities done cyclically during the year. These events are part of the socio-cultural tradition of Kawaguchi town, having an impact on the life style of residents. In addition to the official events reported, other minor activities such as monthly communal meetings, group informal meetings and activities are also observed. However, a straight division appears with the community relationships highlighting a strong regional difference between the central, peripheral and isolated areas within Kawaguchi town.

Most of the population in Kawaguchi resides in the central area. Although the community boundaries are official, cases representing lack of collaboration appear in a portion of the population during daily activities and also in the case of emergency. The larger amount of residents negatively influenced the successful organisation inside the community. The main issue is represented by the different ideas of those having their roots in the town with a deep community tradition and the new comers, often younger and living in governmental buildings without any interest in the community life. The type of working activity contributes in weakening the social network between residents, with monthly meetings and scheduled activities as the only occasion of acting as a community. Another factor affecting the behaviour in the central area is the lack of provisions due to the working activity type, explaining the weak collaboration between community members during the post earthquake period.

A different situation appears in the peripheral area. As shown in Table 3-2, the number of official activities is reduced compared with the other two research areas. The main reason resides in the physical location of households, which are dispersed, preventing the residents to have daily contact with each other. However agricultural activity becomes progressively predominant in the area explaining the good connection between residents. Hence, due to the larger space separating each household, stronger bonds appear to be more evident at neighbourhood level rather than at community levels. This daily behaviour is also observed during the rehabilitation process, where residents in the peripheral area preferred to group with their neighbours rather than move to the shelters or have a more community centred organisation.

The isolated area, despite being the community with the highest average age in Kawaguchi, is also the most active. The community activities are not only limited to daily life, local management and events but include extra activities for guest coming from out of town. The calendar is full of community activities all along the year, showing the strong will of the community members to maintain a strong relationship between residents. Agriculture as the main working activity and the higher average age positively contribute in strengthening the social connections within community members. However, the reduced population living in the hamlets provoke difficulties in organisation, especially with long term activities. Due to the strong relationship maintained during the daily life, the bond allowed the community members to give support each other event after a disaster and succeeding in being independent especially during the first week of the recovery process in which the area was completely isolated.

The age and the working activity type are proposed as main factors explaining the difference in behaviour according to the geographical location. Moreover the social bond among residents is directly dependent on the two factor previously mentioned. Table 3-3 is proposed with the aim of better understanding these regional differences. The Table shows the distribution of the numbers of farmers over the Kawaguchi town. The central area in the Kawaguchi section reports the lowest percentages of households working as farmers, with an average of 6.7%. However the number rapidly increases moving towards the peripheral area in the Nishi-Kawaguchi with percentages fluctuating from 24% until 84%. The isolated area represents the community of Kizawa and have a farming household value of 67.3%. Moreover in the three research areas a percentage fluctuating between 25% and 40% is representative of those farmers having more than 65 years old. These statistics allow to understand the impact of the agriculture over the daily life activities.

Another factor affecting the residents' behaviour derives from the residents characteristics. Table 3-4 proposes an example of the typical type of residents living in the three research areas. Two type of residents are observed in Kawaguchi town. The new comers appear mainly in the central area, they are often working outside the town and living in governmental houses. In the other hands, the stable residents represent the majority in the town, however a difference in characteristics is observed according to the research area. In the central area local business is the main type of work, instead the peripheral and isolated areas the farming becomes more prominent as previously highlighted. Despite the same working type the peripheral area uses farming as local business activity, whereas the isolated area has a reduced production often limited to the household itself.

Table 3-2: Community activities in daily life before the 2004 Chuetsu Earthquake.

Area	Period	Activity name	Constraints
Central	January February April June June July August October	God of "Sai" (さいの神) Winter festival (冬まつり) Cooperated joint work(共同作業) Cooperated joint work(共同作業) Ground golf competition (グラウンドゴルフ大会) Kawaai temple festival (川合神社祭礼) The Bon dancing (盆踊り) Cooperated joint work(共同作業)	High population density Issues in active community life between those living in the town from long time and the governmental houses residents and those coming recently.
Peripheral	January August October	God of "Sai" (さいの神) Summer festival (夏まつり) Ground golf competition (グラウンドゴルフ大会)	The community members are spread out over the area. Difficulties in organisation at community level. Groups activities
Isolated	January April June August August September	God of "Sai" (さいの神) Cooperated joint work(共同作業) Field day (運動会) The Bon dancing (盆踊り) Cooperated joint work(共同作業) Yoriaikko(寄り合いっこ)	Before Chuetsu earthquake they had around 60 houses with a very good community connection. The continuous emigration prospect difficulties in organising activities.

Data source: fieldwork 2010

Table 3-3: Residents engaged in farming activities.

Section	Community	Total household number	Household not-farmer	Household farmer	Farmer population	Farmers over 65 years old	% of farmers over 65yo	% of household farmer
Wanadu (和南津)	Hachirouba (八郎場)	14	8	6	23	6	26	43
	Vegahara (上河原)	41	23	18	84	25	30	44
	Nagasaka (長坂)	27	10	17	69	19	28	63
	Shimomura (下村)	31	14	17	83	27	33	55
Nakayama (中山)	Noda (野田)	36	22	14	78	24	31	39
	Nakayama (中山)	54	30	24	108	32	30	44
	Takeda (竹田)	11	4	7	26	9	35	64
	Ushigakubi (牛ヶ首)	9	2	7	26	10	38	78
Kawaguchi (川口)	Kawaguchi 1 (川口1)	50	40	10	42	11	26	20
	Kawaguchi 2 (川口2)	279	271	8	38	9	24	3
	Kawaguchi 3 (川口3)	185	174	11	54	16	30	6
Nishi-Kawaguchi (西川口)	Aikawaguchi (相川口)	29	11	18	77	20	26	62
	Iwadehara (岩出原)	54	31	23	114	33	29	43
	Araya (荒屋)	67	44	23	105	30	29	34
	Nishiki (新敷)	55	42	13	68	14	21	24
	Harashinden (原新田)	47	21	26	113	30	27	55
	Nakashinden (中新田)	39	17	22	106	28	26	56
	Nishikura (西倉)	31	5	26	130	31	24	84
Tamugiyama (田麦山)	Maehara (前原)	47	16	31	136	37	27	66
	Ogata (大形)	55	23	32	160	42	26	58
	Tanaka (田中)	26	5	21	101	26	26	81
	Oyauchi (大谷内)	18	3	15	88	19	22	83
	Odaka (小高)	26	6	20	96	26	27	77
Ushigashima (牛ヶ島)	Ushigashima (牛ヶ島)	114	74	40	195	56	29	35
Budokubo (武道窪)	Budokubo (武道窪)	46	18	28	128	27	21	61
Aikawa (相川)	Aikawa 1 (相川1)	42	15	27	121	38	31	64
	Aikawa 2 (相川2)	35	8	27	120	25	21	77
	Aikawa 3 (相川3)	18	11	7	34	8	24	39
Araya (荒谷)	Araya (荒谷)	21	7	14	70	16	23	67
Kizawa (木沢)	Kizawa (木沢)	58	23	35	116	47	41	60

Data source: Agricultural census (Nogyoshuuraku-caado)

Table 3-4: Example of residents divided by main attributes.

	Central area		Peripheral area	Isolated area
Type of resident	New comer	Stable resident	Stable resident	Stable resident
Nb of family members	3	4	5	2
Age	41	46	53	68
Type of work	Company (Nagaoka city)	Local business	Farmer	Retired (Farmer)
Housing	Governmental building	Own house	Own house	Own house

Data source: fieldwork 2010

Note: The table shows the typical example of attribute difference among residents in Kawaguchi town. The central area results to be the only one having a mixture between stable residents and new comers.

3.6 Causes of the vulnerability generation

In order to better understand the processes by which vulnerability was generated in Kawaguchi, Table 3-5 shows the concept introduced by Wisner et al. (2004) about the PAR model. The purpose is to use the main headers of the PAR model (root causes, dynamic pressures and unsafe conditions) to summarize and understand the reason of the vulnerability that lead to the lack of preparedness and awareness in the study area. The root causes are strictly connected with the lack of economic attention in rural areas, as the main attention generally focuses in areas where the benefit can be maximised. Similar lack of interest can be observed in providing proper maintenance and anti-seismic technology. The housing is often built after the Second World War. Moreover, the strong community bond that was once very strong amongst community members is progressively weakening, showing a less dense social network among residents. The dynamic causes, translating to the unsafe conditions are described in Table 3-5. Japan is considered as a high seismic risk country. However, the importance of preparing and being aware to face an earthquake is often neglected. Consequently, the general lack of awareness from the risk of seismic activity provokes a lack in earthquake resistant building constructions, as earthquakes do not occur frequently, as for instance a seasonal heavy snow in winter period in Niigata Prefecture. Another factor responsible for the advent of unsafe conditions resides in the constant migration that is occurring from rural to urban areas. The migratory flux is often composed by younger generations leaving the elder populating the rural areas. In Kawaguchi town, most of younger people expressed their desire to move outside once they finish higher education and those living in town are often working outside.

In Kawaguchi town, the main causes generating vulnerability include social, structural and governmental disaster protection and awareness. As previously observed, the community bond is progressively weakening through time. Issues in social network organisation appear evident especially between different sections or communities. Moreover, each community lacks in preparation which was responsible for the uncontrolled reactions during the earthquake and difficulties in organising the recovery process. The high presence of elderly population in town also requires additional support, especially during the immediate aftershock time as these moments crucial for the success of the evacuation and the rescuing process. Concerning the structural causes, the lack of knowledge, awareness, earthquake resistant construction techniques and safety are responsible for the unsafe constructions and the disposal of dangerous objects inside the houses. Additionally, the lack of maintenance observed in the whole town increased the level of unsafe houses. The high landslide risk was also underestimated until the earthquake occurred. This lack of awareness is responsible of the total isolation of the town for 3 days and constrained the rescuers to reach the damaged areas. Finally, the governmental planning, preparedness, awareness and coordination lacks are also negatively contributing to the weakening of the community system organisation and resulting in to a slower recovery process.

Table 3-5: Causes of vulnerability generation in the Chuetsu earthquake.

Root causes

- Unequal distribution of economic power between rural and urban
- Agricultural economy
- Concept of community slowly disappearing in younger generations

Dynamic pressures

- Lack of awareness about the high seismic risk in Niigata Prefecture
- Lack of awareness in anti-seismic building construction
- Poor quality housing often with a cheap wooden structure and covered by thin metal
- Constant migration from the rural to the urban
- Population ageing

Unsafe conditions

Social lacks
- Issues in the social network organisation
- Lacks in community preparation
- Need of assistance for elderly

Structural lacks
- Unsafe housing system, especially anti-seismic one and often without any maintenance
- Main communication roads under high risk of landslide
- The lack of knowledge responsible of unsafe constructions

Governmental lacks
- Lack of disaster planning
- Lack of preparedness and awareness raising
- Lack in coordinating the different sections and community

Hazard

- Earthquake shaking
- Consequent landslides provoking isolation

Chapter Four

Space-Time Changes in Behaviour

4.1 Introduction

As discussed in the previous chapter, differences emerged in communities of distinct geographical locations, causing specific behavioural patterns and reactions according to the main social and economic factor. The social network has been considered as the main reason of different community behaviour during the recovery process. In order to fully understand the reactions after the seismic event, a STC analysis is provided. The time geography allows to consider the behaviour of Kawaguchi town's residents along the time line, better explaining the reactions and movement patterns. The following discussion is limited to the first 30 days of the recovery process as this is the moment in which the main spatial movements were recorded (Gismondi M., 2010b). Moreover, particular attention will be given to the first 24 hours as it is considered the most important moment, especially because it is connected to finding victims of the earthquake. Each ST path corresponds to a group of people moving together. The strict correlation between behaviour and movement makes the time geography an indispensable tool, examining the geographical phenomena in specific spatial and temporal contexts (Andrienko et al., 2007).

4.2 Space-Time-Cube 3D view of the central area

The central area is recognised in this paper as the core of the town. Despite the compact urban tissue and population density, certain differences in the reaction and actions during the rehabilitation process are observed. Figures 4-1 show the ST paths of respondents for the time considered during the recovery process. Each stroke represents the lifeline of a household or group of households inside the domain considered in this study. A graduated scale is proposed in Figure 4-1, showing the daily time span represented in the three dimensional representation using the STC. The first 24 hours are considered the most important after an earthquake. Considering the spatio-temporal behaviour of residents, three main phases can be highlighted as follows.

The first phase occurs within the first 24 hours and is representative of the more irrational and immediate reactions just after the first shock. The population is divided geographically, to those living close to the local governmental office and those living on the fringe of the central area. For the first case, the ST paths tend to converge towards the local governmental building, presenting a co-location in space and time in one spot immediately after the seismic event. However, the second case presents a more heterogeneous behavioural pattern, showing a co-location in time but more rarely also in space, as smaller groups such as neighbours were formed. The lack of pre-arranged evacuation strategies explains the convergent spatial movement towards the local governmental building. Oppositely the relatively further distance moved by the other groups explain the wish to maintain a co-location in space as close as possible to their own house.

The second phase starts 24 hours after, when a more logical behavioural pattern arises. The area had three main buildings used as shelters for emergency; an office building, a nursery and a gym (partially collapsed during the earthquake). However, despite the large amount of space available inside the shelters, a co-location in space and time is observed during the first days after the seismic event, especially in the areas further from the governmental building. The local government has an important role in this phase. In fact, despite the lack of pre-planning, a post earthquake rehabilitation plan is proposed. The plan consists of moving a portion of the victims to the shelter and another portion to a tent camp close to the riverside leaving to the possibility to also stay close to their own house. The episodes of non co-location in time and space, with movements towards the shelters and the riverside occur immediately after the advent of the rescuers in the central area, providing a certain supply of provisions and tents.

A third and final phase can be observed after the first week. The emergency movements were completed with the tent camp and provisional sheltering functional. For this reason, a reduction of spatial movements is recorded. The lifelines of the respondents become almost perpendicular to the area in the map showing a co-location in time and space for good part of the rehabilitation process. The high damage did not allow the survivors to rapidly return to their own houses, obliging a forced stay in the designated areas. However, although the general trend shows certain stability in space and time, certain ST paths have shown different behaviour. In fact, some of those who received a large damage to their own property preferred to move outside town after the first period of the recovery process. On the other hand, a ST path grouping in the designated shelter and provisional shelter areas close to the own house and together with part of community members was visible after passing part of the post earthquake time.

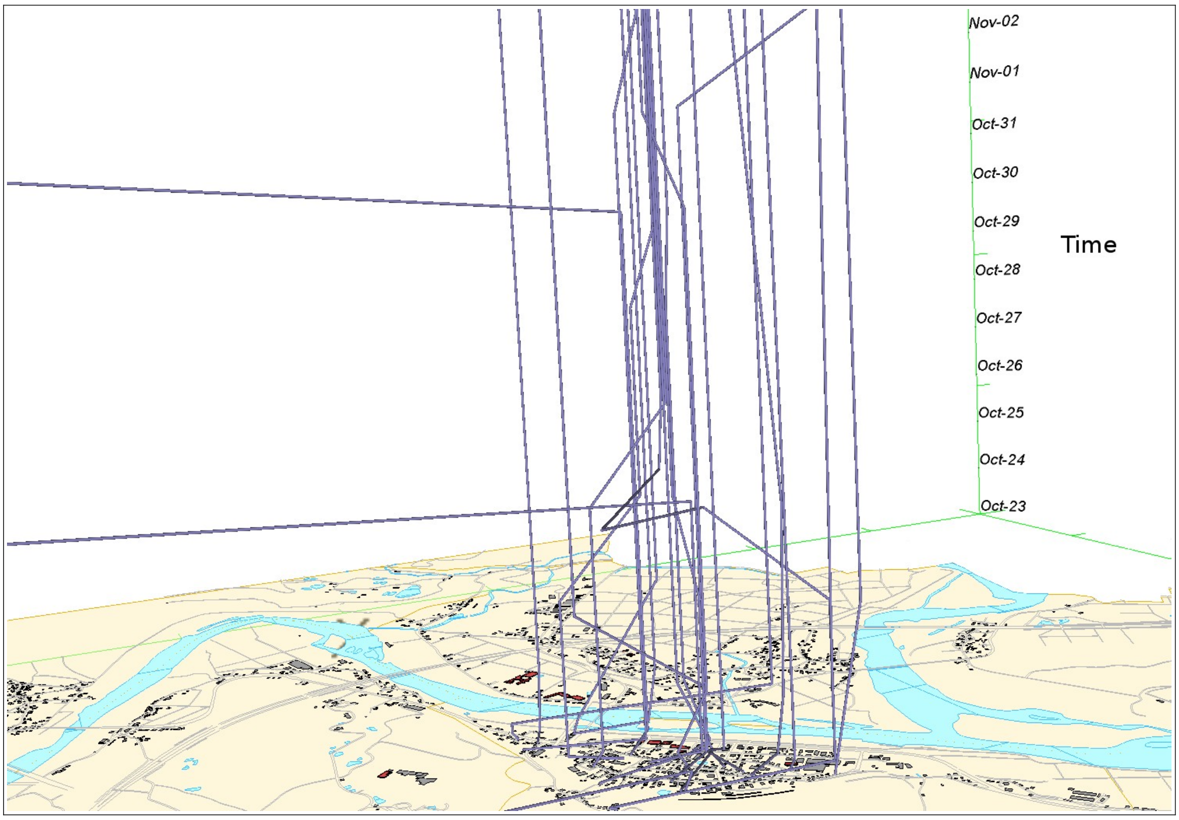


Figure 4-1: 3D space-time view of the central area.

Data source: fieldwork 2008-2010

Note: The figure shows the three-dimensional representation of the spatial movements of the residents interviewed. Each line represents one resident and his movements over time

4.3 Space-Time-Cube 3D view of the peripheral area

The survey results portrayed the peripheral area having a recovery process mainly based on small groups. Moreover the lower structural damage allowed shortening of the recovery process. Figure 4-2 shows the 3D space-time view over the peripheral area. The households are physically disposed over the area with a spread and inhomogeneous pattern and for this reason, the ST path do not show wide movements in space. After the earthquake, most of the residents tend to be in close contact with their own house. A co-location in space and time occurs over the first 24 hours, mainly because of the fear of crime. After the first night, two types of ST path patterns can be highlighted.

For the first type, the lifelines of the respondents tend to concentrate to the local shelters. Several cases of co-location in space appear around the two local schools of the area, used as shelter in emergency cases. The residents leading to two main shelters were those mainly needing assistance after the earthquake. However, the lack of co-location in time clearly shows the lack of an evacuation plan, as each household or group decided on their own of how and when to evacuate their own property without considering the risks of living close to damaged areas. The shorter recovery process allowed those who have moved to the local shelters to be able to start the reconstruction of their own property and move back within the 4 weeks of the analysis considered in this study. Temporally only two locations appear in their lifeline, the own household and the shelter, with a ST path pattern that can be applied to most of those evacuated to the shelter.

Considering the second ST pattern, a more limited spatial movement in time can be observed. In fact, in this case residents tend to assemble in small groups and pass the recovery process close to their own property, showing a persistent location in space over most of the recovery process. The different ST paths from the first and second pattern are clearly visible after the first 24 hours, the co-location in space and time of the survivors moved to the shelters and the co-location in time but not in space of those passing the recovery process close to the own household. The importance of the social network highlighted in the previous chapter is the main reason showing this pattern. The collaboration among residents is therefore responsible of a 3D representation of the lifelines that is perpendicular to the map as no main movements are needed, using the resources within the neighbourhood as principal way to sustain the residents in each location.

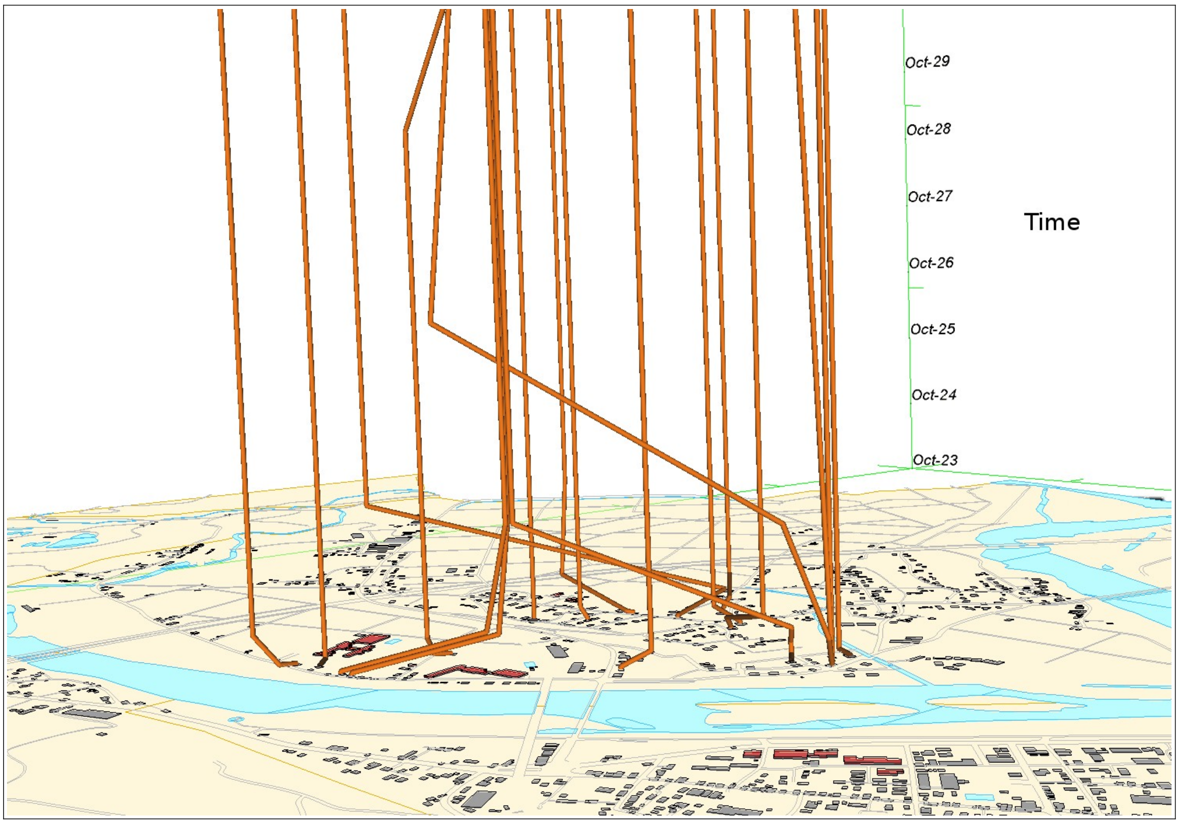


Figure 4-2: 3D space-time view of the peripheral area.

Data source: fieldwork 2008-2010

Note: The figure shows the three-dimensional representation of the spatial movements of the residents interviewed. Each line represents one resident and his movements over time

4.4 Space-Time-Cube 3D view of the isolated area

The isolated area, despite a similar urban tissue to the peripheral area but smaller in size, is characterized by a particular behavioural pattern with tendency focusing movements towards one location, as observed in the chapter 3. The high quality of the social network is considered as the main factor explaining this pattern. Figures 4-3 represent the 3D space time viewer over the isolated area at the time of the earthquake and 2 hours later respectively. In this area, the lifelines are more linear and all following a similar pattern, explaining a certain organisation within the members of the community despite the higher average age registered.

Immediately after the earthquake, a co-location in time clearly appears from Figure 4-3, explaining issues in evacuation and mobility of the residents. The respondents' ST path appears stable close to their own property without any major movements. However, two hours after the earthquake, a general trend of co-location in time and space appears in proximity of the dismissed local school used as shelter. Despite some residents' ST paths joining, the others are in the sheltered location in the second phase; this is a concrete example of a successful emergency organisation without any proper preparation. The rest of the rehabilitation process shows constant ST path lifelines in co-location in time and space as the main shelter was considered as secure by respondents.

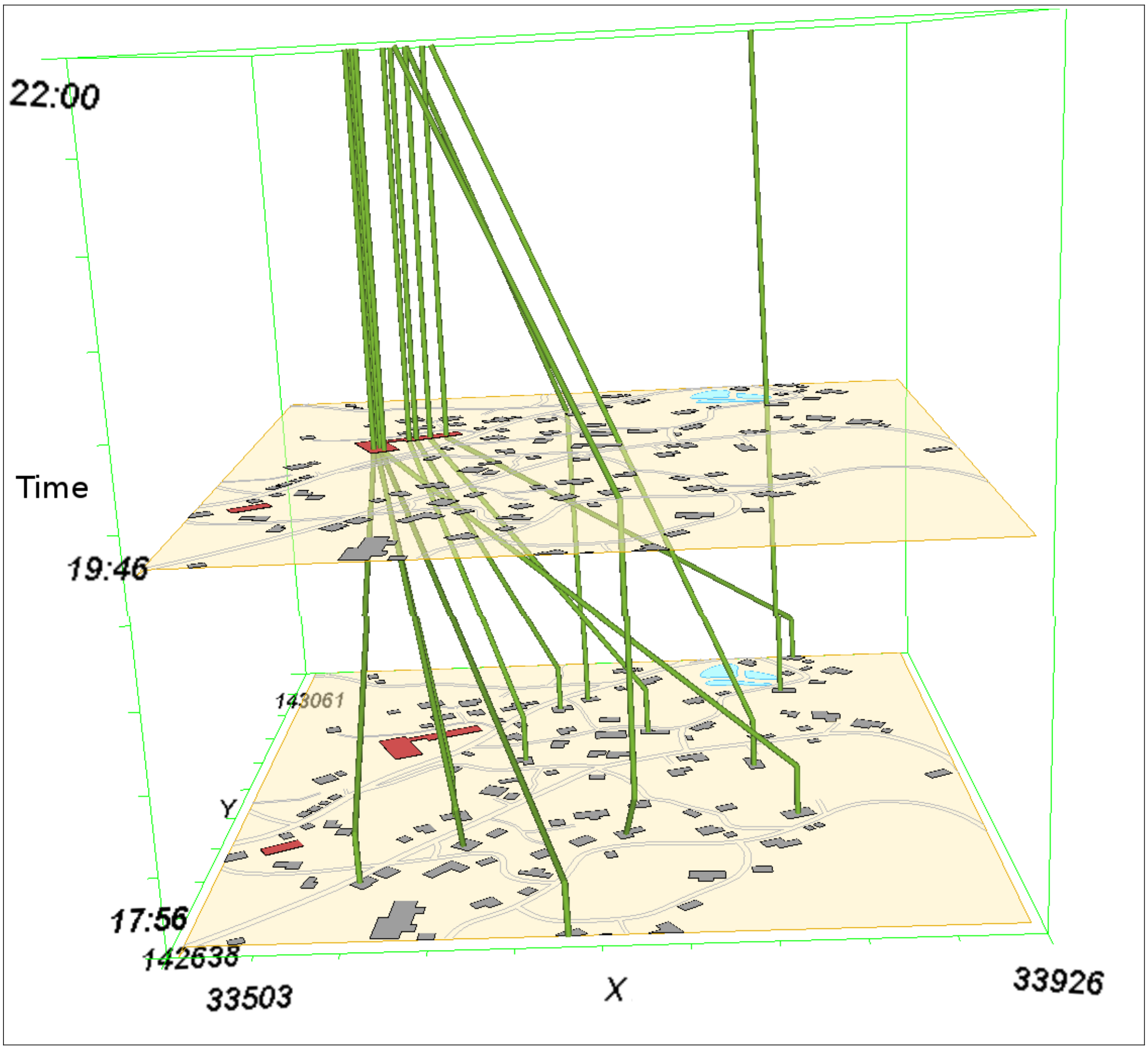


Figure 4-3: 3D space-time view of the isolated area.

Data source: fieldwork 2008-2010

Note: The figure shows the three-dimensional representation of the spatial movements of the residents interviewed. Each line represents one resident and his movements over the first hours after the earthquake. Coordinates appear in at the corners of the ST viewer

4.5 Differences in ST behaviour in the three research areas

Considering the results showed in the previous sections, differences in temporal and spatial paths patterns are observed in Kawaguchi town. The length of the rehabilitation process considered in this study of 4 weeks is the same for the three areas. However, the ST paths show clear differences in how the behaviour and movements occurred according to the geographical location. The Figure 4-4 is therefore proposed to summarize the spatio-temporal movements and highlight the main recovery pattern representative of each research area. In the short period the general trend shows central and peripheral areas having a heterogeneous movement behaviour of individuals and groups, in which the location of the household and the connection with the neighbourhood are important factors affecting the ST path during the evacuation process. A similar trend also continues during the long period. However, whereas the ST paths of the central areas were strictly connected with the local government, behaviour recorded in the peripheral area suggests an independent organisation in smaller groups and communication between provisional shelters. On the contrary, in the isolated area a point centric movement pattern is observed.

Although Figure 4-4 represents the general differences in behaviour over time, the movements observed reflect the most common reactions of the household members. Three examples of household behaviour, one from each research areas, are proposed as representative of the behavioural patterns in each research area. In the central and peripheral area a larger number of family members was observed in Figure 3-2, however the reactions among the household members had several differences as explained in the following two examples. Concerning the central area a 5 members household are considered. A Husband, a wife, a child and two grandparents were present in the house at the moment of the earthquake. When the earthquake occurred, the panic spread in the house, preventing the family members from supporting each other. However after the first shake, the family immediately moved outside from the building and started to communicate with other neighbour to verify also their safety. The next step was to move towards the local governmental building, as this family as most of the residents in the central area did not have any emergency plan. After receiving several instruction, the family preferred to move into their garage and give only a limited support to the other community members especially because of the limited amount of provisions. The situation changed since the arrival of rescuers bringing support and stock of food, allowing the family members to provide more effective support especially in building provisional housing, however the garage was maintained as family shelter for the whole recovery process, showing the wish to maintain a certain detachment from the rest of the community. A different episode occurred in a household located within the peripheral area. In this case the family was composed by 4 family members, however in the moment of the earthquake the wife with two children were in Nagaoka city for shopping, whereas the husband was home alone. The first reaction of the husband was an instinctive move outside the building heavily damaged. In the other hand the rest of the family were blocked 20 km from the town because of landslides. This family represents a good example of lack of communication planning and emergency organisation. In fact, the husband decided to move to a town shelter without any possible communication with the rest of the family. Only the day after, with the help of other residents, the family could return together. The rest of the recovery process passed with the family staying in a provisional shelter together with other neighbour sharing their resources and giving mutual support. Concerning the isolated area a particular interesting case of an elder woman living alone and needing support to evacuate is proposed. Unlikely the other two examples of household previously proposed, living alone is an adverse condition in case of earthquake because no immediate support can be offered. However, thanks to the good relationship with other community members an early support was provided to the woman to move from the damaged house to the local shelter. This example highlights the importance of the community in emergency situations especially to support those most needing help. During the rest of the recovery process and further the woman could live together with the other community members in the local shelter with an optimal share of provisions.

From these examples emerges the capital role of the shelters, especially during the recovery process. In Kawaguchi, the partial or complete convergence towards these safe spots is observed, mainly after the rescuers could reach the affected areas. The convergence to the local shelters affected only one part of the residents and occurred at a different period in time suggesting several waves of residents. A lower population density is observed in the peripheral and isolated areas compared with the central. However, the location of high capacity shelters (two schools in the peripheral area and one school in the isolated area) are not in the geographical area most needing secure spots. Provisional housing built by the rescuers and provisional shelters mainly constructed by the community were the most common solution to accommodate those without the possibility to access the town shelters as over crowded.

In order to better interpret the spatial movement in time, Figure 4-5 is shown. The time line has a number of spatial movements in constant evolution for the all lengths of the period considered in this study. However, two main time periods defined as short and long, are highlighted as important moments of the recovery process. The first 24 hours is the most delicate moment of the evacuation process due to the aftershock reactions occur during these hours. A heterogeneous choice of evacuation location is observed in the central area, considering their own judgement as main reason of the movement behaviour. Instead the peripheral area focused mainly on sheltering and community based organisation. The isolated area showed the majority of the recovery process focused on the main shelter. Following the 3 to 5 days time span, the residents are isolated and start to organise a rehabilitation plan. In the first week, the lack of planning shows a very various ST paths behaviour that starts to become more organised and logical only after a certain organisation is provided. In fact, after the first week (short period) a general stabilisation of the ST paths show the introduction of guidelines for residents driving their behaviour towards common locations. The time interceding between the first evacuation and a successful organisation reach almost one week, highlighting how deep the lack of awareness and organisation affected the residents' behaviour in the post earthquake time period. Despite the time required to provide an effective organisation, the ST paths are limited inside the boundaries of the three areas. The lack of ability to move with a vehicle in the first period after the earthquake and the compact size of the research areas, are the main factors explaining the lack of ST paths superposed from different areas. Therefore, each one of the research areas has a limited potential path not allowing long distance movements. Exceptions to this trend can be highlighted considering those moving outside from the town and not participating in the recovery process. The length of the recovery process is also determined by the amount of damages received. In fact the peripheral area thanks to the lower damages reported a faster recovery compared with the central area.

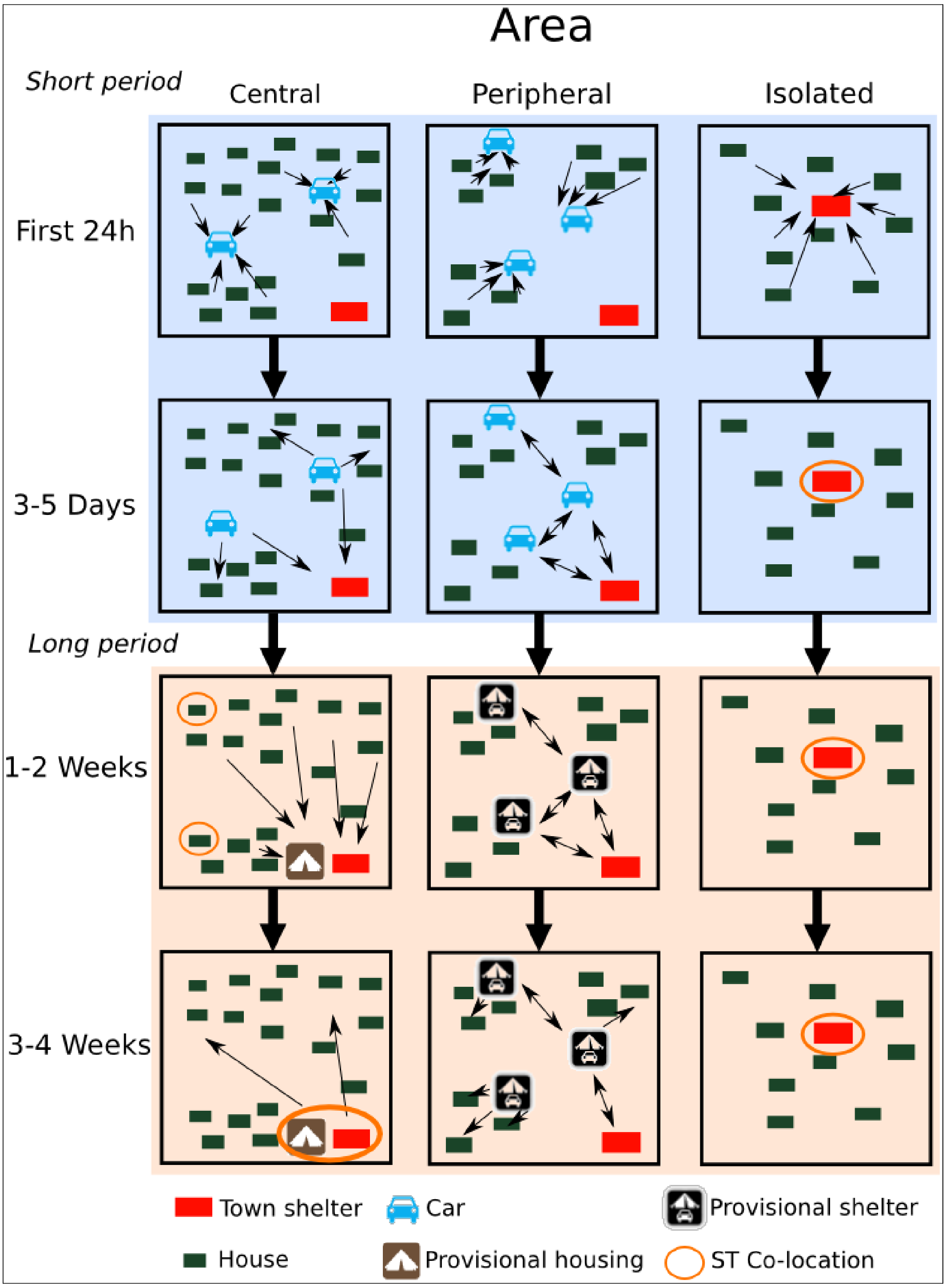


Figure 4-4: Differences in movement behaviour over time.

Data source: fieldwork 2008-2010

Note: The arrows represent the movement of residents during the short and long period of the recovery process

Figure 4-5 – Respondents' location over time.

Central area

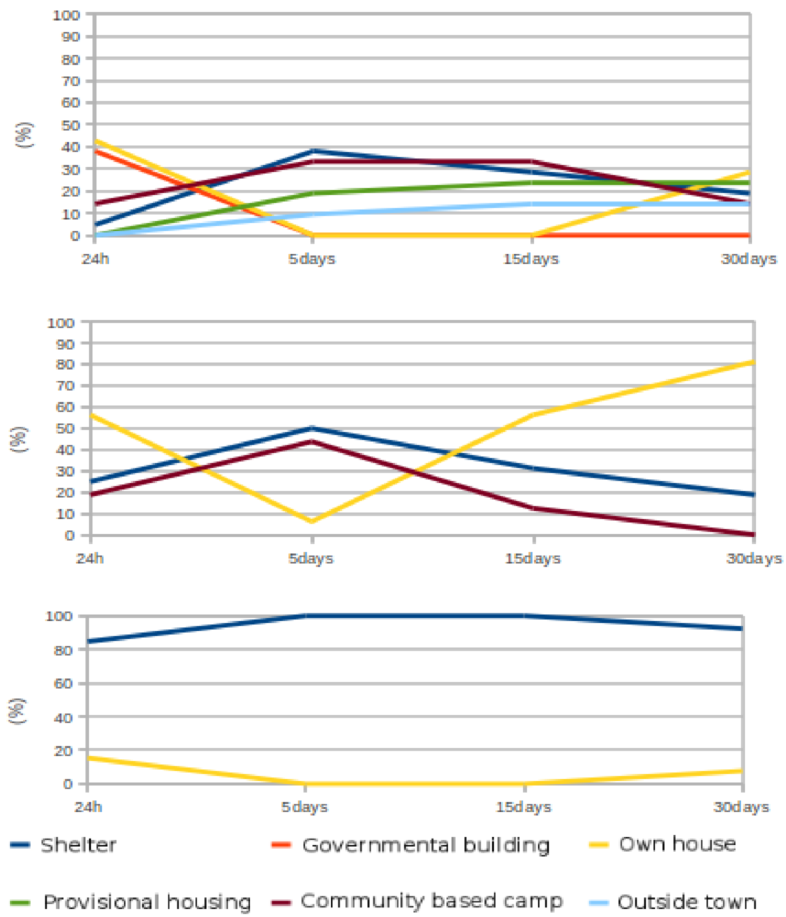
Location\Time	24h	5days	15days	30days
Shelter	4,8	38,1	28,6	19,0
Governmental building	38,1	0	0	0
Own house (close to/ inside)	42,9	0	0	28,6
Provisional housing	0	19,0	23,8	23,8
Community based camp	14,3	33,3	33,3	14,3
Outside town	0	9,5	14,3	14,3

Peripheral area

Location\Time	24h	5days	15days	30days
Shelter	25	50	31,3	18,8
Governmental building	0	0	0	0
Own house (close to/ inside)	56,3	6,3	56,3	81,3
Provisional housing	0	0	0	0
Community based camp	18,8	43,8	12,5	0
Outside town	0	0	0	0

Isolated area

Location\Time	24h	5days	15days	30days
Shelter	84,6	100	100	92,3
Governmental building	0	0	0	0
Own house (close to/ inside)	15,4	0	0	7,7
Provisional housing	0	0	0	0
Community based camp	0	0	0	0
Outside town	0	0	0	0



Data source: fieldwork 2008-2010

Chapter Five

Community Differences in Residents' Behaviour

5.1 Regional differences in behaviour in Kawaguchi town

This study explored the Kawaguchi town residents' behaviour after the 2004 Chuetsu Earthquake. Differences in behaviour and organisation appeared over the study area suggesting communities with different characteristics according to the location in the town centre, in the peripheral area and in the isolated fringe section. The three research areas chosen as representative of the regional differences in behaviour within Kawaguchi town clearly show socio-economical differences in daily life, consequently affecting their actions after the seismic event. As Anderson (1994) and Cutter et al. (2008) observed, the pre-existing patterns inside the community members are the main reason behind the regional differences in organisation and behaviour causing vulnerability. Succeeding to understand these patterns is the first step to reinforce the community itself. Chapter 3 highlighted geographical location, everyday relations, social interaction and organisation as the main factors explaining the differences of behaviour in communities within the same thematic area. These same factors are also responsible for the successful resource management and organisation among residents as discussed by Blaikie et al. (1994).

Succeeding in preparing communities to face a disaster is a main topic of discussion world wide, with concrete examples such as FEMA programs in United States (FEMA, 1997). However, each geographical location has specific natural and human features that require a different action plan in order to successfully provide preparation and awareness in case of natural disaster (Appendix VI).

In Kawaguchi town, an evident lack in preparation appears at different levels: the single individual, household, local community members and local government. Glenn (1979) highlights how individual and group reactions to a natural disaster such as an earthquake differ and are highly dependent on each individual personality. However in this study, despite major differences in behaviour a common reaction can be observed, aiming to protect one's own families and give as much support as possible to the limit of each individual or community. The issue lies in factors such as the weak social network and the lack of food provision limiting the desire to give support in certain areas, mainly for the fear of unknown future prospects. The social structure and social interaction are considered essential in understanding collective behaviour as also observed by Smith and Belgrave (2003). In a thematic area such as the isolated case in Kawaguchi town, enduring social relationships is considered an important step in improving the collective behaviour. Aguiree et al. (1998) also consider enduring social relationships very useful; firstly to have a differentiation between the general residents' behaviour and the institution's and secondly to retrieve a clearer dynamics attending the occurrence of the collective behaviour.

The lack of awareness is an important factor causing the increment of vulnerability as discussed in chapter 3.6. The cultural and cognitive variables can be considered as the most important variables explaining the response to earthquake risks, among the factors limiting the people's ability to react during a seismic event. Often as in the case of Asgary and Willis (1997), the main conclusion leads to the important use of education and information before the event, prompting better responses when a natural event occurs. Therefore, the massive educational campaign done months after the Chuetsu earthquake in Kawaguchi town as reported from the local government was surely too late and not efficient as it is not maintained throughout time. The campaign consisted of distributing booklets containing information about pre-earthquake arrangements and first aid to the local schools and courses to improve risk awareness and preparation (Appendix VII). These types of campaigns are occurring worldwide. However, the heterogeneity of the community structures and interests always produce additional issues in successfully promoting the information at all social and age levels inside a community. Natural events such earthquakes, being unpredictable are often underestimated. In fact, in the case study residents were aware of phenomena such as heavy snow and landslide risks during the year (Konagai, 2004). However an event such as an earthquake was instead underestimated, because of the impossibility of forecasting the event and the low experience of the event in the area. The awareness of disasters, the knowledge of neighbours, and past earthquakes are important to provide educational information (Tanaka, 2005). Succeeding in maintaining earthquake awareness and readiness at high levels in time is often considered a priority in different regions in Japan (Imai et al., 1997; Information Bureau of Cabinet Secretary of the Japanese Government, 1998; Tanaka and Hattori, 2001). Despite the general trend aiming to increase the knowledge and preparation in the Japanese territory, in rural areas such as the study areas of this paper certain fragility in the emergency educational system is observed.

The absence of earthquake resistant buildings explains the high damage on infrastructure. Only the local government building and schools did not report notable damages as they are earthquake resistant. The rest of the buildings were mainly wooden constructions dating more than 20 years. Because of the high risk of the residential building collapsing, the community had an important role to guarantee the safety of residents. The behaviour observed highlights the lack of personal knowledge in emergency procedures that were not given by the local government until the earthquake occurred. It is relatively easy to raise the awareness of population on a certain topic, however maintain such awareness and preparation over time is an ardours task (Coburn and Spence 2002).

The community was considered indispensable by residents to improve the quality and safety during the recovery process. The Japanese community system in rural areas still conserves the flavour of the old periods in which the community activity was part of daily life. The practice of attending community meetings allows the creation of a stronger network among neighbours, as underlined by Tanaka (2005). This practice is a characteristic of the Japanese population, in fact in other countries such as United States community meetings and close linked daily life activities are not seen (Tanaka, 2005). However despite the stronger community based activities compared with other locations worldwide, different surrounding environment condition appeared evident according to the geographical location. In fact the typical concept of Japanese community progressively disappearing is clearly showing a weakening in the social tissue. This effect is occurring meanly in places more populated such as the central area in Kawaguchi town. However, a stronger bond is still recognisable in more remote locations such as the isolated area in Kawaguchi. Therefore, the typical organisation of Japanese communities with a responsible person for each group and recurrent meetings is now losing its effectiveness as observed in this paper. In fact the recent trend of working outside of town negatively contributes to weakening the links between residents and prevent the preservation of a robust social network. Although the local communities had a proper planning for the local activities and maintenance of public spaces as show in Table 3-2, no specific emergency preparation or knowledge was present at the moment the earthquake occurred. Aged, disabled people, residents living alone or in single family units did not receive sufficient special disaster education (Miura, 2000; Dooley et al, 1992). Another important issue to be considered concerns the food reserve, in case of natural disaster or isolation. The stock of food and water is not a common practice in Japan, contrary to the United States where disaster prevention education, produced a certain sensibility on this topic (Tanaka, 2005). The amount of provisions is also considered as a determinant for the sharing during the recovery process, especially in the first week.

Figure 3-2, Tables 3-1 and 3-3 emphasise how strong characteristics such as age, work and community size are affecting the residents living in a thematic area. Starting from the three research areas considered in this study, it is possible to understand how the surrounding environment is determinant in creating specific regional characteristics. Time is a fundamental component to construct a strong relationship among community members. Therefore the research area having higher number of aged residents also showed a stronger social network. In fact, in the central area 25.7% are between 45 and 65 years old and 21.7% over 65. Similar trend appears in the peripheral area where respectively 29.1% and 23.3% are observed. Exception is the isolated area with 30.4% and 48.1% respectively, with an overall of 78.5% of more than 45 years old residents. From these statistics can be observed that the amount of aged residents and the number of residents is directly proportional to the strength of bonds within each community.

Nevertheless not only the age and community size are significant characteristics of Kawaguchi town, also the working activity has an important weight affecting the everyday relationships and communication in the communities. The statistics issued from the agricultural statistics shown in Table 3-3 are explicative of how much the agricultural activity is producing a link between residents living in the same area and the household members. Considering the statistics, there is a progression of the percentage of household engaged in agricultural activity, starting from the lower value of 6.7% in the central area and raising to 48.7% and 67.3% in the peripheral and isolated areas respectively. Moreover percentages of 21% and 23% highlight the presence of over 65 years old engaged in agricultural activities in the central and peripheral area respectively, hence the percentage raise until 41% in the isolated area. In fact, the younger generations and the new comers are mainly located in the central area, preferring an urban life style often working outside the town and the community. This is the main reason explaining also the low percentage of residents engaged in farming. In the contrary residents from the peripheral and isolated areas, being engaged in farming, will show a traditional life style in which the working activity is also a determinant of the socio-cultural tradition. In this sense, the farming is complementary to the community activities as the same residents are involved. The strong bond originated in every-day life of the community overcomes other issues such as the dispersed population in the peripheral area and the lack of sufficient amount of people in the isolated area. The presence of newcomers negatively affects the relationships among residents as the creation of a strong bond requires time. This phenomenon explains how neighbourhoods with a higher age average are better integrated and have stronger bonds as they share the same working activity but also their relationships have accumulated over time forming a trustful network.

However, despite older neighbourhoods and communities having a stronger connection and a natural impulse for community life, there is still need of further efforts from the younger generation and new comers to also establish a social network, using the community activities and meetings in a more effective way. By organising events, increasing the knowledge about the territory where they are living, ensuring a proper collaboration in case of emergency is needed. The local government has an important role in supporting the subsistence of the older community and the creation of new ones.

Promoting collaboration, infrastructures and providing the knowledge to prepare each community to a natural disaster is required according to the regional characteristics specific to each area. In fact, the surrounding environment creates specific characteristics that make a community different from another. These regional differences appear clearly in the central area, contrary to the surrounding and fringe areas. The life style is directly responsible of how a single individual relates himself with the own family and the community. It appears evident that there is no unique way of providing awareness and preparation, hence the residents themselves have the capacity of overcoming this lack as integrated in the area they are living in and more prone to understand the main issues and provide the support needed in case of emergency.

The Kobe earthquake is considered by many as a lesson about the reason why a highly developed area like Kobe could be so heavily damaged (Wisner et al., 2004). After this episode, the disaster reduction and awareness became an important topic of discussion in Japan. However, when the Chuetsu Earthquake occurred in 2004, the damage produced was still severe and the population was highly unprepared to face the unexpected. Despite differences between the Kobe and the Chuetsu earthquake in geographical location, the time of the seismic activity, population affected and damage to the economy remain common points. Wisner et al. (2004) used the PAR model headings to show the progression of vulnerability in the Kobe Earthquake. Comparing the results with the results of the present study (Table 3-5), the lack of population awareness and organization, earthquake resistant constructions and mobility issues of elderly are evident in both earthquakes. Moreover, the public institutions are considered lacking in disaster planning and preparedness at all levels. This comparison is useful to underline the lack of concrete improvements from 1995 to 2004 although almost 10 year separates the two seismic events. Despite the multiple actions provided by the Japanese government in order to improve national safety, it is evident that the awareness of the people has not sufficiently improved and are unprepared every time an earthquake occurs.

5.2 Spatio-temporal behavioural patterns in Kawaguchi town

An earthquake is among others definitions, a temporal phenomenon. For each seismic event, it is in fact possible to consider the starting point, the length of time and the end. At the moment an earthquake occurs, a chain of temporal occurrences both natural (landslide, inundation, etc.) and human (evacuation, rehabilitation, etc.) will follow. Time is also an important variable to consider during the rescuing process. Especially in the case of Kawaguchi town, where the lack of immediate external rescue was considered as the main factor affecting the first stages of the recovery process. Successfully understanding what happens, when, and for what reason helps to provide a wider picture of the natural event. Therefore, geovisualisation and time geography have an important role in better understanding the factors affecting the behaviour in the time period following a seismic event.

The time geography has rapidly developed since the advent of GIS and computers. Several overview over the STC and the importance of geovisualisation are given by Kraak and Huisman (2009) and Huisman, Santiago, Kraak and Resios (2009). Also Andrienko G. and Andrienko N. (2006) highlight its importance to interpret movements and behaviour in various studies. A common point of these authors, is that the concept provided by Hägerstrand's research 30 years ago is now ready to be used in scientific research as the development of computer science is now allowing to pass from the theoretical idea of time geography to the practical representation with the STC used in this study. As time geography has now evolved, it is indeed rare to successfully find similar case study with the same aim of this research, combining the social approach with the temporal visualisation in order to receive more detailed information about the behaviour of survivors in a seismic event. In this sense, this is the distinctive contribution of this work.

The accuracy of the measurements is an important step to consider during the data collection and data processing (Kraak and Huismann, 2009). When approaching a theoretical problem, the accuracy can be considered not as the main factor but important in determining the reliability of the results shown through the geovisualisation process. This research started in 2008, 4 years after the Chuetsu earthquake. For this reason, occasionally issues in collecting high quality data occurred especially during interviews with the elderly. The division of time was in 4 portions: first 24 hours, 5, 15 and 30 days were also considered to verify the reliability of data using wider portion of time. Experiences from different respondent were compared in order to check how much accurate the ST paths were.

In this study, time geography offered an empirical supportive method to the qualitative behavioural analysis provided. The three areas: central, peripheral and isolated are proposed as characteristics of a specific ST path behaviour unique to each location. In fact, human behaviour and perception are strictly inter-correlated with the spatial movement. Therefore the main factors highlighted as responsible of the issues highlighted during the recovery process are also responsible of the temporal movement behaviour. The ST paths often diverge according to the geographical location as shown in Figures 4-1, 4-2, 4-3. These images represent thematic areas within the same town but with differences of social background, age level and working activity. The central area has a dense urban tissue, whereas the peripheral and isolated have a dispersed house location. The uniqueness of the ST paths is inversely proportional to the distance from the city centre. In other words, moving away from the city centre, the ST paths tend to a more stable co-location in space and time. Despite the dynamism of the local residents, these patterns highlighted that the use of geovisualisation tools clearly show the social differences in approaching a catastrophic event according to the geographical location and community bonds and characteristics. The household location and the space between households have a deep impact on the ST path development. However, the characteristics highlighted in the previous chapters are determinant in this study.

Figure 5-1 is proposed with the aim of summarizing the different types of temporal behaviour within Kawaguchi town starting from the results exposed in chapter 4 (Figure 4-4). The Figure 5-1 is composed by two images representing the main ST path movements over short and long period of the recovery process. The aquarium concept is used as a reference in these images to highlight the main elements by which it is composed: domain, lifeline, bundle and potential prism as presented in the Figure 1-1. As a common element of both images the domain is first discussed. The number of households present in the domain are progressively decreasing moving from the centre towards the fringe area of 432, 80 and 52 households in the central, peripheral and isolated area respectively. Therefore, beyond the differences in urban tissue, the area of the domain is consequently smaller in the isolated area. The life lines represent the ST paths of an individual for a determined amount of time t. Because a fixed time span is considered in this study, the lifeline of all the respondents will have the same lengths. However the ST path composing each lifeline has a different form according to the location and the period considered. The potential path reached its maximal expansion within the borders of the area considered. In fact, the limited mobility and the partial isolation during the recovery process are responsible for the reduced lifeline movement range. As each area had a different type of rehabilitation process, with support of local government in the central area, mainly focused on neighbourhood support in the peripheral area and totally community based in the isolated area, also the range of movement and the moments of bundle vary according to the residents' characteristics.

Short period. In the central area, two types of ST behaviour are considered as representative of the general trend in the thematic area. One consists in a limited potential path prism with several situations of bundle with other residents. The limited potential path phenomenon occurs mainly in two occasions, in case of elderly with limited movement possibilities and in case the neighbourhood chooses to corporate in a unique group to give support. The moments of bundle represent when a co-location in time and space occurs with residents sharing the same location during the recovery process. The second trend has a larger potential path representing those having the possibility for wider range. These lifelines are those directly depending on the local government directives, waiting for provisional housing to be constructed. The Peripheral area presents a similar pattern as the central area, however because of the larger distance interceding between households, the potential path prism becomes wider. The lifelines and the situation of bundle are a combination of the two spatio-temporal movement trends highlighted in the central area. In fact, despite larger movements, a more community and neighbourhood centric rehabilitation process makes that frequent situation of bundle also appear in this thematic area. In fact, during the short period provisional housing and shelter were still unavailable, explaining the higher number of situation of bundle due to frequent movements in both central and peripheral areas. Different situation appears in the isolated area, having a more limited potential path prism due to the high average age, the limited communication with other isolated communities and the strong community relationship allowing a certain level of independence. In this case, the bundle period results in a longer co-location in time and space as no further movements are required, using the community strengths to support the recovery process.

Long period. The behaviour changes in the three research areas after the construction of provisional housing, sheltering and also after the arrival of rescuers. The potential prism is visibly reduced in the central and peripheral area, showing longer situation of bundle. This change is due to the progressive organisation of the communities and the support of rescuers allowing to support residents during the recovery process with any further movements. The longer situation of bundle are also explicative of the progressive improvement of the collaboration among community members. The isolated area presents a similar structure to the short period one, highlighting the higher response in organisation and the collaboration among residents.

These differences in behaviour in both space and time are directly related to the surrounding environment conditions. The specific characteristics of a geographical location are therefore the main causes of a divergent behaviour among relatively close research areas. The residents are differently linked to the social network according to which type of social activities they are engaged in. Festivals, meeting, corporation in the agricultural activities are socio-cultural feature that have a direct impact in the life style. Therefore, the quality of social organisation becomes a marker of the strength of the social network itself, explaining the regional differences in Kawaguchi town.

World wide researchers are promoting the earthquake preparedness, awareness and vulnerability reduction. This research presents a hybrid between social and time geography that uses GIS technology as a tool to better interpret the human behaviour. By understanding the evolution of the Japanese community and by highlighting its characteristics, it is believed that a more reliable and effective solutions can be provided. The differences in behaviour and time response explain how differently a community or even a single neighbourhood perceive the community life. Therefore, although the temporal approach in emergency situation varies according to which area and group of people is affected. Considering the time as an important aspect of the evacuation and recovery process, the socio-temporal characteristics typical of each thematic area are considered indispensable in order to efficiently provide improvements in awareness and preparation in rural areas.

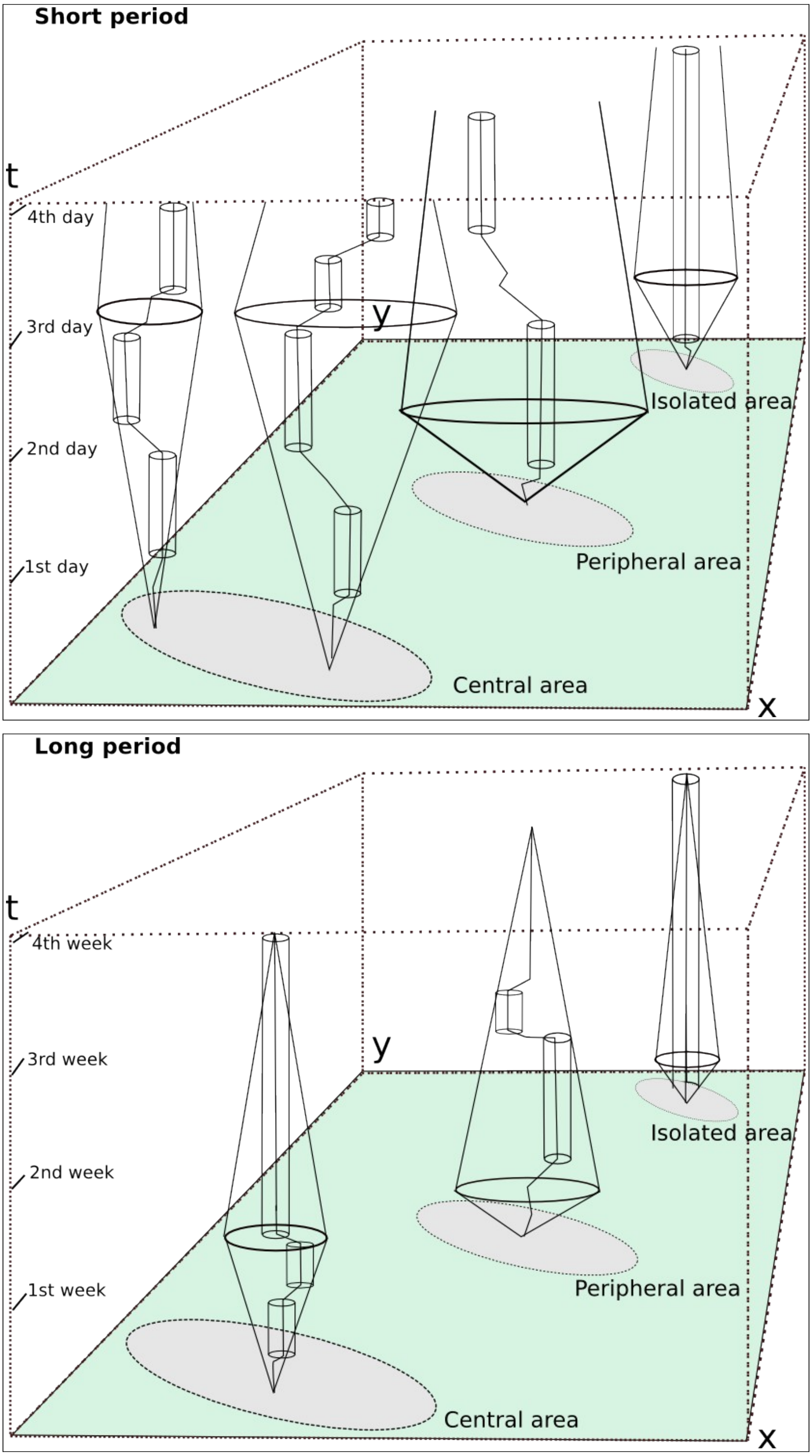


Figure 5-1 – Spatio-temporal behavioural patterns in Kawaguchi town.

Chapter Six

Conclusion

Kawaguchi is an example of Japanese rural town, with a progressively decreasing number of inhabitants, age increasing and community bonds deteriorating. Despite the high number of earthquakes occurring in Japan, to successfully promote awareness and preparation is an arduous task. At national level, major lacks appear in successfully maintaining awareness and organisation among citizens, despite the constant improvements in anti-seismic technology and organisation done by the government and public associations. Kawaguchi town well represents the actual situation in rural areas where the technological and anti-seismic development still needs to be fully adopted, making the role of the community essential to sustain residents in case of an earthquake or another natural disaster.

This paper aimed to explore the causes behind the regional differences in behaviour among three research areas in Kawaguchi town. Therefore, a double approach composed of social geography and time geography is proposed. Data are collected from the residents of the town during fieldworks, with the purpose of understanding the surrounding environment conditions explaining the difference in behaviour among the three areas proposed. As a result it became clear that the different ways to behave after the earthquake, with differences in evacuation patterns and rehabilitation process organisation, were due to the conditions of the surrounding environment. Four main causes of the regional differences are therefore proposed: geographical location, community characteristics, working type and social organisation. The geographical location is responsible of the isolation in the aftermath of a seismic event. The accessibility to the main communication ways is considered also determinant to establish a communication network and have access to primary resources. The size of the community is also considered a relevant factor, larger communities are complex to manage as they contain a variety of age groups and type of residents. However if managed, they are most likely to become the most supportive. Smaller communities are certainly easier to manage but are composed of elderly. Hence new issues appear on how to organise support. The daily life activities and the organisation resulted to be strictly connected to how residents are linked to the social network. Therefore, areas with a stronger social organisation in daily life, such as the peripheral and especially the isolated areas, showed a better interaction and support during the recovery process successfully organising in groups and providing resource sharing. The prominent agricultural activity in these two areas is believed to be an important factor explaining the original strength of the community, engaged already in daily life in group activities and get used to social organisation. Oppositely the central area, presented a weaker social bond, as most of the residents are originally not engaged in the daily community life, because of the working activity outside the town and the lack of interest in social activities of younger generations. These conditions are responsible of the limited resources sharing and the longer time needed to organise the residents living in the city centre.

A rural area in occurrence of a seismic event is most likely to become isolated. For this reason, to successfully be independent and have a fast response is essential to guarantee the safety of one's own family and other residents. A general lack of organisation is observed in the whole study areas from both residents and local government. The general trend recorded a mutual support during the recovery process, stronger and faster in the isolated area and progressively weaker and slower in the peripheral and central area, directly depending on the different surrounding environment conditions previously highlighted. The differences observed in the community social organisation in the three research areas of Kawaguchi town, showed that the general approach used until now to provide knowledge and organisation in local communities is not sufficiently efficient. It is therefore believed a community driven supportive plan, that takes in account the specific characteristics of each single community, erected by the community itself with the support of local government, could be a more effective way to make residents aware of the actual seismic risks. Therefore, the Japanese rural community system could be used more efficiently to guarantee faster response, organisation and security especially in the first moments of the recovery process in which the rapidity of the action is essential. Although a positive evaluation in the community response to the earthquake is examined, it is recommended to encompass major efforts in community survival planning, especially on a short time scale, focusing on the characteristics of each community. The definition of roles within the community, assignment to shelters and the emergency provisions are suggested as actions needed in the central area. Moreover, an improved emergency communication is believed to be necessary in order to connect the peripheral and isolated communities in the case of emergency. The division in the three areas: central, peripheral and isolated is a categorization that can be recognised in a rural settlement. Therefore, the concept proposed in this study composed by social and time geography can be also adapted in other regional structures to examine community behaviour after an earthquake.

Acknowledgements

I would like to express my deepest gratitude to my academic supervisor, Professor Yuji MURAYAMA, for being always present during this three years and offering always encouragement and support. Thanks to his guidance and sincere comments and advices I could grow my scientific knowledge and advance my preparation level in the field of geography. His support also helped me in international publications and conferences always offering precious comments to improve my research. It is also my wish to thank Professor Akira TEZUKA, Professor Kiyomi YAMASHITA, Professor Masaaki KUREHA and Assistant Professor Takehiro MORIMOTO, members of the dissertation advisory committee for their helpful and constructive suggestions that strongly helped me to improve my research and this paper.

I would like also to thank the Government of Japan for awarding me JASSO and Monbukagakusho scholarships in these years.

Hearthfelt thanks go to the residents of Kawaguchi town for their collaboration and their kindness during the fieldworks. I want also to thank the local government of Kawaguchi town especially Mr. Ryuichi YAMAZACHI and Mr. Tatsuya MIZUOCHI, for their constant support during these three years and the rapidity in providing answers and materials when needed.

This study used the Zenrin Z-map data to visualise the data and the Hokkaido-chizu DEM.

I would like to thank my colleagues and friends in the University of Tsukuba for their constant support and help also with the Japanese language. Finally, I would express my gratitude to my family, who gave me a strong encouragement and moral support day after day.

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Appendix I: Shelter address in Kawaguchi town

Section	Address	Name
Higashi-Kawaguchi (東川口)	川口1979番地130	Public meeting centre
	川口1979番地128	Cultural museum
	川口1979番地115	Higashi Kawaguchi Nursery
	川口1974番地20	Commercial industry
	川口1979番地38	Public office
Nishi-Kawaguchi (西川口)	西川口951番地	Secondary School Gym
	西川口1149番地	Primary school Gym
	西川口1605番地	Development centre
	西川口1602番地	Nursery
	西川口36番地5	Meeting centre
	西川口2954番地	Meeting centre
	西川口1947番地	Meeting centre
	西川口804番地	Development centre
	西川口1874番地	Meeting centre
	西川口2296番地	Development centre
	西川口934番地	Meeting centre
	西川口3843番地	Development centre
Wanadu (和南津)	和南津1738番地1	Development centre
	和南津882番地2	Development centre
Nakayama (中山)	中山839番地	Community centre
	中山199番地	Development centre
	中山1964番地	Community centre
	中山2456番地	Public gym
	中山253番地12	Public centre
	中山84番地2	Local products shop
Aikawa (相川) and Budokubo (武道窪)	相川1945番地1	Public meeting centre
	牛ヶ島424番地1	Primary school Gym
	相川1153番地3	Development centre
	武道窪200番地32	Child raising centre
	武道窪156番地5	Development centre
Ushigashima (牛ヶ島)	牛ヶ島1098番地1	Development centre
	牛ヶ島300番地26	Public meeting centre
Araya (荒谷)	荒谷431番地1	Public meeting centre
Tamugiyama (田麦山)	田麦山543番地	Primary school Gym
	田麦山1912番地1	Development centre
	田麦山605番地1	Development centre
	田麦山2485番地2	Development centre
Kizawa (木沢) and Touge (峠)	木沢507番地2	Development centre
	木沢467番地	Primary school Gym

Appendix II: Questionnaire in Japanese

問１）あなたの家はどこにありましたか。あるいは、どこにいましたか。

問２）あなたの最初のリアクション・行動はどうでしたか。

1. 動けなかった	2. 家の中にいた	3. 外に逃げた

問３）問２の理由

1. 恐怖を感じて	2. 安全だと思った	3. 避難場所に逃げるため

問４）地震の後、どのような行動をしましたか。

問５）地震発生後の最初の夜はどこで寝ましたか。

1. 自宅	2. 知人の家	3. 近所の人の家	4. ホテル	5. 車の中

問６）地震発生時の家族との連絡方法・集合場所は決めていましたか。
- a) それはどのような方法でしたか。
- b) その集合場所はどこですか。どのようにその場所着きましたか。

問７）どこの避難場所へいきましたか。
- a) 指定の避難所
- b) 一番ちかくにあった避難所・行き当たりばったり

問８）地震発生後、どのように以下の情報を得ましたか。

	電話で	尋ねて	他の人から情報を聞いた	情報を得られなかった
a) 自分の家について				
b) 家族の家について				
c) 家族の安否について				
d) 知人の安否について				

問9）地震発生後の最初の夜、あなたの安否について誰かに知らせましたか。

1.家族	2.近所の人	3.友人	4.連絡できなかった

問１０）誰かを助けたり、手伝った経験はありますか。（２００４年地震発生時）

1. できる限り手伝った	2. 家族のみ手伝った	3.手伝いたかったが、何をすればいいのかわからなかった	4. 何もしなかった

問１１）地震発生後、あなたはだれかに助けられたり、てつだってもらったりしましたか。

1.家族	2.近所の人	3.地域の人	4.知人	5.レスキュー隊

問１２）避難援助が必要な方の有無

1. 乳幼児、小学校低学年児	2. 高齢者	3. 障害や病気で動けない方	4. そのような人はいない	5. その他

問１３）自宅の被害レベル

1. 全壊	2. 大規模半壊	3. 半壊	4. 一部損壊	5. ほどんど被害はなかった	6. 被害なし

問１４）怪我の有無

1	2	3	4	5

問１５）あなたは地震発生時にとるべき行動ができたとおもいますか。

1. できたと思う	2. 何をすればいいかわからなかった	3. できなかった	4. その他

問１６）性別

1. 男性	2. 女性

問１７）年齢（さしつかえなければ、ご記入ください）

問１８）世帯人数

1. 一人	2. 二人	3. 三人	4. 四人	5. 五人	6. それ以上

Appendix III: Questionnaire in English

Q1) Where was your location when the earthquake occurred.

Q2) Your first reaction

1. Did not move	2. Stayed in	3. Went out

Q3) What is the reason of your answer in Q2?

1. Scared	2. Thought was more safe	3. Reach the shelter

Q4) Movement during the recovery process

Q5) Where did you sleep the first night?

1. Own house	2. Friend house	3. Neighbour house	4. Hotel	5. Car

Q6) Did you prepare a communication plan?

a) Did not do
b) Defined shelter

Q7) Shelter knowledge

a) Prefixed shelter
b) Closest shelter

Q8) After the earthquake how did you collect information about the following

	Phoned	Visited	Heard from somebody	Did/could not check
a) Own house				
b) Family house				
c) Family members				
d) Acquaintance				

Q9) Who did you inform the first night?

1.Family	2.Neighbourhood	3.Friend	4.Could not inform

Q10) Could you help somebody?

1. I helped who needed	2. Yes but only the family members	3. Yes, but I did not know how to help	4. I did not hep

Q11) Did somebody helped you

1.Family	2.Neighbours	3.Community	4.Friends	5.Rescuers

Q12) Did somebody in your house needed help to evacuate?

1. Young children	2. Elder people	3. Invalid or very old people	4. Nobody	5. Other

Q13) House damage level

1. Completely destroyed	2. Big damage	3. Half destroyed	4. One part destroyed	5. Minor damages	6. No damage

Q14) Where you injured?

1	2	3	4	5

Q15) Auto-evaluation of your behaviour during the recovery process

1. I think I did well	2. I did not know what to do	3. I could not do anything	4. Other

Q16 Sex

1. Man	2. Woman

Q17) Age

18) Number of family members

1. One	2. Two	3. Three	4. Four	5. Five	6. Six or more

Appendix IV: Questionnaire results summary tables

Damage received and evacuation methods (%)

	Central area	Peripheral area	Isolated area
House damage			
Completely destroyed	43	13	23
Big damage	10	19	38
Half destroyed	29	19	23
One part destroyed	10	44	15
Minor damages	5	6	0
No damage	5	0	0
First reaction during the earthquake			
Went out	19	19	15
Stayed in	29	44	38
Did not move	52	38	46
Reason of the first reaction			
Scared	81	69	54
Thought was more safe	19	31	39
Tried to reach the shelter	0	0	7
First night provisional shelter			
Car	62	88	0
Neighbour house	14	0	0
Outside	19	0	23
Shelter	0	0	77
Own house	5	13	0
Shelter knowledge			
Prefixed shelter	52	50	85
Closest shelter	33	31	15
Did not know	14	13	0
Did not go	0	6	0

Support during the recovery process (%)

	Central area	Peripheral area	Isolated area
Support given			
I helped who needed	66	64	85
Only the family members	19	18	15
Did not know how to help	10	6	0
Did not help	5	12	0
Auto-evaluation of the behaviour			
I think I did well	33	44	85
I did not know what to do	24	38	8
I could not do anything	43	19	8
Support received			
Family members	23	36	27
Neighbourhood	20	14	27
Community	20	18	23
Rescuers	10	5	10
Friends outside the community	10	9	13
Nobody	17	18	0
Residents requiring assistance			
Young children	27	19	8
Elder people	30	29	54
Invalid or very old people	17	19	8
Other	3	0	0
No	23	33	31

Appendix V: Damages produced by the Chuetsu Earthquake in 2004

Photo 1: Damaged house in Kawaguchi town

Photo 2: Heavily damaged shop and roads in Kawaguchi town

Photo 3: Road damages in Kawaguchi town

Photo 4: Heavily damaged houses in Kawaguchi town

(Source: local residents)

Appendix VI: Photographs done during the fieldworks

Photo 1: Examples of NGO awareness and preparation activities in Kawaguchi area (1)

Photo 2: Examples of NGO awareness and preparation activities in Kawaguchi area (2)

Photo 3: Typical community driven emergency sheltering house in Kawaguchi town

Photo 4: The earthquake produced severe damages and caused landslide all around Kawaguchi town