THESIS

AGRICULTURAL LOSS CAUSED BY 2007 FLOOD AND ITS HOUSEHOLD IMPACT

A Case Study In Sidoharjo Village, Sragen Regency, Indonesia

Thesis submitted to the Double Degree M.Sc. Programme, Gadjah Mada University and Faculty of Geo-Information Science and Earth Observation, University of Twente in partial fulfillment of the requirement for the degree of Master of Science in Geo-Information for Spatial Planning and Risk Management

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UNIVERSITY OF TWENTE
2013

ecce ancilla Domini; fiat mihi secundum verbum tuum

I am the handmaid of the Lord; let it be done to me according to your word

~ Mary, Mother of the Faithful ~

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Author,

Leo Agung Widiarto

ABSTRACT

Flood is an undeniable reality in Sidoharjo Village as part of Sragen District. It is affected by the presence of Mungkung River, the tributary of Solo River, which crosses in the area. It is certainly going to be one of the factors inhibiting the development and economic growth in the region, given the agricultural sector is one of the backbones of the economy which has the potential to be disturbed by the flood. The information about the flood and its impacts specifically related to agriculture are needed to determine the precise policies. The research focuses on 2007-flood mapping, agricultural production loss assessment, and farmer resilience expressed in their ability to continue the next cropping after hit by the 2007-flood.

The flood map was built by integrating the local knowledge and the Digital Terrain Model (DTM). The information about 2007 flood was collected by interviewing the local people. The DTM was built by interpolating the detailed spot height directly measured in the field. RTK-GPS technology was used on it. Based on the RMSE values of several interpolation methods, natural neighbour is the most appropriate method in this area. As the result of the integration, the depth of the flood immersing the paddy fields reaches approximately 3 meters.

Beside the flood depth, the growth stage of rice also determines the paddy vulnerability. It refers to the plant height and the sensitivity to the water immersion. There are three stages i.e. vegetative, generative, and graining phases. The vulnerabilities were constructed based on the synthetic data obtained via Focus Group Discussion (FGD). The production loss of paddy of the research area was counted based on the vulnerability. A grid-based GIS method is used in the loss calculation which produces a value of Rp. 1,137,350,000.00 (one billion, a hundred and thirty-seven million three hundred and fifty thousand rupiahs).

The losses influence the farmer ability to continue the cultivation in the next season, which in this study is defined as farmer resilience. To investigate the resilience level, 32 respondents were proportionally randomized to each flood zone. There are three zones were created based on the flood depth. The influencing factors and their weights and scores were determined by the farmer representatives via FGD. Meanwhile, the socioeconomic data were collected by using the questionnaires. The results show that most of the farmers in the area (56.3%) are categorized in moderate level.

Keywords: 2007-flood, local knowledge, DTM, FGD, paddy vulnerability, grid-based GIS method, production loss of paddy, farmer resilience

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ABBREVIATIONS AND GLOSARIES

BAPPEDA	:	Badan Perencanaan Pembangunan Daerah (Local Agency of Planning and Development)
BNPB	:	Badan Nasional Penanggulangan Bencana (Natural Disaster Management Agency of Indonesia)
BPN	:	Badan Pertanahan Nasional (National Land Agency)
BPS	:	Badan Pusat Statistik (Agency of Statistical Data)
DGPS	:	Differential Global Positioning System
DTM	:	Digital Terrain Model
FAO	:	Food and Agriculture Organization
FGD	:	Focus Group Discussion
GIS	:	Geographic Information System
GNP	:	Gross national Product
GPS	:	Global Positioning System
IDW	:	Inverse Distance Weighted
IRRI	:	International Rice Research Institute
PGIS	:	Participatory Geographic Information System
RBI	:	Rupa Bumi Indonesia (Topographic Map of Indonesia)
RMSE	:	Root Mean Square Error
RTK	:	Real Time Kinematic
UNDRO	:	United Nations Disaster Relief Organization
UNISDR	:	United Nations International Strategy for Disaster Reduction
USGS	:	United States Geological Survey
UTM	:	Universal Transverse Mercator
WGS 84	:	World Geodetic System 1984
Balitbang Pertanian	:	Badan Penelitian dan Pengembangan Pertanian (Research and Development Agency of Agriculture)
Farmer Resilience	:	farmer ability to continue the next-season cropping
Flood Depth	:	inundation height; the height difference between the ground and flood surfaces
Flood Level	:	elevation of flood surface
Generative Phase	:	paddy growing period at the start of flowering and pollination
Graining Phase	:	paddy growing period of post-pollination in which the grain begin to be formed
Indica	:	sub-species of rice developed in Asia which has short lifespan
Japonica	:	sub-species of rice developed in Asia which has long lifespan
Nota Dinas	:	official memorandum
Pupus	:	top of rice straw
Sample	:	randomly chosen paddy field as part of population
Sampled Point	:	chosen spot height
Spot Height	:	elevation point; measured point representing the ground surface elevation
Vegetative Phase	:	paddy growing period of stem and leaf improvements
Water Pass	:	a tool to measure the height of a point terrestrially

1. INTRODUCTION

1.1. BACKGROUND

Indonesia is an agrarian country, in which agriculture is one of leading sectors in Indonesia's economy (Ruslan, 2011). He also stated that 33% of Indonesian people work in this sector. Even in the past, Indonesia's agriculture has achieved good results and made a significant contribution in the growth of Indonesia's economy and job availability. For example, in 1939, it accounted for 61.0 % of Indonesia's GNP, accommodated 73.9 % of the workforce, and became a major export commodity by 65.0 % (Anonymous).

On the other hand, Indonesia is located in the disaster prone area. So many disastrous events have occurred in Indonesia. BNPB (natural disaster management agency of Indonesia) stated that there were 13,221 events in a long period of 1815-2012. Of those disasters, flood has the highest frequency than others by 4229 events (38%). Flood is defined as extremely high flows or levels of rivers, lakes, ponds, reservoirs and any other water bodies (Marfai, 2003). As the most common disaster, flood becomes a serious threat to the economy of Indonesia associated with losses in agriculture. This is related to many areas in Indonesia that set the agriculture as a leading sector to drive their economic growth.

Such condition is often found in Java Island, including Sragen regency. This region, located in the eastern part of Central Java province, is one of the areas traversed by Solo River, one of the longest rivers in Indonesia. The existence of the river pushes the agricultural sector in this region in term of soil fertility and water supply. Relatively high rainfall reaching 3,000 mm per year in certain part and 150 rainy days in average, as published in *Sragen-Online* (the official *website* of Sragen), also strongly support the development of the agricultural sector. It is evidenced by the 42.52 % of land use or about 40.037 Ha of total area 94.155 Ha is paddy field. However, the presence of the river and its tributaries has also led to flooding in this area. According to BNPB, there were 15 flood events in the last decade in Sragen.

Based on some of the above, flood-based information specifically related to the agricultural sector need to know as anticipatory measures and as a basis in the policy determining in term of sustainability of food. It is necessary to do a research in order to add information in which case there is no previous data, as well as to validate the existing data. The production loss value, the flood-based impact on the farmer households, the capability of the farmers to continue cropping the rice for the next season, as well as the public perception about the agricultural policies particularly in post-flood recovery efforts are the others things are needed to be known trough a research.

In addition, the International Rice Research Institute (IRRI) found a new variety of rice which is not only resistant to two-week flood immersion but also quality maintained (Balitbang-Pertanian, 2006). The problem is why the variety is not used by farmers in the Sragen regency whose paddy fields are located in flood prone areas during the rainy season. Is it because lack of information (they do not really know), or any other reasons? This finding is also needed to be known to support those have been presented previously.

1.2. PROBLEM STATEMENT

Flood is an undeniable reality in Sragen district. It has been clearly presented in the previous section. It is certainly going to be one of the factors inhibiting the development and economic growth in the region, given the agricultural sector is one of the backbones of the economy which has the potential to be disturbed by flooding. The lack of adequate information about the flood itself, both in general and specifically related to agriculture, causes the analysis of it becomes difficult to carry out. It certainly impacts on the difficulty of determining the precise and measurable policies related to it.

Something like flood characteristics affecting agricultural land is needed to build a disaster and vulnerability information. Each area and elements at risk has different influencing flood characteristics. The information are used as the key materials in the process of further analysis such as loss assessment. The results can be used to formulate a policy in case of loss data lacking, or can also be used as a comparison and evaluation materials, when the data are already available. The best method will produce accurate data as a reference in formulating mitigation strategies within the framework of disaster risk management.

To support the framework, information on the ability of the farmers to continue their cultivation process when the flood hits their fields, hereinafter referred to as resilience level, and the influencing factors also need to be measured scientifically. Any flood affected areas should be treated differently based on the level. Again, accurate information will determine the accuracy of a policy.

1.3. RESEARCH OBJECTIVES AND RESEARCH QUESTIONS

The objectives of the research are :

1. To construct the 2007 flood event map by integrating local knowledge and DTM
2. To do the agricultural loss assessment
3. To analyze resilience level of the farmers

The research questions serving as a guidance to achieve the objectives are shown in the following table.

Table 1.1. *Research objectives and research questions*

RESEARCH OBJECTIVES	RESEARCH QUESTIONS
To construct the 2007 flood event map by integrating local knowledge and DTM	1. To what extent the flood coverage in study area based on the integration between social and technical aspects? 2. What is the flood depth according to this integration?
To do the agricultural loss assessment	3. What is the paddy vulnerability of several flood scenarios? 4. What is the agricultural production loss of the study area which is calculated in the research? 5. How it compares between the calculated looses and those published by the local government? 6. What is the farmer perception about the future losses?

To analyze resilience level of the farmers	7.	How far do the losses affect the lives of the farmers?
	8.	How do the farmers able to continue the cultivation after the flood?
	9.	What courses have been done by the local government and how far the farmers able to adapt them?

1.4. CONCEPTUAL FRAMEWORK

The basic idea of this research plan is to examine the impact of a flood event on the agricultural sector, especially in rice. The impact is measured by value of loss with respect to the production process. There are two things that are expected to be achieved, those are assessment of the effect of the losses on farmer households, as well as some theoretical findings such as the loss calculation method and paddy vulnerability. Conceptually, the research plan is described in figure 1.1.

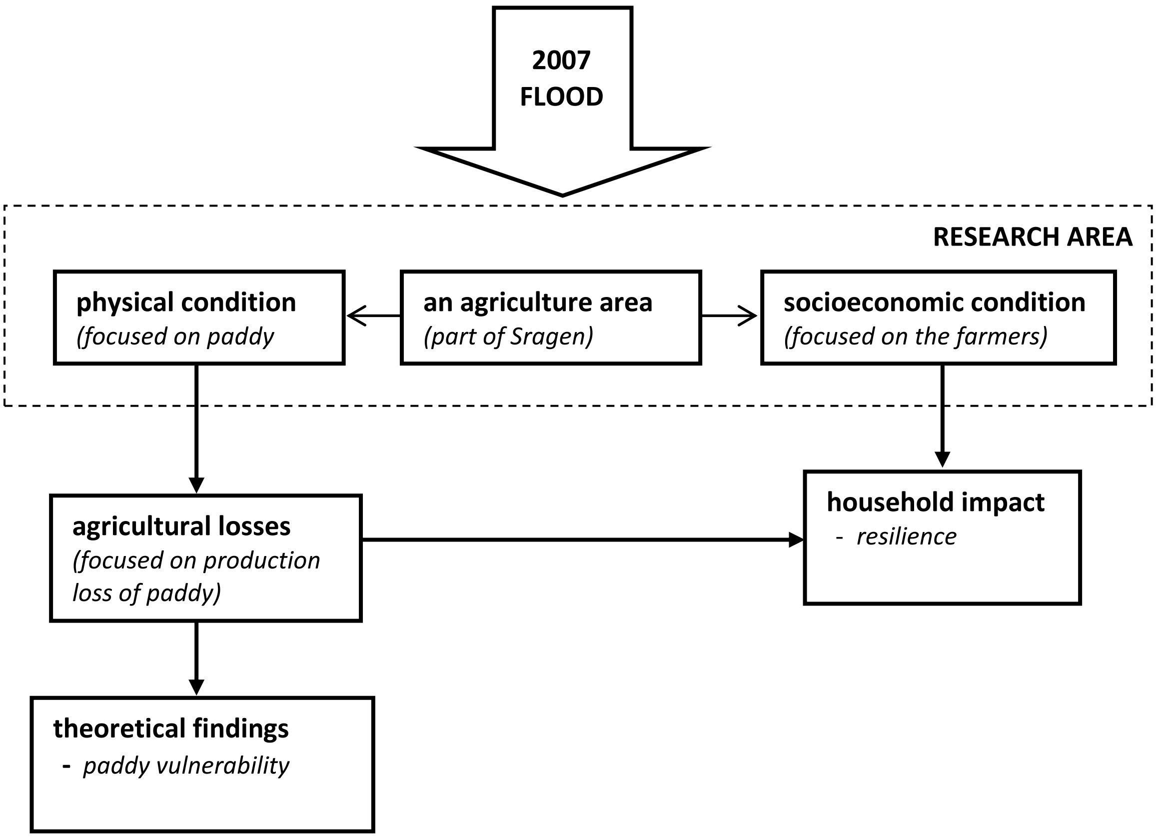

Figure 1.1. *Conceptual Framework*

1.5. BENEFIT OF THE RESEARCH

This research provides a real figure of 2007 flood event in the area as well as the impact on the agriculture sector. It consists of the loss, vulnerability, and resilience level. Also, the farmer perceptions of government involvement and future losses are measured. They can be used to evaluate or formulate flood-based agricultural policies.

1.6. RESEARCH LIMITATIONS

There The agricultural-based flood losses in this study is limited to the cultivation of rice, and more specifically on production loss of paddy related to the 2007 flood event. Meanwhile, the resilience investigated in this study is in individual level in term of the farmer ability to continue the cultivation for the next season after the flood event.

2. LITERATURE REVIEW

2.1. FLOOD HAZARD

"Hazard is a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage" (UNISDR,2009)

"Flood is any relatively high stream flow overtopping the natural or artificial banks in any reach of a stream" (USGS, 2011)

According to those definitions, if the overtopping stream flow mentioned by USGS has potential for causing loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage, it can be called with flood hazard. There are six characteristics determining the danger level of the flood, namely water depth, inundation duration, water velocity, sediment load, rate of rise, and frequency of occurrence (Marfai, 2003). However, not all of these characteristics have always worked together in any flood event. Each area or each case may have had different flood characteristics working on it.

2.2. AGRICULTURE

Provincial Agricultural Land Commission of British Columbia defines agriculture and agriculture land as follow :

"Agriculture is the systematic and controlled use of living organisms and the environment to improve the human condition".

"Agricultural Land is the land base upon which agriculture is practiced. Typically occurring on farms, agricultural activities are undertaken upon agricultural land to produce agricultural products".

According to those terms, when agricultural land is seen as an element at risk in the context of disaster, the caused losses related to agricultural land involve agricultural products and production activities. There is a wide variety of agricultural products, including rice which be the focus of this study.

There are two main sub-species of rice developed in Asia, namely *Japonica* which has a longer lifespan (about 150 days) and a high posture, and *Indica* which has a shorter age (about 120 days) and a smaller posture (Norsalis, 2011). In general, both of them have ten stages of growth. Specifically on short-lived paddy, Sudarmo (1991) described the stages as follows:

1. Stage 0
   It starts from germination to the first leaf appearance, usually takes about 3 days.
2. Stage 1
   It is also called as seeding phase, starts from the formation of the first leaf to the form of the first tiller which usually takes about 24 days.
3. Stage 2
   Known as tiller stage, in which the number of tillers is increasing to the maximum extent, duration up to 2 weeks.
4. Stage 3
   The rod extension, takes about 10 days.
5. Stage 4
   The grain formation, takes about 10 days.
6. Stage 5
   It is the phase of grain development, takes about 2 weeks.
7. Stage 6
   Flowering phase, takes about 10 days, when the flowers begin to appear, pollination and fertilization.
8. Stage 7
   In this phase, the seeds contain milk-like liquids, takes about 2 weeks.
9. Stage 8,
   The seed hardening, takes about 2 weeks or 102 days after planting.
10. Stage 9
    The seed ripening, takes about 2 weeks.

To be simpler, these stages can be grouped into three phases, namely vegetative phase, generative phase, and graining phase (Hanum, 2008).

1. Vegetative phase.

   In the short-lived varieties, the length of this stage is around 55 days, whereas the long-lived varieties the duration is approximately 85 days.

2. Generative phase, from flowering to grain formation.

   The stage duration is about 35 days for both In the short-lived and long-lived varieties.

3. Graining phase or seed formation,

   The length is around 30 days, for both short-lived and long-lived varieties.

2.3. SAMPLING METHOD

According to Yunus (2010), there are three main aspects determining the characteristics of a research i.e. the population existence, the object characteristics, and the kind of analysis used. Related to the population existence, there are three kinds of research method i.e. census, sampling and case study. In a census, all population members will be studied to get the population characteristic, while in the sampling method, only some members will be studied to get an overview of the characteristics of the entire population. In order to get the overview, the representation degree of the sample must be considered. It involves some factors such as sample size, character variations of the population, spatial variations of the population, as well as temporal variation of the population to determine the sampling method used.

Broadly, there are two kinds of sampling methods, namely random and non-random sample selection. Especially on random selection, the sample can be directly encrypted (Simple Random Sampling), can be randomized using a certain pattern or interval (Systematic Random Sampling), can be randomized with respect to the groups in the population (Cluster Random Sampling), can be randomized by considering the character gradation of the population (Stratified Random Sampling), and can be randomized in a balanced (Proportional Random Sampling). Both in the cluster random sampling and stratified random sampling, sample division into groups works in reducing the variability that is expected to produce a high accuracy of alleged value (Walpole, 1995).

There are several references to determine the sample size even though no one really standard for it. Sevilla (2009) stated that for a descriptive study, the sample size is equal to 10% of the total population. This statement was adopted what Gay (1976) delivered before. Sevilla also expressed Slovin (1960) formula to determine the sample size.

$n = N / 1 + N.e^2$

in which,

n = sample size

N = population size

e = the desired critical value (the accuracy)

2.4. VULNERABILITY

"Vulnerability is characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard" (UNISDR, 2009)

Based on the definition, characteristics determining the vulnerability are both those of the community, system or assets as the affected parts, and those of the hazard as the causing one. In term of agriculture, the commodity is the affected part, while flooding becomes the common causing one. Thus, for example, vulnerability of paddy due to flood hazard is determined by the characteristics of the paddy such as the variety, the age (cropping stage) as well as the flood characteristics such as water depth, and duration of inundation.

Each rice variety has specific characteristics both physical and non-physical. The physical, in this case is the plant height, is also affected by the age of the paddy. The plant height and the flood depth determine the submerged parts of the plant. Together with the duration of inundation, it affects the level of paddy vulnerability to flooding. It can be described that flood is relatively harmless to the paddy when the crops are only partially submerged. However, it becomes dangerous when the plants are flooded for a long time. Vice versa, the short duration of inundation can be harmful to the paddy when the crops are completely submerged (Kundu, 2010).

Vulnerability is also defined as potential or degree of loss (UNDRO, 1991; Cutter, 1996; Provention Consortium, 2007). In term of flood-based vulnerability, specifically on paddy productivity, it can be expressed as potential production loss of paddy of several flood scenarios. Its level depends on not only the magnitude, usually express in the depth and duration, but also on the growth stage of paddy. The last mentioned relates to the plant height which is different in every stage.

2.5. RESILIENCE

Resilience is believed to have close relationship with the vulnerability. Zhou *et al.*, (2010) described the relationship in the figure 2.1. Vulnerability gives an overview of the possible losses which will occur as a response of a hazardous event. In other words, vulnerability is an expression of how sensitive a system to the event. Meanwhile, resilience shows the response rate for a system to be able to recover after suffering losses due to a disaster. Of the process perspective, vulnerability is actually focused on pre-disaster stages to strengthen the preparedness concept, while resilience more emphasis on post-disaster stages to support the ability of a system to recover after the disaster.

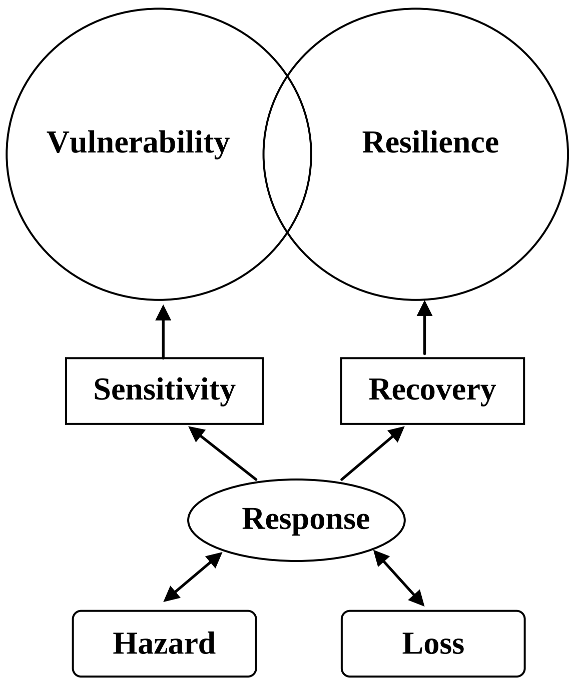

Figure 2.1. *The relationship between vulnerability and resilience*
source : (modified from Zhou et al, 2010)

Wildavsky (1991) defines resilience as the capacity to cope with unanticipated dangers after they have become manifest, learning to bounce back (Zhou *et al*., 2010). It includes inherent resilience which refers to the ordinary ability to deal with crises using available resource, and adaptive resilience which need some extra efforts (Rose, 2007). Also, it includes resilient response of production rescheduling, which refers to making up or ‘‘recapturing’’ lost production at a later date (Park *et al*., 2011).

Further, Boon *et al*., (2012) mentioned that resilience can be studied at several levels such as individual, community, or ecosystem, with the individual is the simplest one. Norris and Stevens (2007) added that economic factors are necessary to support individual resilience. Individuals or households having only one source of income have lower level of resilience than those who have more income sources (Freudenburg, 1992).

The resilience in this research is focused on the farmer ability to continue the paddy cultivation after a flood event. It was studied at individual level. Data used in assessing resilience were obtained from the questionnaires, so that the assessment accuracy is unnecessary because the data were relative, not the absolute one (Sun *et al.,* 2012). The five major forms of capital; *Social, Economic, Physical, Human,* and *Natural,* can be used as a framework to assess the resilience (Mayunga, 2007). However, only two forms are studied in this research namely human and economic capital.

Human capital is defined as the innate and derived capacities of working-age people that allow it to work productively with other forms of capital to sustain economic production (Smith *et al.,* 2001). It includes of education, skill, health condition, values, and personal characteristics, which not only affect the wellbeing of individuals but also flow on to society generally (McIntosh *et al.,* 2008). Particularly in this study, data about human capital collected trough the questionnaires are age, education, and cropping experience.

Economic capital is an essential factor in resilience. It directly supports the ability of both individuals and communities to absorb disaster impacts and speed up the recovery process (Mayunga, 2007). The investigated economic capital in this research consists of household income, dependent number, losses, and financial sources of next cropping.

3. RESEARCH AREA AND METHOD

3.1. RESEARCH AREA

Sidoharjo Village is chosen as the study area. It is one of villages in Sragen Regency, the eastern district in Central Java which is directly adjacent to East Java province. Clearer view of the village location is shown in the figures 3.1 and 3.2.

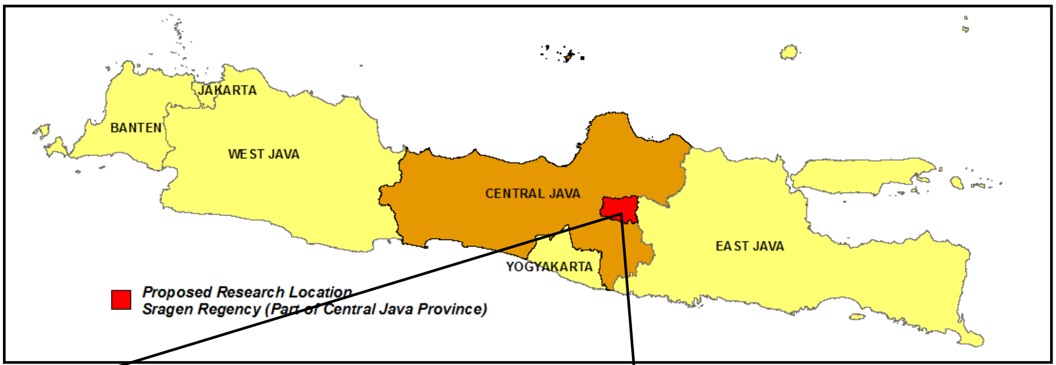

Figure 3.1. *Location of Sragen Regency in Java Island.*
(source : RBI map)

Figure 3.2. *Location of Sidoharjo Village in Sragen Regency*
(source : RBI map)

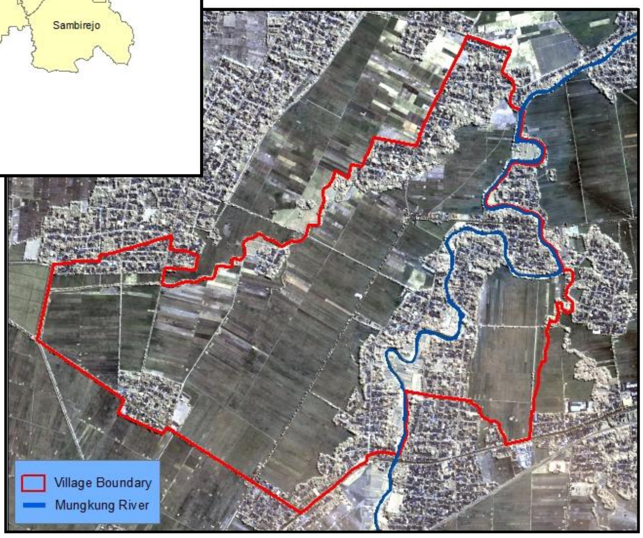

Figure 3.3. *Figure of Sidoharjo Village*
(source : Quickbird Image)

Sidoharjo village is selected as the study area because it fits with the research topic i.e. the production loss of paddy due to flooding. According to the description of the head of the local agriculture department as the results of pre-survey measure, Sidoharjo is one of granary in Sragen Regency. Most of the area in the village is designated as agricultural land. Irrigation system and the existence of farmer groups show that agriculture is the leading sector in this village. The existence of farmer groups facilitates the government to regulate the cropping to be done simultaneously. Figure 3.4 provides an overview of these conditions.

Figure 3.4. *Paddy field in Sidoharjo Village*
(captured during fieldwork)

Regarding the flood, the village is traversed by Mungkung River as the source of the flood in this area, see figure 3.3. According to the public communications center of Public Works Ministry of Indonesia, the river has a total length ± 32.00 km, the width of the cliffs either side is 30 m. It is a tributary of the Solo River which flows from the western slopes of Mount Lawu. Flood of 2007 was the biggest flood in the area in recent decades, so even though it was quite a long time ago, the incident still lingering in the memories of the residents and the farmers.

"Rikala beno 2007, kula munggah wonten wuwungan, pasrah nunggu asat."
(During 2007 flood, I went up to the roof, and I could only wait the flood recede).

It is a piece of story said by a farmer during the process of data collection through interview and giving questionnaires. Some also still remember very well how they were evacuated, and there are even some people who deliberately leave marks on the walls of their homes, as displayed in figure 3.5.

Figure 3.5. *2007 flood in Sidoharjo village*
(source : BAPPEDA archives)

3.2. RESEARCH METHOD

This research aims to construct the 2007 flood event map by integrating local knowledge and DTM, to do the agricultural loss assessment, and to analyze resilience level of the farmers. In order to achieve those objectives, several questions are built as shown in Table. 1.1. Meanwhile, what methods used to answer the questions are shown in the table 3.1.

Table 3.1. *Research questions and methods*

RESEARCH QUESTIONS	METHODS
1. To what extent the flood coverage in study area based on local knowledge and DTM?	Interview and using DTM
2. What is the depth of the flood in the research area according to community knowledge and DTM?	Interview and using DTM

3.	How about the damage in rice in the research area based on society knowledge?	Focus Group Discussion
4.	What are the total agricultural losses in the study area?	Spatial Analysis (GIS)
5.	How it compares between the calculated looses and those published by the local government?	Direct Comparison
6.	What is the paddy vulnerability of several flood scenarios?	Focus Group Discussion
7.	What is the farmer perception about the future losses?	Focus Group Discussion
8.	How far do the losses affect the lives of the farmers?	Questionnaire
9.	How do the farmers able to continue the cultivation after the flood?	Focus Group Discussion and Questionnaire
10.	What courses have been done by the local government and how far the farmers able to adapt them?	Questionnaire

The whole method and processes used in this research broadly consists of three parts, namely pre fieldwork, fieldwork and post fieldwork. All preparation required in the research was done in the pre fieldwork stage, while the data collection is a major part in fieldwork activities. Meanwhile, the collected data was processed and analyzed in the post-fieldwork activities. The entire process is illustrated in the following flow chart.

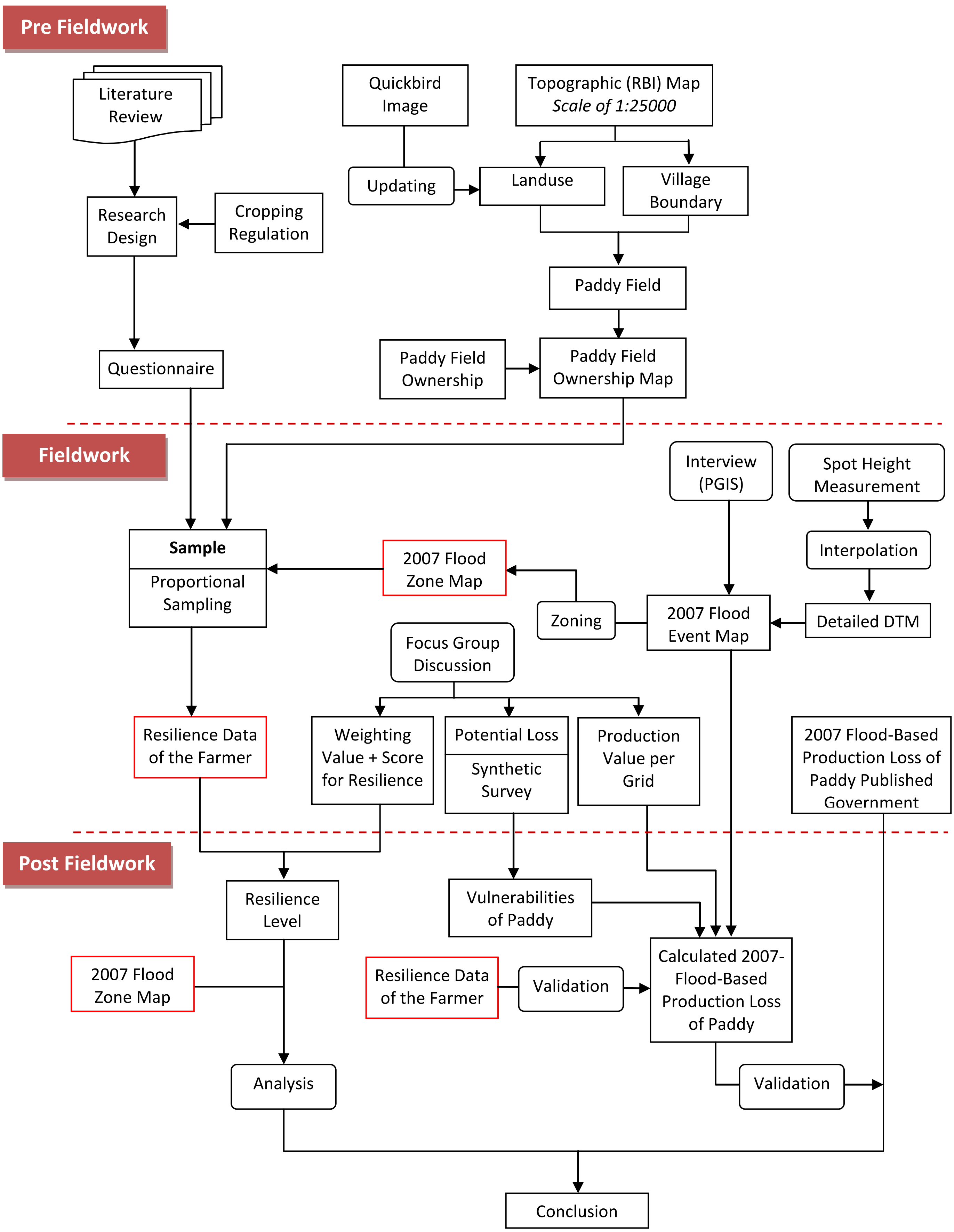

Figure 3.6. *Research framework*

3.2.1. Data Collection

This process took place in two stages as shown in Figure 3.6, in which it performed both in pre-fieldwork and fieldwork. The focuses of pre-fieldwork phase are building contact with the involved parties and prepare materials needed in the study. Some contacts have been built are the village head who formally became supreme leader in the village, the head of Agriculture Agency as the agricultural policy maker, rental provider of measurement instruments, farmer group leader who coordinates farmers in the study area, as well as several agencies that provide the necessary data. While the material collected in this stage is some secondary data such as Topographic map, Quickbird image, data of parcel ownership of paddy field, as well as data on the 2007-flood-based production loss of paddy published by government. Topographic map and Quickbird image were obtained from National Land Agency (BPN), while the parcel ownership data was obtained from village office. Meanwhile, the published production loss of paddy was get from Agriculture Agency of Sragen Regency.

Each secondary data has their respective functions in building the research framework. Quickbird image function for updating and refinement of landuse map extracted from Topographic map. Paddy fields have been identified in Topographic map is fitted with parcel boundaries obtained from the Quickbird. It was what would be filled with the attributes of field owner based on proprietary data obtained from the local government, to build a map of paddy field ownership. Meanwhile, data of the 2007-flood-based production loss of paddy published by government became the material to be compared with the production loss calculated in this study. The other information extracted from the topographic maps were contour and elevation contours used to design the distribution of sampled points of measurement, as well as the possibility of integrating the elevation points extracted from topographical maps and measured directly.

Meanwhile, the primary data was collected on the fieldwork stage. Information about socioeconomic condition of the farmers, paddy cultivation, and flood impact were obtained by giving questionnaire and focus group discussion (FGD).

a. Satellite-Based Measurement

According to topographic condition based on topographic map of the study area, several sampled points were designed. They were distributed by cross pattern along the main road. Specifically on the extreme feature like river, the sampled points were designed densely. First, the main frame points were measured and tied to the coordinate point of order 1 (national base point) by using static differential global positioning system (Static DGPS) method. Then, real time kinematic (RTK) method was used on detailed spot height measurement. See figures 3.7 and 3.8. The use of this technology is intended to improve the spatial accuracy of the point to be measured quickly (ITC, 2011).

Figure 3.7. *Static DGPS for base point measurement*

Figure 3.8. *RTK method for detailed spot height measurement*

b. Participatory GIS

Information related to the hazard in terms of causes and effects are provided in local knowledge. They can be obtained by using participatory approach method (Achmadi, 2012). In this research, the method was done by interviewing people to get information about 2007 flood traces in several locations, see figure 3.10. Then, the society-based flood marks were measured terrestrially using water pass to get the flood level of several points which can be identified on Quickbird image, see figure 3.9. Also, the measured points have to be tied on the sampled points have been measured previously with RTK GPS. It is necessary because the flood level was then integrated with DTM by using raster operation on ArcGIS software.

Figure 3.9. *Water pass measurement*

Figure 3.10. *PGIS by interviewing people*

c. Sampling Method

Sample is part of population. It is needed when all of the population is not possible to be measured considering time and cost. There are several sampling methods, and one of them is proportional sampling which is used in this study. Population of this research is paddy field parcels affected by 2007 flood. There are 318 flooded parcels obtained by overlaying paddy field ownership map (see figure 3.11) and map of 2007 flood extent (see figure 4.10 in chapter 4). Then, 10% of them, 32 samples, were randomized proportionally by considering the area ratio of flood zones. The zones were constructed based on the flood depth considering the damage in paddy. As the result of pre-survey measure, the rice start to be damaged at the flood depth of 50 cm and become very severe at the flood depth of 150 cm and above. The flood was thus divided into three zones namely less than 50 cm, 50 – 150 cm, and more than 150 cm. See figure 3.12.

In fact, there is a situation of which a parcel is in two or even three zones. Parcels with such condition are not included in the sample randomization to prevent ambiguous data, in order to get a result which provides a clear overview of each zone.

The sample distribution is displayed in figure 3.13.

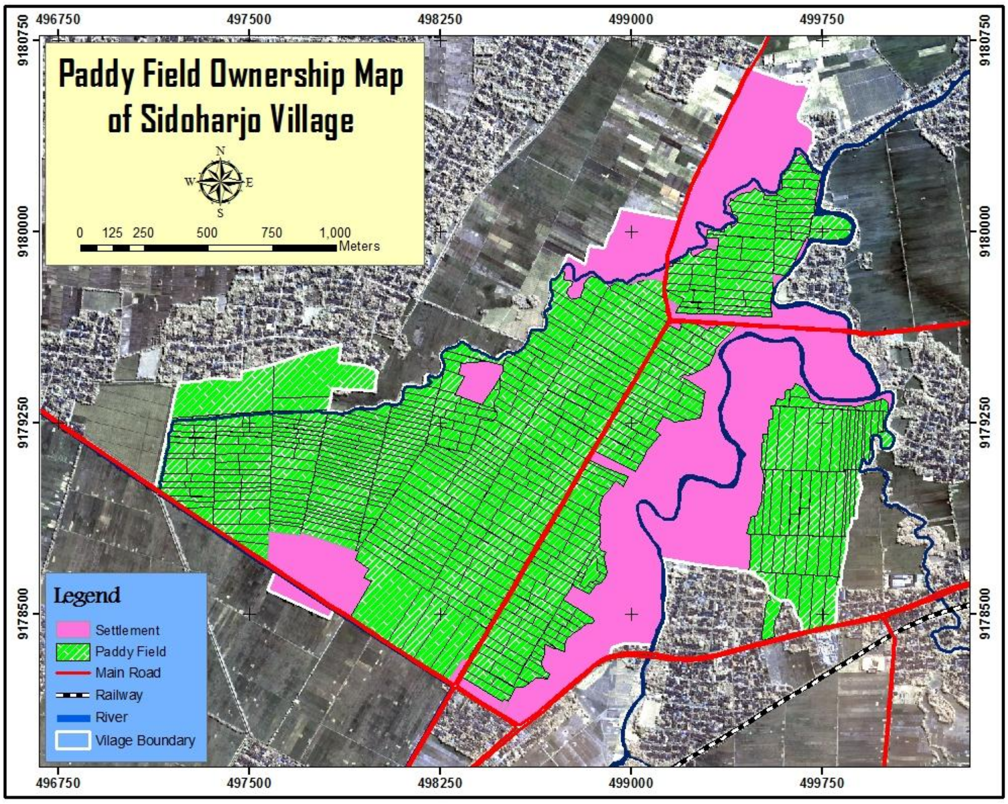

Figure 3.11. *Paddy Field Ownership Map of Sidoharjo village*

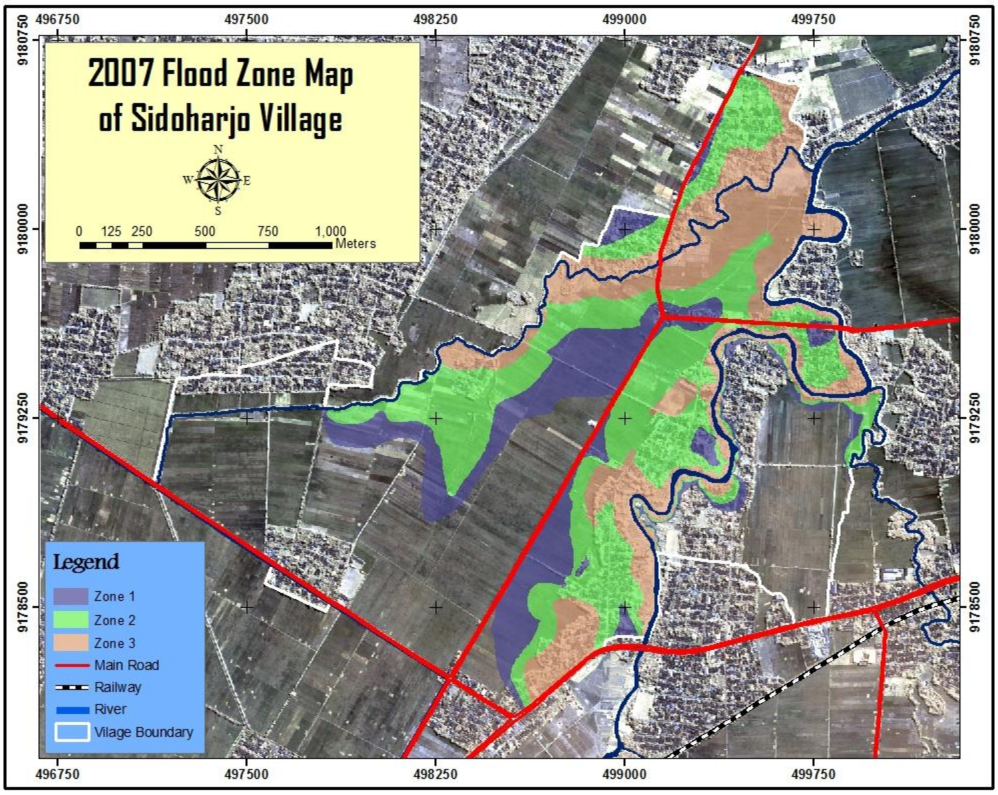

Figure 3.12. *2007 Flood zone map of Sidoharjo Village*

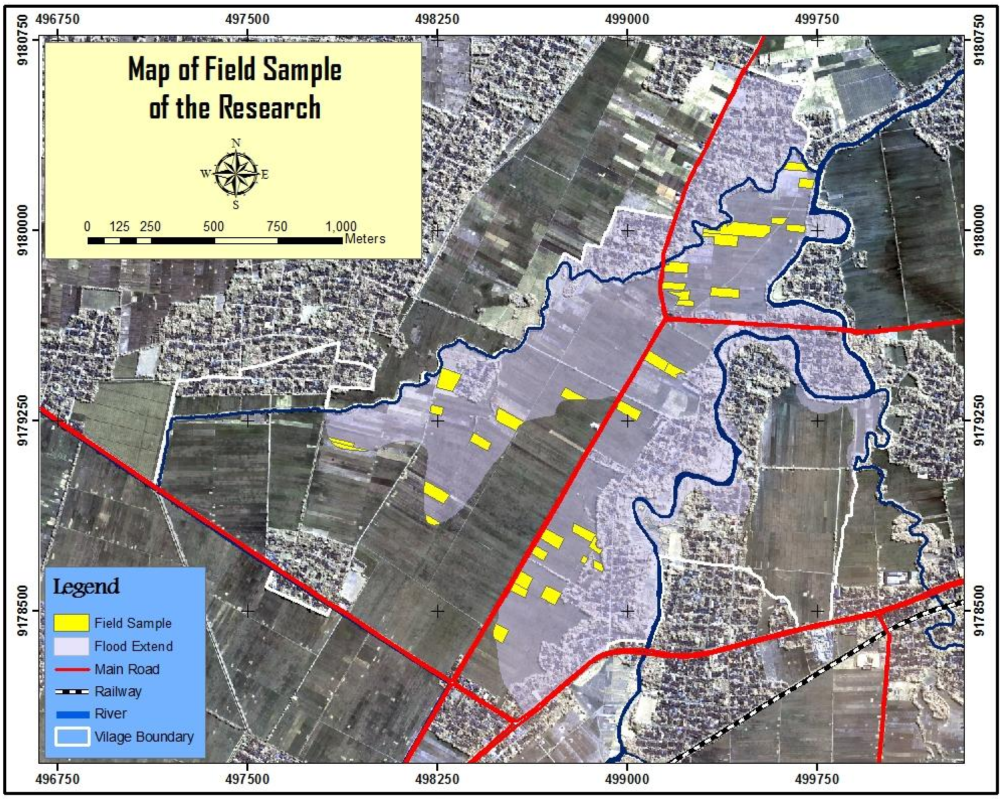

Figure 3.13. *Map of Field Sample of the research*

d. Questionnaire and FGD

There are several techniques of data collection in a research i.e. observation, questionnaire and structured interview (Sugiyono, 2009). Sugiyono added that the questionnaire is a data collection technique by giving written questions to be answered by respondents. In this study, the questionnaire were divided into five groups of questions namely questions about : socioeconomic condition, paddy cropping, flood impact, recovery process, and flood-based strategy.

Beside questionnaire (see figure 3.14), FGD (see figure 3.15) was also used in this research. FGD is a discussion by a group of people on a specific topic. The group is not just a collection of people talking to each other but rather to focus on particular people appropriate to goals to be achieved. Thus participants in the FGD can not be selected arbitrarily (Riyanto, 2011). The participants on this study are representatives of farmer groups. It was focused on weighting and score of resilience, synthetic survey (what-if scenario), and future flood perception.

Figure 3.14. *Primary data collection using questionnaire*

Figure 3.15. *Primary data collection using FGD*

3.2.2. Data Processing

After the needed data were collected, the next step is data processing. In this study, data was processed on pre-fieldwork, fieldwork, and post fieldwork stages. On pre-fieldwork phase, data like topographic map, Quickbird image, and proprietary data of paddy field were processed in ArcGIS 9.3 Software to construct paddy field ownership map as displayed in figure 3.13. The information was extracted from Quickbird image using on-screen visual interpretation. Several features identified and needed on this research are river, settlement area, paddy field (by parcels), and road. The village boundary is obtained from topographic (RBI) map.

The next data processing was done during the fieldwork. It was done in this stage in order to support other activities in this phase. First, the sampled points as the result of satellite-based measurements were interpolated using four methods i.e. kriging, spline, natural neighbour, and inverse distance weighted (IDW). All of them were done by using ArcGIS 9.3 software assistance. Using of four interpolation methods aimed to determine the most appropriate method in this research area. Then, the results of all used methods were validated using some of sampled points chosen randomly. The points included in the randomization are only points located in a flat area. This means that the points in extreme areas such as around the river and in the surrounding street that have a huge height difference by paddy field or other objects in the vicinity, were not included in the randomization process. If one of the points in that area was selected as a validation point of validation, the error generated would be enormo*u*s. See figure 3.16. Validation was conducted twice i.e. by 10% and 20% of validating points. The result is expressed in root mean square error (RMSE). The method that results the lowest RMSE in both 10 % and 20 % of validating used is the most appropriate method to create DTM of the area.

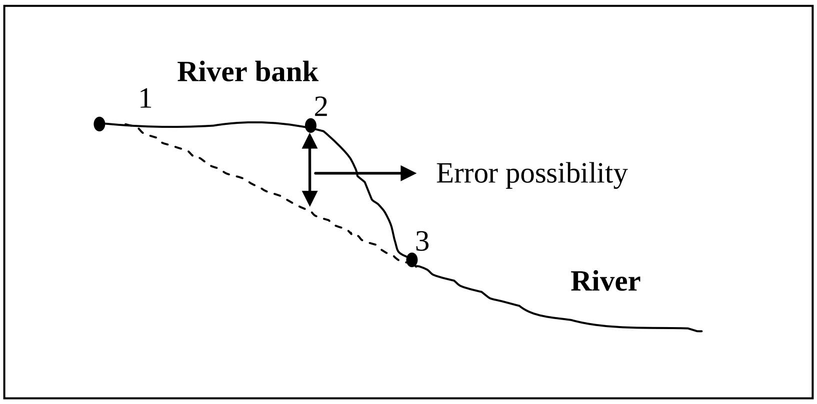

Figure 3.16. *Illustration of error possibility if a point in area around the river was eliminated*

The next process was constructing 2007 flood event map. It consists of flood extend and flood depth. First, the points of flood level as the result of participatory GIS process were interpolated to construct the raster of flood level in the research area. Then, the raster of flood level and DTM were processed using raster calculator in the software. The flood extent and flood depth would be the result of the process. An overview of the processes is displayed in figure 3.17.

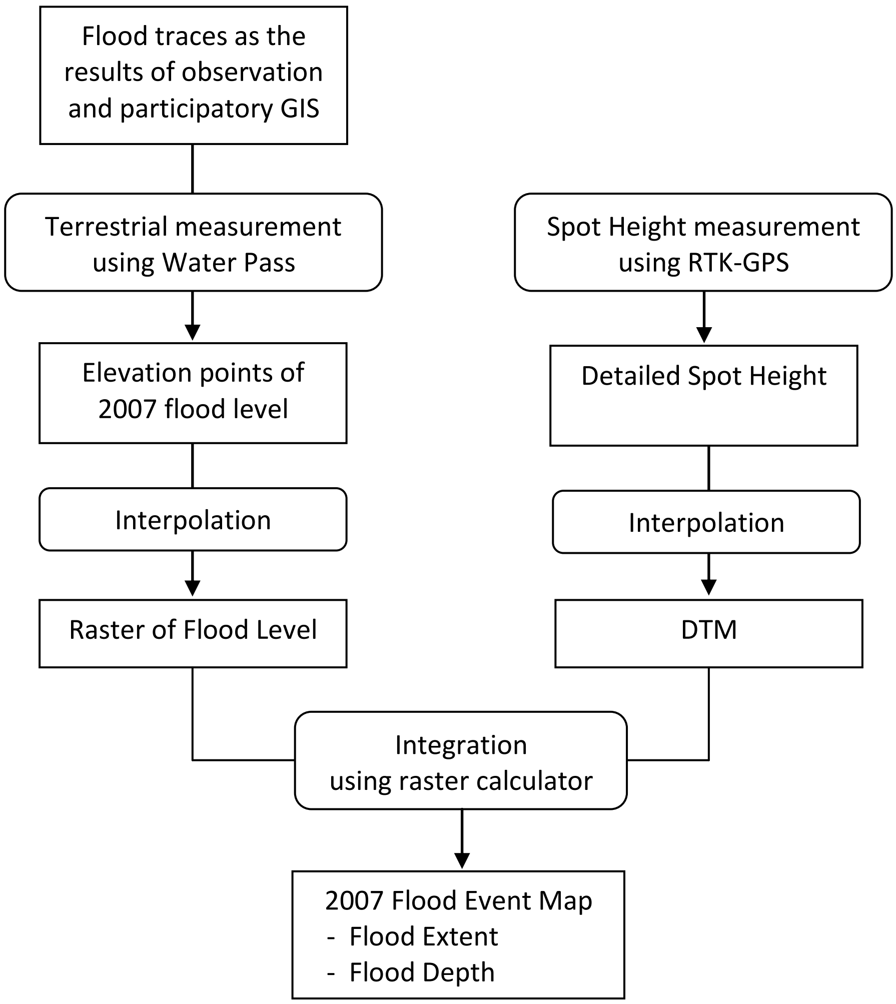

Figure 3.17. *Flowchart of constructing of 2007 flood event map*

Boolean operation was used to build the flood extent, in which if flood level is greater than the DTM so that the pixel values were changed to 0, and the other is 1. The logic is translated into the formula in ArcGIS as follows.

Con(([Flood_Level]>[DTM]),1,0)

Meanwhile, there were two steps in the flood depth constructing. First, raster of flood level was reduced by the DTM. If the results were negative then the pixel value of the pixel values were changed to 0, and the other values were the reduction results. The logics are translated into the formulas in ArcGIS as follow.

[Flood_Level]-[DTM]

Con(([Calculation]<0),0,[Calculation])

Some other data processing such as resilience level calculation, vulnerability curve construction, and production loss calculation were conducted in the post fieldwork phase. The individual resilience value of each sample was computed by using the weighting value and score obtained from FGD. Damage level of several scenarios which is also obtained from FGD was processed and converted into vulnerability curves. Both of them were carried in Microsoft Excel 2007 software. Using the curve, the production loss of paddy in the research area could be calculated. The loss value of each grid cell (pixel) was calculated and was then aggregated.

All of the needed materials and data processing were displayed in the following table.

Table 3.2. *Research data and processing technique*

Materials	Function	Source	Technique
Topographic (RBI) map	Getting the administrative boundary + contour line	National Land Agency	Clipping using ArcGIS 9.3 software
Quickbird image	Updating the landuse	National Land Agency	Visual Interpretation
Paddy field ownership	Attributing the paddy field ownership map	Village Office	Filling the attributes using ArcGIS 9.3 software
Measured points	Creating DTM	Satellite-based measurement	Interpolation using ArcGIS 9.3 software
Flood level	Constructing 2007 Flood Event Map	Interview (PGIS)	Raster operation in ArcGIS 9.3 software
Resilience data	Computing resilience value	Questionnaire	Calculating using MS Excel 2007
Weighting value and score of resilience factors	Computing resilience value	FGD	Calculating using MS Excel 2007
Several damage scenarios	Constructing vulnerability curves	Synthetic survey in FGD	Creating curves using MS Excel 2007

3.2.3. Data Analysis

In this section, all of the data and the results of the data processing were analyzed to answer the research question (see table 3.1). In terms of resilience level, the obtained value was analyzed by looking for relationship trend with factors that build it. Also, in this section the relationship propensity between the flood zone and resilience level as well as the influencing factors were also sought. Meanwhile, on the production loss of paddy, the data obtained from the relevant authority, Agriculture Agency of Sragen Regency, was validated using the value of production loss calculated in this study. The calculated value was also previously validated using loss data obtained from the questionnaire.

4. MAPPING OF 2007 FLOOD EVENT IN SIDOHARJO VILLAGE

This chapter describes about all processes and results about the 2007 flood event map constructing in Sidoharjo village. Since the flood event is created by integrating local knowledge and DTM, so that it consists of several activities such as satellite-based measurement of sampled points, DTM constructing, 2007 flood extent mapping, and 2007 flood depth mapping. All of the processes are related to the research area, Sidoharjo village.

4.1. SAMPLED POINT MEASUREMENT

Sampled point meant in this study is the spread of points representing terrain condition in the field, which will be then interpolated to construct the DTM. Basic idea of the measurement is to detail the existing DTM built from an existing contour map as part of a topographical map of Indonesia (RBI). Unfortunately, the contours used as a base for the DTM construction have a considerable interval i.e. 12.5 meters. It causes difficulties in flood modeling of the study area since the detail of DTM directly influences the depth of flood at the site. Moreover, the main subject of this research is paddy in which the vulnerability highly depends on how the flood soaks the plant.

Technically, the sampled points were measured directly by GPS equipment assistance. There were two steps of it namely main frame building and detailed spot height measurement. On the first step, a web of base points was designed as the references on the next step. This web was tied to the coordinate point of order 1 (national base point), so that all measured sampled points were automatically integrated in WGS 84 coordinate system and projection system of UTM. Also, since the elevation of point measured by GPS refers to the ellipsoid, an initial setting is necessary to change the vertical datum into geoid. In this study, three receivers were used. A receiver was set on the national base point while the two receivers were put on the measured points. It serves to improve bias error, in which the receiver on the known coordinate counts correction for each satellite signal and send it to others (Morales and Tsubouchi, 2007).

Then, one of the measured points was used as base station for the next measurement. There were totally seven base points measured in the field. After the web of base points had been established, the next one, detailed spot height measurement could be done.

Measurement of the sampled points was done by following the point distribution previously designed. They were distributed by cross pattern along the main road. Specifically on the extreme feature like rivers, the sampled points were designed densely. In this activity, RTK GPS method was used to speed up the process. Basically, it is the same method as DGPS, but the receiver in the base station will transmit real time radio links containing information and corrections (Morales and Tsubouchi, 2007). The process of signal reception in this method only took approximately 60 seconds, so that the rover receivers could move freely and quickly. Since the research only took 2007 flood as the focus, the known changes in feature after 2007 were not included as the measured object. For instance, the road shown as yellow line on figure 4.1 was elevated in 2011, so that the measured elevation was the old one (before raising). There were 930 sampled points measured. The distribution of them is shown in this following figure.

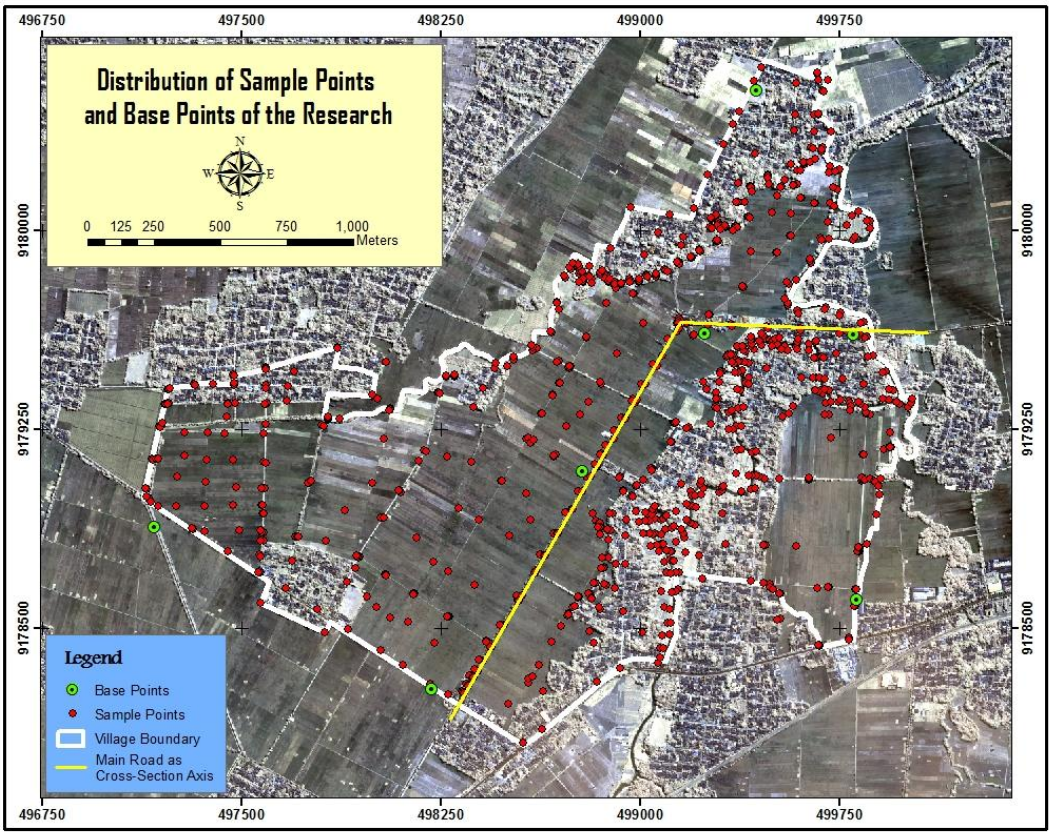

Figure 4.1. *Distribution of base and sampled points*

4.2. DTM CONSTRUCTION

Topographic data is a very important material in flood modeling, and DTM is the inner part which is widely used in the topographic analysis (Masood and Takeuchi, 2011; Neelz and Pender, 2007). The DTM in this study was constructed by interpolating several measured points directly. Interpolation is basically used to create a continuous surface from sampled point values. The interpolation are generally divided into deterministic method which creates surfaces refers to the extent of similarity or the degree of smoothing, and geostatistical method which uses the statistical properties of measured points to create them (ArcGIS Desktop Help).

Both of the methods were served to interpolate the sampled points in the research, i.e. Inverse Distance Weighted (IDW), Spline, Natural Neighbour, and Kriging. It was conducted in ArcGIS 9.3 Software in default setting. The most suitable method used in this area was determined by comparing the methods in term of the validation result. They were validated statistically by computing RMSE values as described in section 3.2.2.

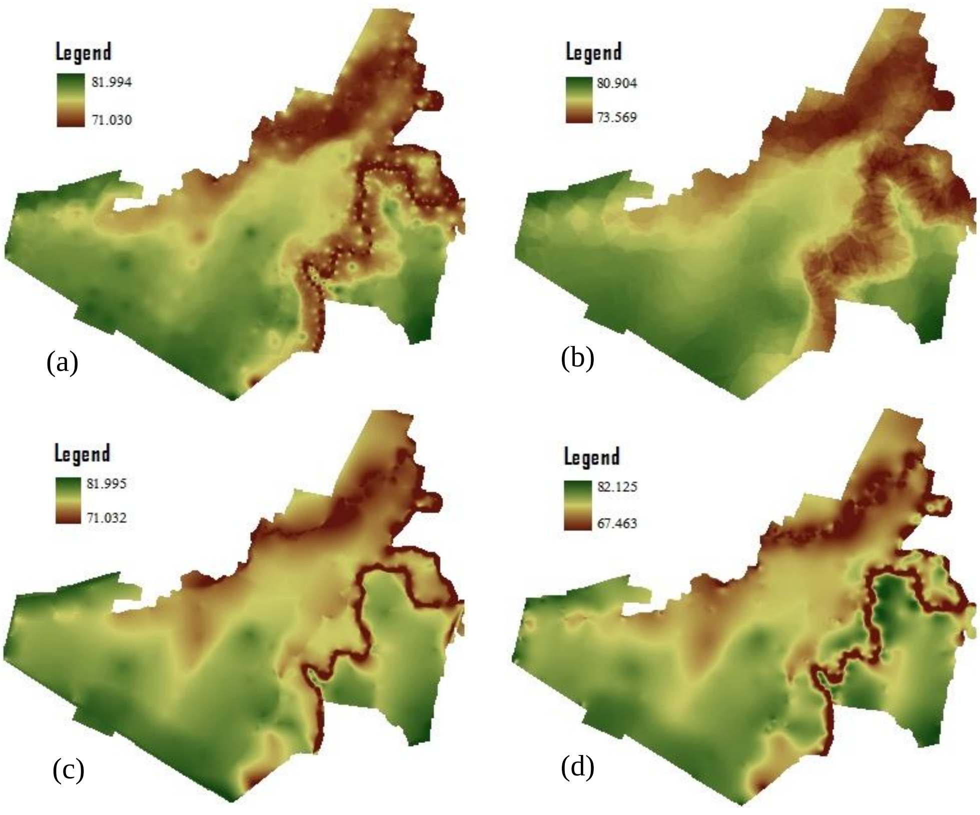

Figure 4.2. *DTM as the results of (a).IDW method, (b).Kriging method, (c).Natural Neighbour method, (d).Spline method, (minus 10% validating points)*

Figure 4.2 above shows the results of interpolation methods used in this research i.e. (a) inverse distance weighted, (b) kriging, (c) natural neighbour, and (d) spline. The interpolation processes use the measured points which is previously reduce about 10% as the validating points. Visually, they show differences of each used method. However, the natural neighbour and spline give results visually close to each other. If we assume the lower and upper bounds of the generated surface can express the closeness between the interpolation results and sampled points, then the inverse distance weighted and natural neighbour give the results that are closest to the points. The lowest Z value of the measured points is 71.038 while the highest value is 81.996. Similar results were also seen in the second validation process in which 20% of the measured points were randomly selected to be validating points. However, the most appropriate outcome is determined not visually but statistically by looking at the overall correspondence between the source and result which is expressed in RMSE values of the representing points.

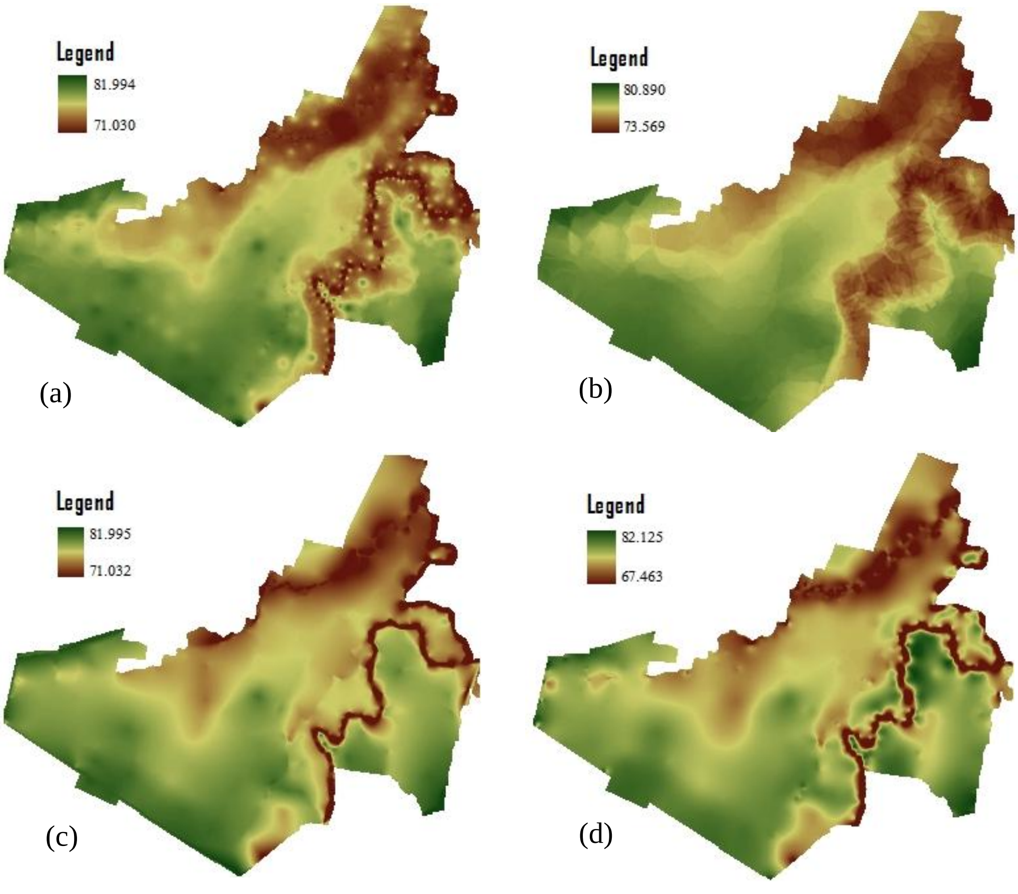

Figure 4.3. *DTM as the results of (a).IDW method, (b).Kriging method, (c).Natural Neighbour method, (d).Spline method, (minus 20% validating points)*

Table 4.1. *RMSE values of interpolation results*

Validating Point	RMSE of Several Interpolation Methods			
	Spline	Kriging	IDW	Natural Neighbour
10%	0.516	0.792	0.615	0.262
20%	0.919	1.267	1.068	0.903

According to Table 4.1, the most suitable method to be used in DTM construction of the research area is natural neighbour. It refers to the RMSE value in which the natural neighbour results the lowest one both of the 10% and 20 % validating points. Error distributions of the methods are displayed on Figure 4.4, 4.5, 4.6, and 4.7.

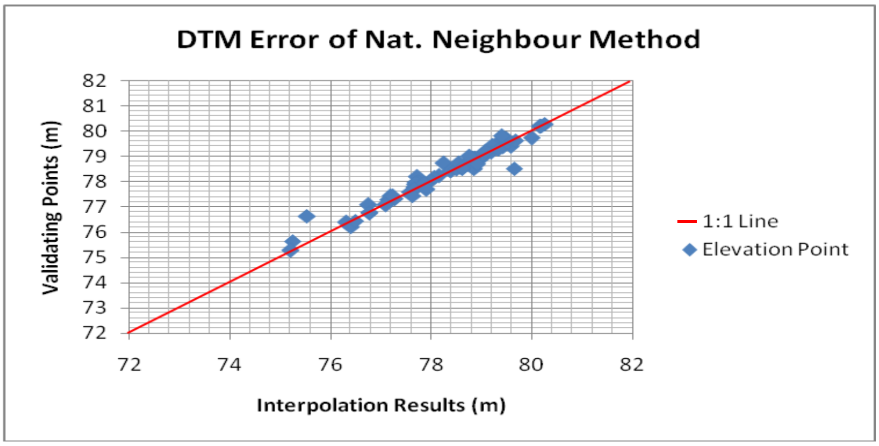

Figure 4.4. *Comparison between the elevations of DTM as result of natural neighbour method and corresponding validating points*

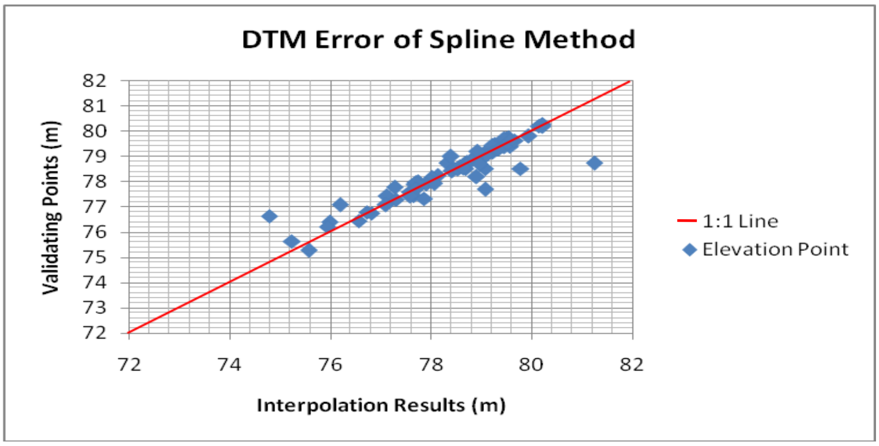

Figure 4.5. *Comparison between the elevations of DTM as result of spline method and corresponding validating points*

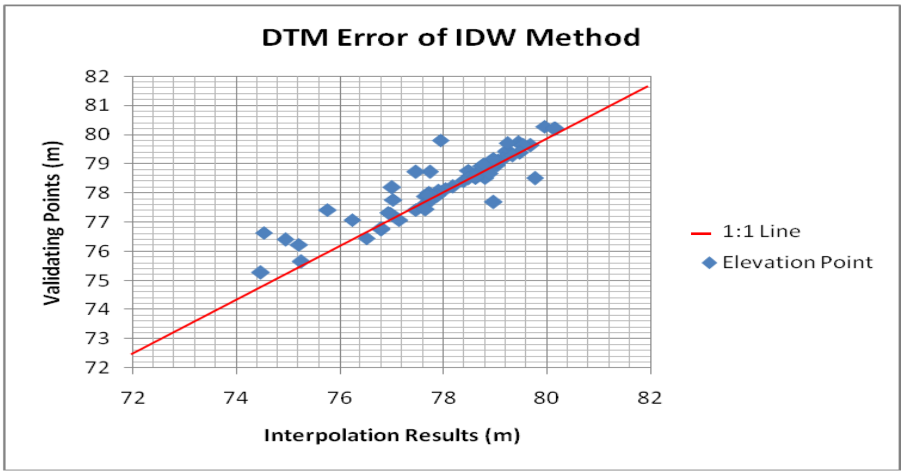

Figure 4.6. *Comparison between the elevations of DTM as result of inverse distance weighted method and corresponding validating points*

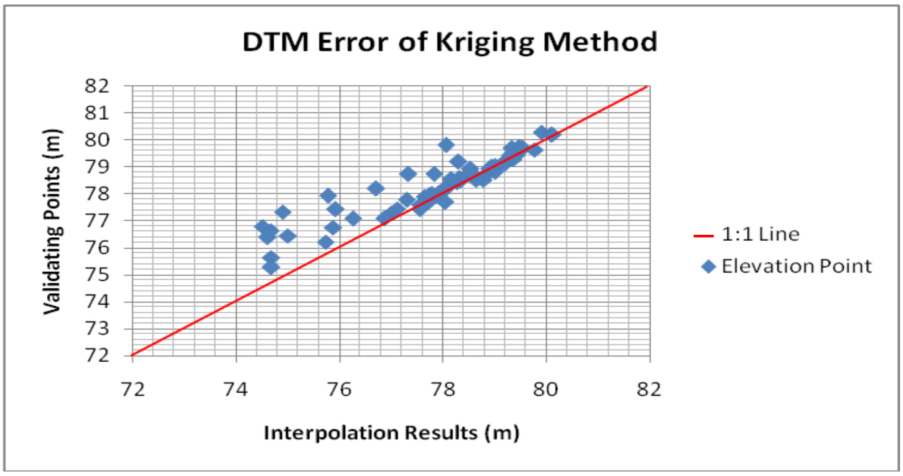

Figure 4.7. *Comparison between the elevations of DTM as result of kriging method and corresponding validating points*

The charts show comparisons between the elevations obtained from the interpolation of the four used methods used and those of validating points obtained from the field measurement. A total of 64 points (10%) of all measured points were used in the comparisons. The red lines in the graphs are 1:1 lines exhibiting a condition in which both of the elevations have the same value (zero error). The closer the plotted elevation points with the red line, the smaller the error at that points. They show obviously that the natural neighbor has the best result. However, all of four methods provide good outcomes in elevation between 78-80 meters. Henceforth, all measured points were interpolated using the natural neighbour method to build a DTM of the research area based on the measured points.

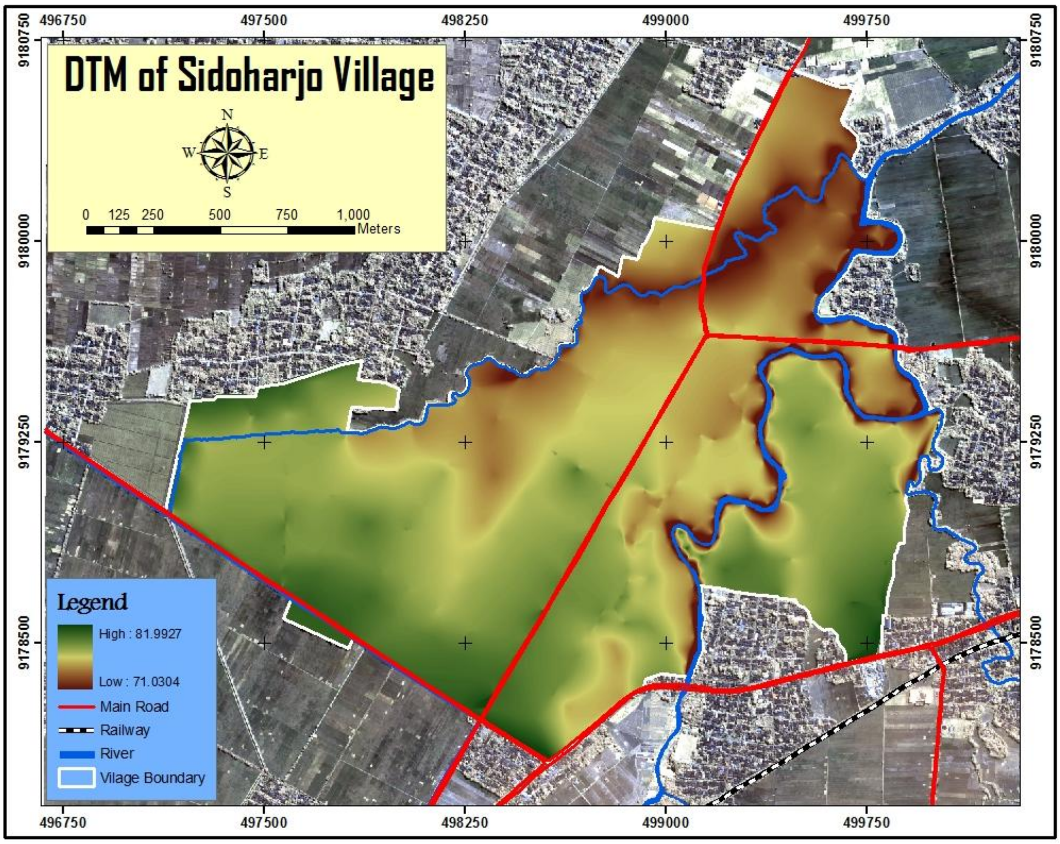

Figure 4.8. *DTM of research area based on measured points*

As mentioned earlier that the sampled point measurement was conducted to detail the existing DTM built based on contour line of RBI map. Or conversely, some elevation information can be extracted from the existing DTM to refine the measurement-based DTM measurement results, especially in regions with a low density of sampled points. Therefore, the RBI-based DTM was firstly validated by using 10% of sampled points used in the previous validation process. From this process, the resulting RMSE value is 3.372. This value is somewhat large so that the elevation data obtained from RBI map is not suitable for DTM completion. It is possibly caused by the map scale of used RBI is 1:25000 with the 12.5 meters contour interval, so the DTM generated from the contour lines is even less detail. Figure 4.9 shows that there are only a few elevation value generated from RBI contours, and even all points in height of 76.5 - 78.5 meters are indicated by a single value in the RBI-based DTM i.e. 75 meters. Thus, the DTM used in the next process is the measurement-based one.

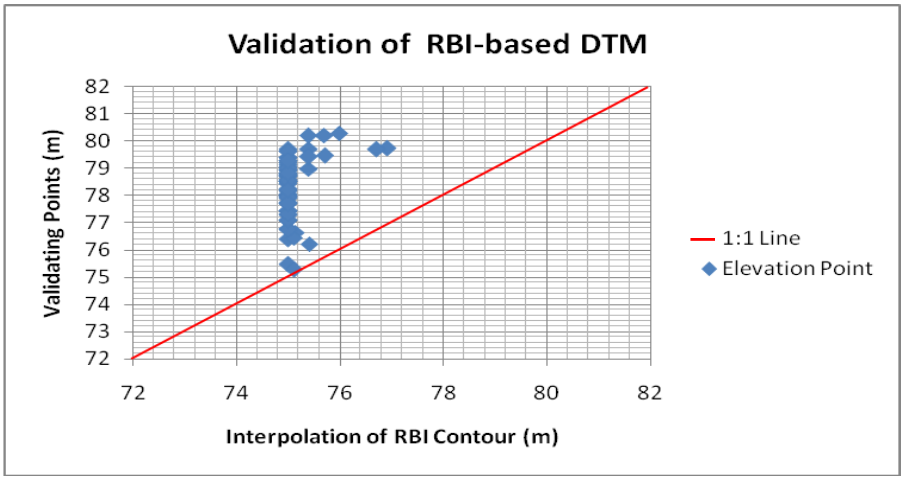

Figure 4.9. *Comparison between the elevations of RBI-based DTM and corresponding validating points*

4.3. 2007 FLOOD EVENT MAP BUILDING

Flood event map of research area is the important part of the study. It becomes an essential material of other processes. Also, it is the first objective to be achieved in the research. The map was created by integrating the DTM and local knowledge. The outcomes consist of information about flood extent and flood depth of 2007 event. In the beginning, there were two flood characteristics considered in this study i.e. flood depth and flood duration. However, according to the result of pre-survey interview conducted to some farmers, the only influencing characteristic in the area is flood depth. Flood is not inundated the region more than one day, so that the duration diversity has no effect on damage level of the paddy in the area. In addition, the diversity of flood duration in this area has been integrated on flood depth. It means, the deeper the flood, the longer the duration. Meanwhile, the water velocity, according to the farmers, is not so influential on the damage level of rice. Easy to collapse or not the rice depends on the farmer behavior in fertilization. Fertilizer composition including the type and amount effects on plant characteristics. However, it can not be mapped.

Actually, in the following interview, during primary data collection, there were some respondents who called mud also affect the level of damage to rice, but it also could not be identified spatially. There is no spatial consistency in the respondent answers associated the mud influence. As clarified in the FGD, it was true that flood in this area contains mud. It can be seen from the water turbidity. However, due to the short duration, the amount of mud deposited is not significant enough, so it does not affect the damage of paddy. Thus, only flood extent and flood depth were resulted from the integration of DTM and local knowledge.

The local people provide information about flood level in several locations. Then, they were generalized as the flood level of the whole research area. However, it produced inappropriate outcome. When the map was validated in the field, there were several locations which is actually flooded but they were not identified as flooded areas in the map. After digging more deeply by interviewing more people, there are three sources of flooding in the area which led to the diversity of flood level. They are the rise of Mungkung River as the main source, the accumulation of rain collected and stuck in local channels and sunken areas, as well as the water runoff that does not follow the turned direction of the river. For the last mentioned, it can be explained that the water discharge getting larger in the river bend. There is centripetal force causing the water flow pushed to the outer bend (Warnana, 2008). The flow caused by the centripetal force then become the main stream of the flood, as shown in Figure 4.10.

The detailed flood level of the study area is achieved by interviewing more people to get more flood traces. As described in the section 3.2.1, a terrestrial measurement using water pass was necessary to convert the flood marks in to flood level having the same reference with the DTM. Then, the raster of local knowledge-based flood level was processed together with the DTM to produce the flood extent and the flood depth as described in section 3.2.2 (see figure 3.17).

In the north and upper east parts (see figures 4.10 and 4.11), the flood was interrupted by border of research area, while in the middle; it was cut off by the road as the natural levees, shown by the red line on the map. The same condition also occurs in flood depth map obtained in the next process.

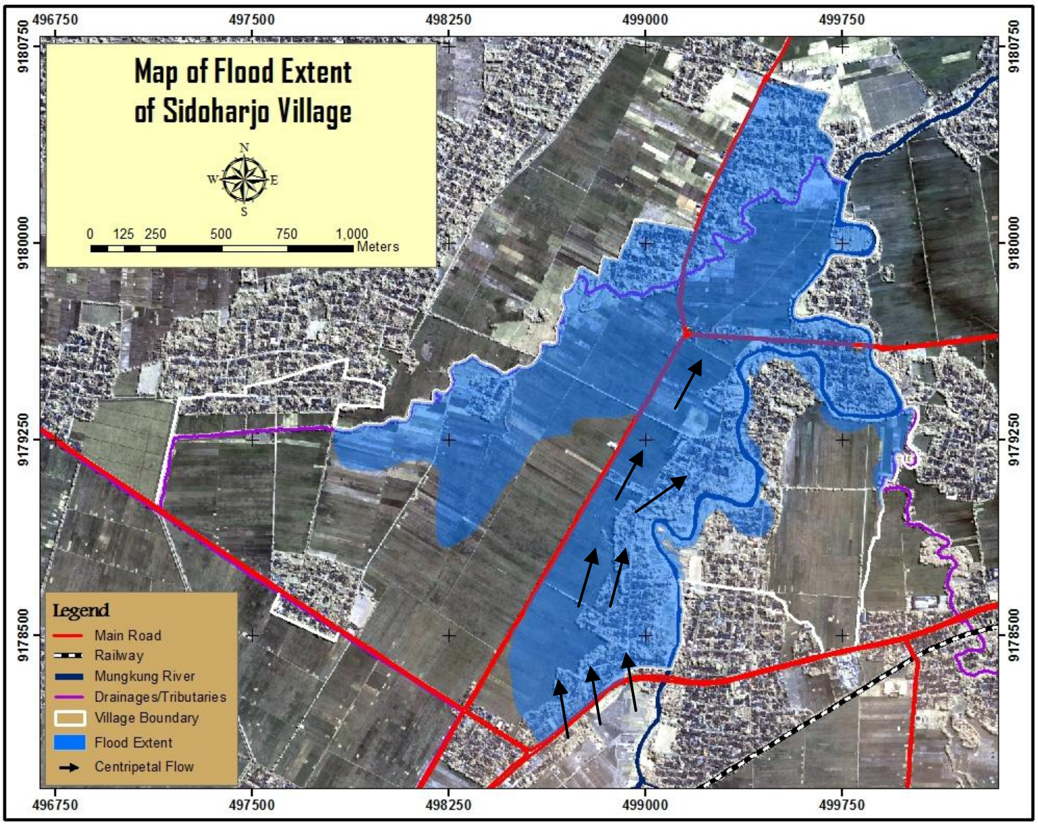

Figure 4.10. *Map of 2007 flood extent of the study area*

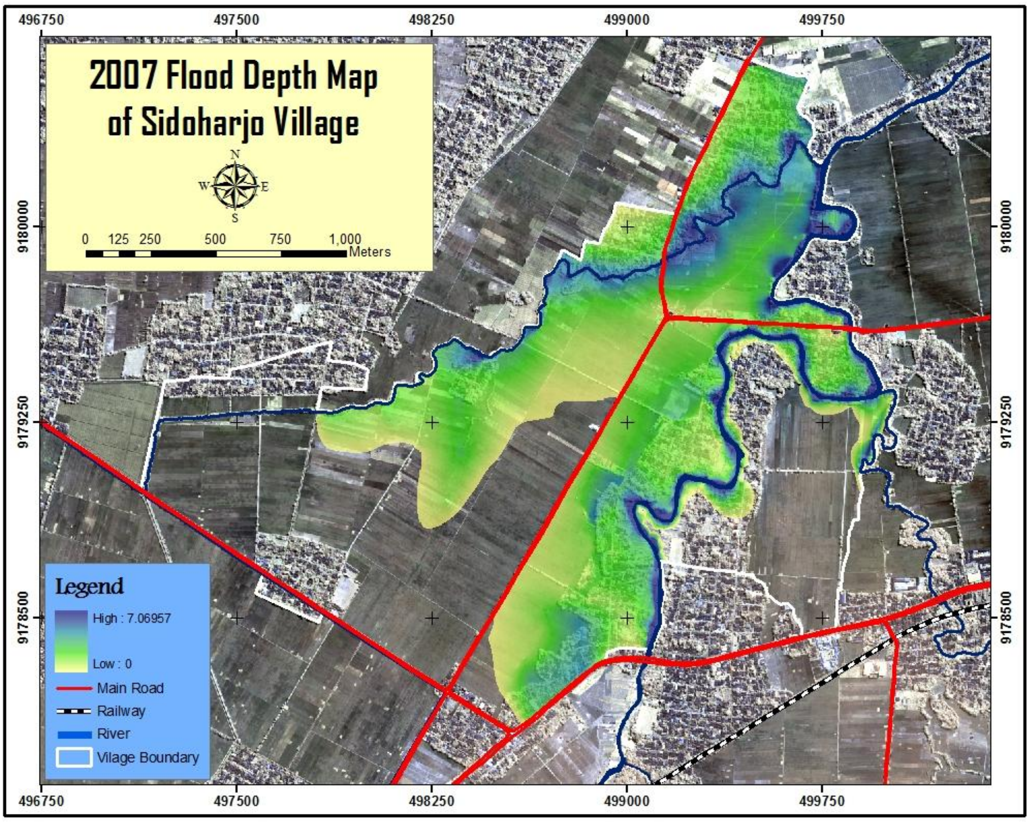

Figure 4.11. *Map of 2007 flood depth of the study area*

5. LOSS ASSESSMENT

One critical factor in flood control planning and flood-based policy making is flood loss assessment. It can be done either based on statistical data or by using GIS. The second method offers abilities not only to analyze but also to display the result (Xie *et al*, 2007). Coverage of loss assessment is so extensive. This study is restricted to the assessment of production loss of paddy. The value of loss is calculated using a vulnerability approach, in which vulnerability is defined as potential or degree of loss (UNDRO, 1991; Cutter, 1996; Provention Consortium, 2007).

5.1. GENERATING PADDY VULNERABILITY

Vulnerability can be described in some manner such as vulnerability indices, vulnerability curve, fragility curve, and vulnerability table (van Westen and Kingma, 2012, MHRA Session 5). This study displays it in the curves relatively by associating the damage percentage of paddy and the hazard magnitudes. The damage data was obtained from synthetic survey through FGD considering flood depth, paddy variety, and growth stage of paddy. Flood depth is related to the several scenarios of magnitude to construct the curve, while variety and growth stage of paddy are related to the plant height during the exposure.

There were four varieties cultivated at the time of 2007 flood i.e. *Ciherang, IR-64, Wayapo Buru*, and *Situ Bagendit*. The first three varieties have a relatively same life phase and plant height, while *Situ Bagendit* has a slightly different phase and height. However, the differences have no effect on the generated synthetic damage data. Moreover, the *Situ Bagendit* was not a favorite in the area. Of 32 respondents, only a farmer planted this variety. Thus in this study, the variety is considered no effect on the level of damage to rice. Hereinafter, the phase and height of the three varieties were considered to be representative in the collection of synthetic damage data. Meanwhile, related to the cropping stages, there are three main phases to be considered i.e. vegetative, generative or flowering, and graining phases (Hanum, 2008).

Table 5.1. *Synthetic damage data of paddy in Sidoharjo village*

Cropping Stage	Age of Paddy *(days)*	Plant Height *(cm)*	Damage Percentage When Exposed by Flood up to *50 cm*	*100 cm*	*150 cm*	*200 cm*
Vegetative	60	75	0	30	60	100
Generative	80	120	30	80	100	100
Graining	115	105	40	60	80	80

Table 5.1 shows the result of synthetic survey to get the damage data on paddy of several flood depth scenarios through FGD. As a note, the results are associated with the research area that has brief flow duration, so it can be ignored.

5.1.1. Paddy Vulnerability at Vegetative Stage

According to the FGD results, paddy at this phase is not very sensitive to water. A brief immersion insofar as not reaches the *"pupus",* rod tops, can still be tolerated by the plants. The height at this stage is 75 cm with a rod height of 60-70 cm. The age of paddy of the phase reaches 60 days after seeding.

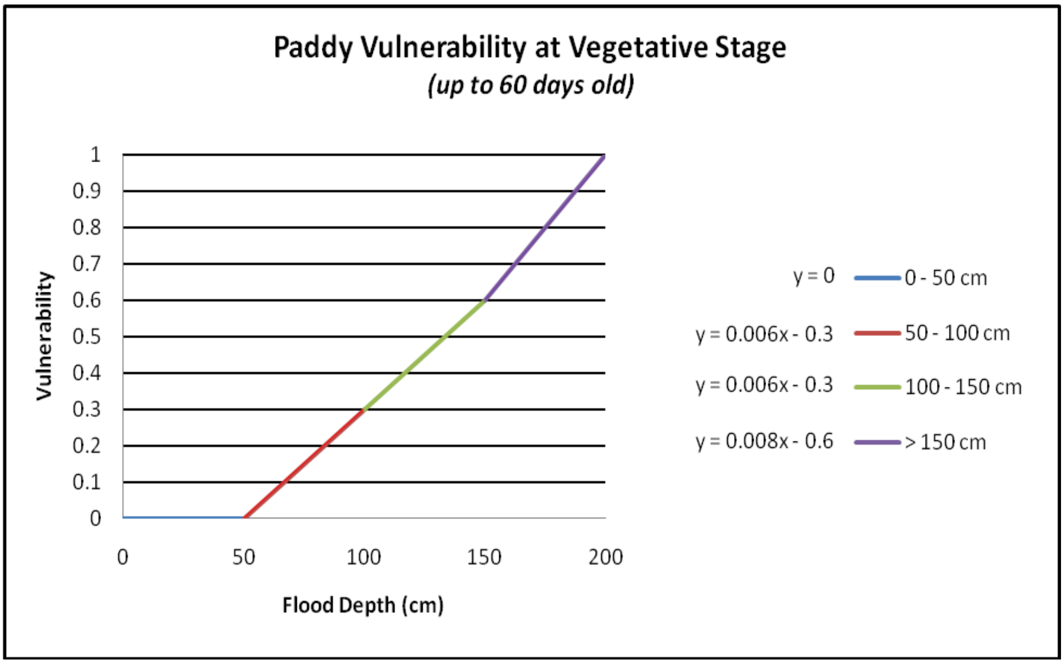

Figure 5.1. *Vulnerability curve of paddy at vegetative stage*

At this stage, the plants are safe until the 50 cm high of inundation, and begin to be affected thereafter. The damage is getting bigger until they are totally damaged at the 200 cm of inundation or larger. At this condition, the flood normally reaches a maximum duration occurred in the area i.e. one day inundation. In case of the flood with a magnitude as it did in 2007, the paddy vulnerability at this phase of Sidoharjo village can be mapped as shown in the following figure.

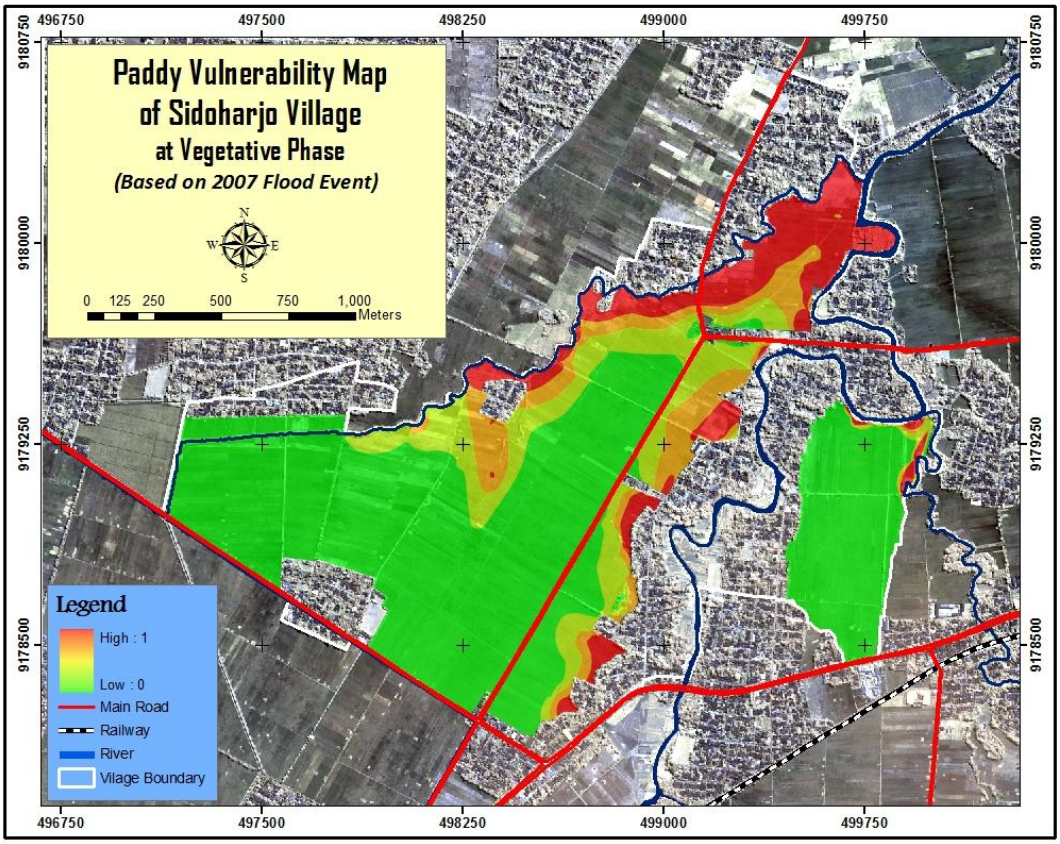

Figure 5.2. *Map of paddy vulnerability at vegetative stage*

5.1.2. Paddy Vulnerability at Generative Stage

Paddy will reach a maximum height of this phase. Of varieties cultivated in this area, they reach 120 cm at this stage. However, the plants are very sensitive to water. They do not need a lot of water in this stage. Water immersion will affect the process of pollination.

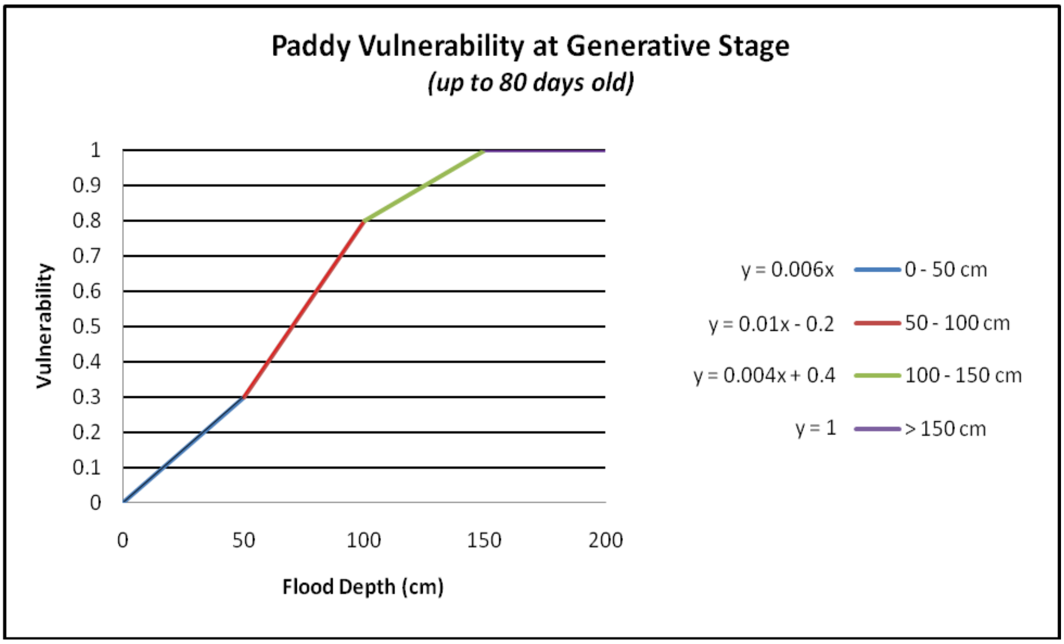

Figure 5.3. *Vulnerability curve of paddy at generative stage*

The damage at this stage is not associated with damage to crops, but the failure of the pollination process. The completely submerged plants can still survive, but no grain resulted from the process, so that no rice can be harvested.

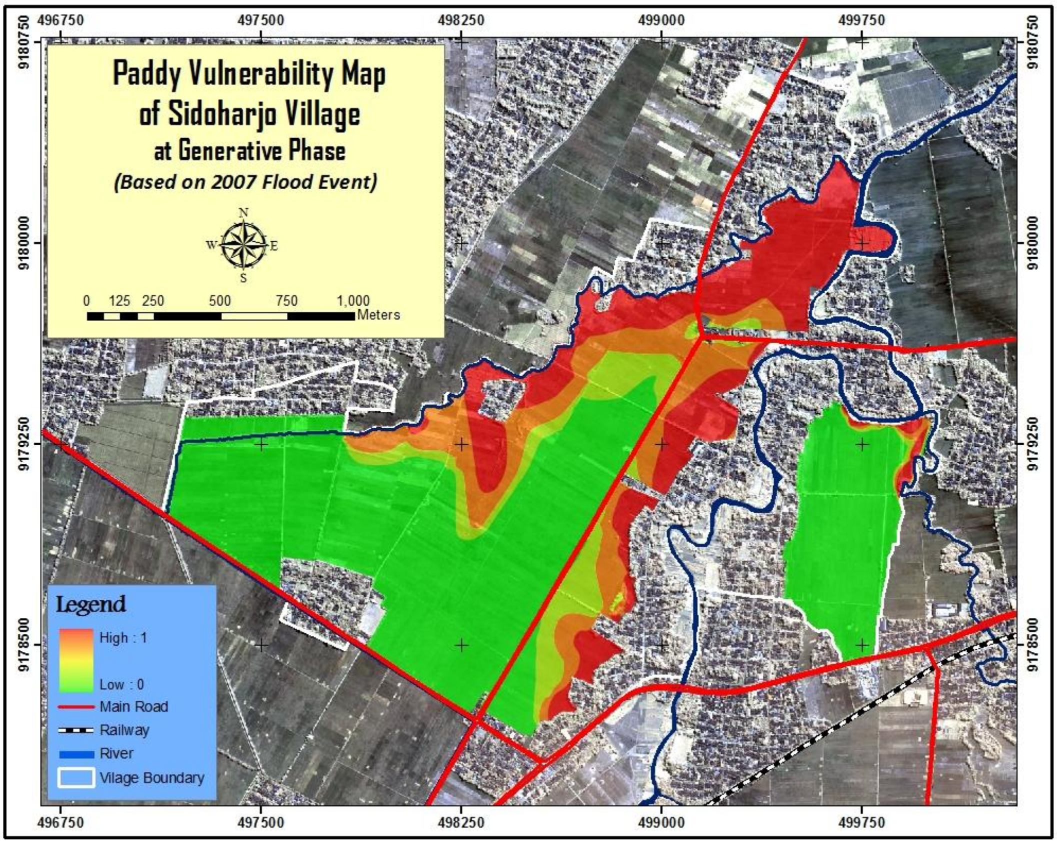

Figure 5.4. *Map of paddy vulnerability at generative stage*

5.1.3. Paddy Vulnerability at Graining Stage

This stage is similar to previous one in which paddy do not need much water, because it is the phase of formation and hardening of the grain. Thus the plants are very sensitive to water immersion. It impacts to the harvest both in quality and quantity. In quality, the produced grain will be changed in the flavor and color; while in quantity, tonnage of the harvest will be reduced along with the disruption of process that occurs at this stage.

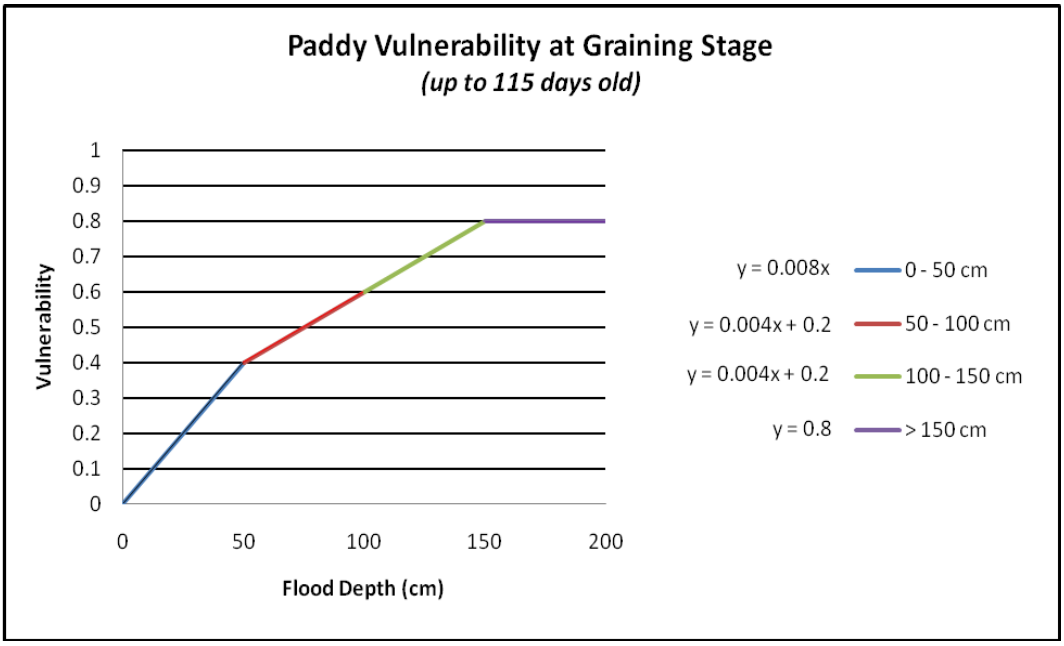

Figure 5.5. *Vulnerability curve of paddy at graining stage*

At this stage, the losses are also not associated with damage to crops but decrease in yield. When grains are formed and just waiting for the harvest, the immersion of any depth will not cause a complete damage, there are still a few results could be harvested. Therefore, the curve does not reach number 1 as the maximum value of the scale. However, there is a huge decline in both quality and quantity, as mentioned previously. In case of the flood with a magnitude as it did in 2007, the paddy vulnerability at graining phase of Sidoharjo village can be mapped as shown in the following figure

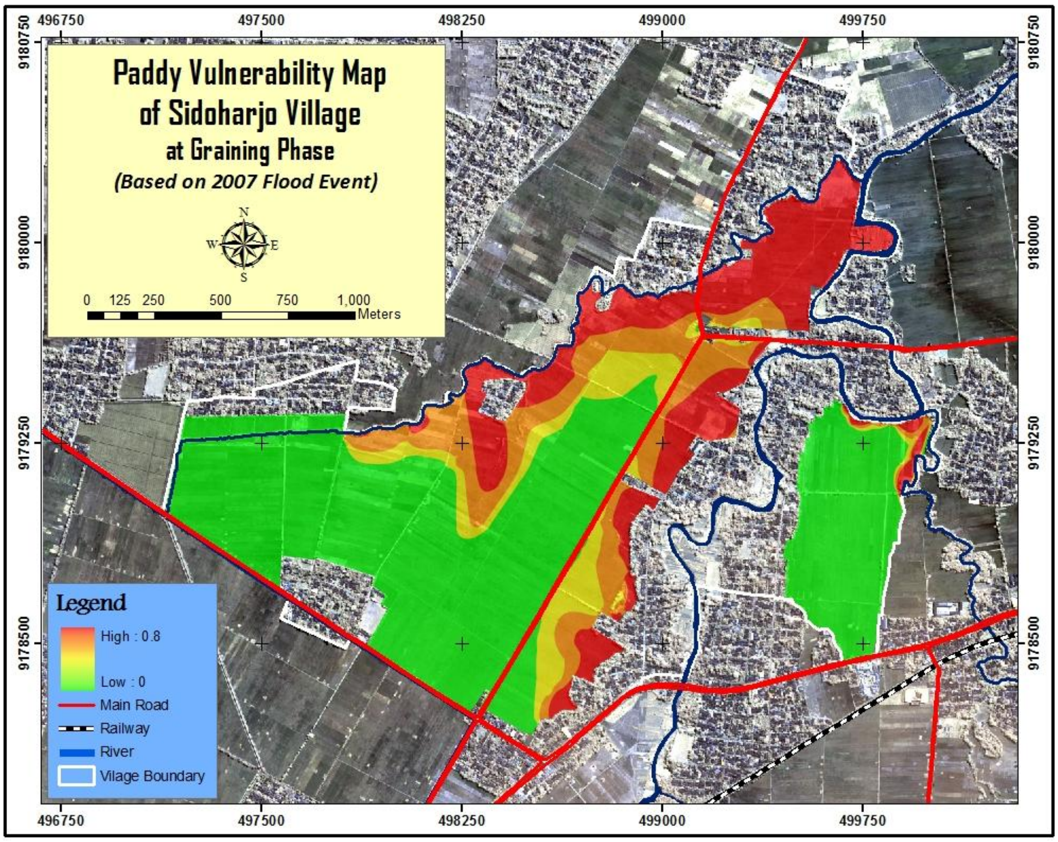

Figure 5.6. *Map of paddy vulnerability at generative stage*

5.1.4. Comparison of Paddy Vulnerability at Three Stages

From the explanations of paddy vulnerability of each phase before, there are differences of each phase. The differences are caused by two things. The first is the difference in plant height for each stage, which would certainly affect the submerged part of the plant for each flood depth scenario. The next difference related to the sensitivity of plants to water for each phase. There is a stage in which the rice is tolerant to water, but there are also stages when the paddy does not need much water.

A clearer presentation of the differences is seen in these following curves.

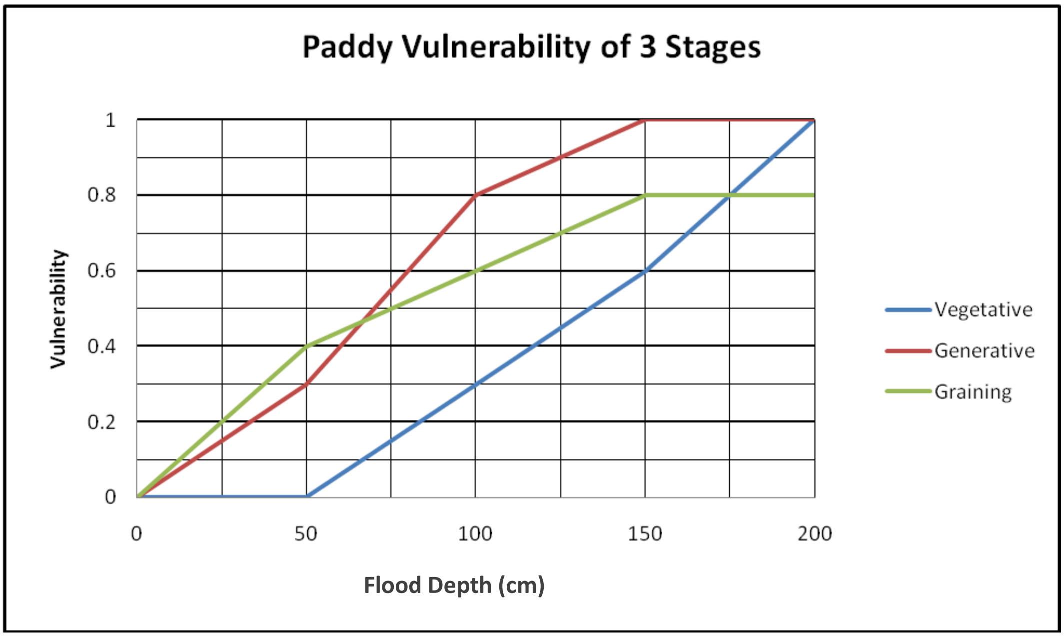

Figure 5.7. *Comparison of paddy vulnerability at three stages*

The graph clearly shows that the rice in the vegetative stage has lower level of vulnerability than the other phases. Despite at the flood depth of 2 meters or more, it can be totally destroyed, a condition that do not appear on graining stage. Until the flood depth of about 50 cm, the plants at generative phase are less vulnerable than those at the graining stage, but afterwards they have dramatically higher vulnerability, even the highest among the others. Generally, the rice at vegetative phase is more tolerant to the water than others.

5.2. CALCULATING 2007 FLOOD-BASED PRODUCTION LOSS OF PADDY

The basic concept of loss calculation in this study uses the risk approach, where risk is formulated as follows (van Westen, 2012. MHRA Session 6).

$$R = H * V * A$$

in which,

R : Risk
H : Hazard
V : Vulnerability
A : Amount of element-at-risk

Since the risk is defined as the expected losses resulting from interactions between hazards and vulnerable conditions (van Westen, 2012, MHRA Session 1), and hazard itself is defined by UNISDR (2004) as a potentially damaging event that may cause the loss of life, property damage, social and economic disruption or environmental degradation (Alkema *et al.*, 2012, MHRA Session 3), so if the hazard is changed into a real hazardous event then the risk is turned into loss. Thus the risk equation above can be derived into an equation of production loss of paddy based on 2007 flood as calculated in this study as follow.

Loss = 2007 Flood Event * Vulnerability * Amount of element-at-risk * Value

The characteristic of 2007 flood considered is only flood depth as previously described. The vulnerability used is it at graining stage due to the flood occurred at the graining phase, while the amount of element-at-risk is the selling price of paddy at the time.

The loss was calculated in each grid cell, while the total loss is the accumulation of them. In this research, the information about the selling price of rice was obtained through FGD. It was agreed at amount of Rp. 21,000,000.00 (twenty one million rupiahs) per hectare, or about Rp. 525.00 per grid since the raster built in this study use a spatial resolution of 0.5 meters. The value of production loss of paddy affected by the 2007 flood in Sidoharjo Village is displayed in the figure 5.8. According to the accumulation, the total production loss of paddy in the area is Rp. 1,137,350,000.00 (one billion, a hundred and thirty-seven million three hundred and fifty thousand rupiahs).

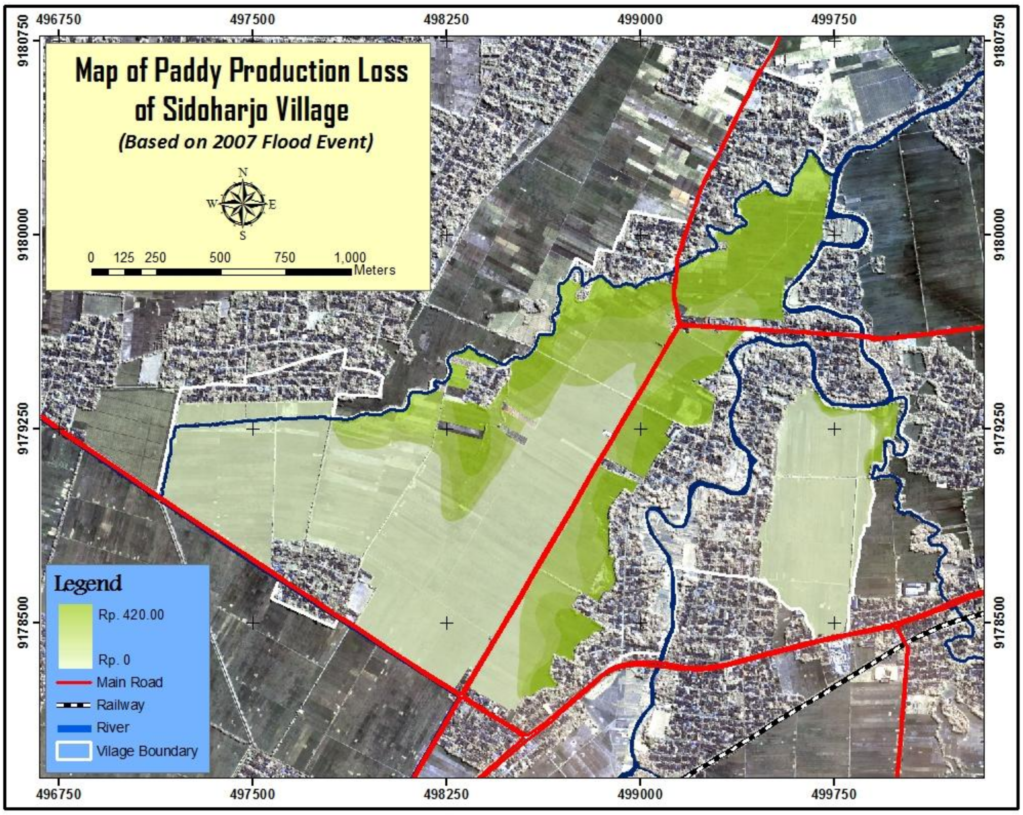

Figure 5.8. *Production loss of paddy affected by 2007 flood in Sidoharjo village*

The calculation was tried to be validated using loss data obtained through questionnaires. There were 32 respondents involved. The loss data were obtained in the form of percentage of lost yields. In order to be comparable, the calculation result was also converted into loss percentage per respondent's parcel.

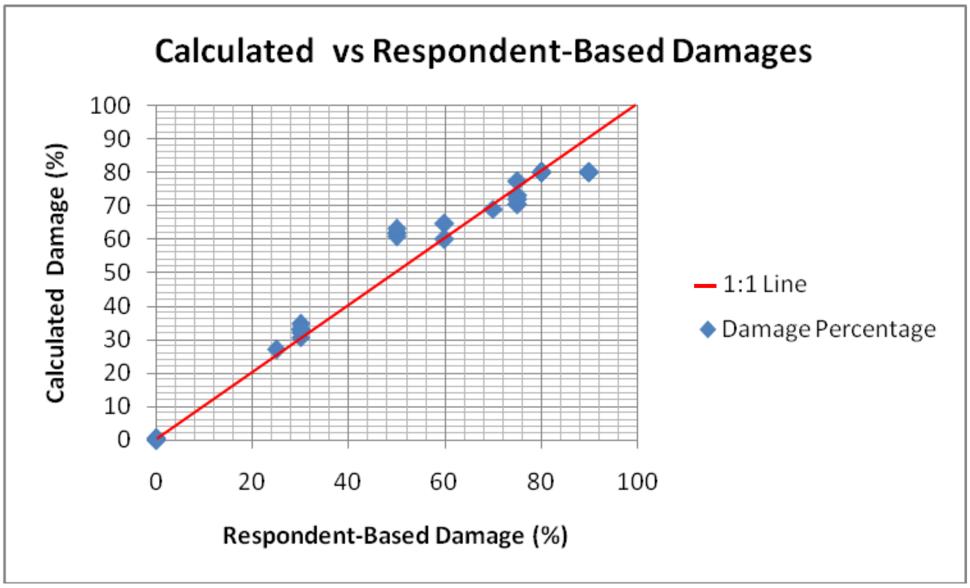

Figure 5.9. *Comparison between calculated damage and respondent-based damage*

Indeed, from this plotting can be seen that many calculation outcomes are not the same with the results of the questionnaire. This is understandable considering what to be compared are public perceptions that are not absolute. However, at least, the plotting forms a pattern which is in line with the 1:1 line, which means that it is close to conformity. In addition, only a minority of respondents were able to understand and call percentage. They just mention the Javanese expression which is then interpreted in percentage. And also, they tend to mention the numbers and phrases that are familiar to them. Here are some examples of such interpretation.

Table 5.2. *Loss percentage interpreted from Javanese expressions*

Javanese Expression	English Translation	Interpretation of Loss Percentage
seprapat	a quarter	25
setelon	a third	30
setugel	half	50
separo luwih	more than half	60
mung iso panen setelon	can harvest only one-third	70
mung gawa mulih seprapat	just can take home a quarter	75
nyisa ra ngasi seprapat	the rest is not up to a quarter	80
meh ludes	almost exhausted	90

5.3. 2007 FLOOD-BASED PRODUCTION LOSS IN SIDOHARJO VILLAGE PUBLISED BY LOCAL GOVERNMENT

In Indonesia, which implements regional autonomy, the authority of the management and policy making at the regional level is in the hand of each local government. Particularly in Sragen Regency, the research area, the authority of agriculture sector is held by the Agriculture Agency. Related to the 2007 flood, the agency issued an office memorandum, Nota Dinas No. 521.1/23/XII/2007, about 2007 flood disaster report. It noted the value of agricultural production losses including paddy and horticulture.

Especially for rice, the value was not delivered in the village level as the unit used in this study, but globally of each sub-district, so that the loss calculation resulted in this study can not be directly compared in rupiahs with the loss published by the government. Nevertheless, there are some principles that can be compared between them, as presented in table 5.3. The loss published by the government is obtained from the multiplication of total area of flooded paddy field and loss index (per hectare) considering the value of cultivation cost. They assess the area based on the report of the farmers whose paddy fields were affected by the flood. The report mentions about the number of flooded parcel which is then converted into a unit area (hectare).

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Table 5.3. *Comparison between loss calculation methods used by the government and used in the research*

Comparators	The Government	The Research
Method	*Based on statistical data*	*Grid-based GIS method*
Area Assessing	*Converting the flooded parcels into a unit area based on farmer reports*	*Using "Calculate Geometry" tool on GIS based on the flood extent map*
Base of Calculation	*Loss index refers to the value of cultivation cost*	*Loss of production (harvest)*
Calculation Unit	*Global, by generating the flood depth in all area (70-110 cm)*	*Pixel, according to the flood depth (pixel value) of each grid cell*

The government's loss index is Rp 6,000,000.00 (six million rupiahs) per hectare. This figure is obtained based on the production cost in a single growing season of rice, with the following details.

a. Costs of labor and machinery amounting to Rp 4,275,000.00 (four million two hundred and seventy-five thousand rupiahs), cover the entire operation from seeding, maintenance, until harvesting.
b. Costs of production means of Rp. 1,725,000.00 (one million seven hundred and twenty-five thousand rupiahs), including seeds, fertilizers, and pesticides.

The use of grid-based GIS method does provide a more objective method because each site has different levels of damage. Also, the result can be displayed spatially. The GIS, especially supported by the presence of the DTM, provides more accurate information of flooded area based on the flood extent as well as information about flood depth distribution. This information can be integrated with the vulnerability curves to give the information of damage level of paddy in every location. As a note, the government assumes that the level of damage across the area is considered equal. Every paddy field affected by the flood is deemed to have the same loss value regardless to the differences of the damage rate based on the diversity of the flood depth. Also, the flood-affected area is assessed by converting the parcel number reported by the farmers into hectares, ignoring how many parts are flooded and how deep the immersion is.

In addition, the amount of production cost took account in index determining should be not simply the total cost in a single season, but the total cost incurred during the flood. In other words, the loss is accounted as the lost investment. Such an approach is more appropriate in case of the flood occurred in generative phase and the farmers have to replant to be able to harvest in the same season, as if they spend a higher production cost to produce the same volume of that season. Meanwhile, in the case of the flood occurred in graining stage, the loss of flooded ready-to-harvest paddy is accounted as a reduction of income, which are valued as the farm gate prices (FAO, 2011).

Further, since the DTM and the vulnerability curves of paddy were already established, the method used in this research provides the fast and accurate calculation of production loss of paddy caused by the floods. Also, the loss predictions for several flood scenarios can also be performed. It can be implemented as a policy assessment. For example, if the impact on flooding of the proposed land use changes in *Mungkung* watershed, or plan of infrastructure development such as road elevating around the paddy field area, can be mapped, then the value of loss production of rice can be estimated. Generally, the loss calculation can be done with the following steps.

1. Define the flood level.
2. Calculate the flood depth using the flood level and the DTM, see figure 3.17.
3. Create a damage map based on the vulnerability curves considering at what stage of paddy growth the flood happens.
4. Calculate the loss using the damage map and the index value, either based on the selling price of the rice or the cost of cultivation already incurred.

6. RESILIENCE OF THE FARMERS TOWARD FLOOD IN SIDOHARJO VILLAGE

Based on the questionnaire results, the flood affects the farmer life in Sidoharjo village. 40.6% of respondents go into debt to cover their daily life. The impact studied deeper in this research is the farmer ability to continue the next-season cropping, which is then defined as resilience. It was studied at individual level. Only two forms of capital were studied in this research namely human and economic capitals. The socioeconomic data used in assessing resilience were obtained from the questionnaires, while the score and the weighting value were gained through FGD.

6.1. HUMAN CAPITAL

In the beginning, there are three aspects of this section investigated through questionnaire, i.e. age, education level, and farming experience. The age is considered related to the mobility to respond the flood effect. It is classified according to the BPS which divides the age structure of the population in Indonesia into four categories, namely: (1). Less Productive: 65 years old and above, (2). Productive: 50-64 Years, (3). Very Productive: 15-49 years old and (4). Not Productive: 0-14 Years. Meanwhile, the level of education and farming experience assumed to be related to the knowledge of farmers for replanting efforts.

The questionnaires say that most of the farmers in the Sidoharjo village are in productive age (53.1%) but have low level of education, in which 43.8% of them are classified in *"No Education"* and 34.4% of them have only completed the elementary school. Nevertheless, they have an incredible experience in agriculture. The complete presentations of the conditions are displayed in the tables 6.1, 6.2, and 6.3.

Table 6.1. *The age distribution of the respondents*

Class	Age (year)	Frequency	Percentage
Highly Productive	15 - 49	9	28.1
Productive	50 - 64	17	53.1
Less Productive	> 64	6	18.8

Table 6.2. *The education level of the respondents*

Education	Frequency	Percentage
No Education	14	43.8
Elementary School	11	34.4
Junior High School	2	6.3
Senior High School	3	9.4
Bachelor Degree	2	6.3

Table 6.3. *The farming experience of the respondents*

Class	Experience (year)	Frequency	Percentage
Less Experienced	≤ 5	0	0
Experienced	6 - 10	6	18.8
Highly Experienced	11 -20	5	15.6
Expert	> 20	21	65.6

In fact, only the third aspect is took into account as the influential factor of the resilience in this study. The others, age and education, are considered having no effect in replanting capability of the farmers. They delivered, in the FGD, that farming is like the soul blending with their lives, so there is no significant relationship between age and willingness to continue farming. In terms of knowledge, they said that they learned a lot about paddy cultivation from experience instead of formal education, thus not the education level affecting the resilience but the experience level.

6.2. ECONOMIC CAPITAL

Every household needs the economic factors to face the disasters. They are necessary "*to jump back*" into the original condition (Norris and Stevens, 2007). The resources used to do that effort are called by economic capital (Damayanti, 2011). This study investigates all factors related to the economic strength of each farmer household, either reinforcing or debilitating. The positives cover household income and resources used in next cropping, while the negatives include number of dependent and the losses.

6.2.1. Household Income

There are two elements studied in relation with income i.e. the sources and farmer status. In term of the sources, the households having only one source of revenue have lower level of resilience than those who have more sources. (Freudenburg, 1992). The farmer status is actually included in human capital in case of it affects the willingness of the farmers to continue the cultivation. In this study, the status is seen from the economic perspective, in which farmers who hire fields have yields less than those who own the fields. There is a value to be paid as the rental fee.

Table 6.4. *The income sources of the respondents*

Income Source	Frequency	Percentage
Single source	14	43.8
Two income sources	9	28.1
Multiple sources	9	28.1

Table 6.5 *The farmer status of the respondents*

Status	Frequency	Percentage
Owner	27	84.4
Tenant	5	15.6

According to table 6.4, most of the farmer households in Sidoharjo village (56.2%) not only depend their livelihood on the flood-affected yield. Half of this amount has another source, and the other half have two or more other earnings. Meanwhile, 43.8% of respondents only have income from the flooded fields.

Other sources in this study not only refer to the respondent, but their household. In other words, it is related to household income, not respondent revenue. For example, if the spouse or son of the respondent has occupation, then the earning becomes another income source for the household. There are three kinds of job becoming the other sources of the farmers in the village i.e. civil servant most of which are teachers, raising cattle, as well as factory worker. In addition, the respondents who have rice field in a secure place (not affected by the flood) are supposed to have another source of income.

Meanwhile, in terms of the field-ownership status, only 15.6% of the respondents are existed as tenants. Most of them are the owners of these fields.

6.2.2. Dependent Number

As mentioned earlier that aspects investigated in this study are not only the strengthening but also the weakening factors of economic capital. One of the attenuator is the number of dependent in the family. It directly affects the amount of domestic spending that will ultimately affect their ability to cultivate in the following season. For example, in the same condition in which they lost 50% of their crops, farmers having fewer dependents may still be able to use the outcome as the cost of the next planting, while those having more dependents only cover the costs of daily life. Nevertheless, the correlation can not be generalized. All the factors determining the resilience level influence each other.

Table 6.6 *The family dependents of the respondents*

Dependent	Frequency	Percentage
1	0	0
2	6	18.75
3 - 4	14	43.75
> 4	12	37.50

The table describes that most of respondents have more than two dependents, and even 37.5% of them have more than 4 burdens. That classification is arranged based on the farmer representatives through FGD.

6.2.3. Losses

The loss of flooded ready-to-harvest paddy suffered by the farmer impacts on their earning since it is accounted as a reduction of income (FAO, 2011). Disruption in revenue will affect the balance of household economy. Of the families having the rest to be saved, the reduction is likely not so influential. Yet on the others, the reduction will impact on the expenditures including *"allocation"* for the next cultivation. Moreover, based on the socioeconomic data obtained through questionnaires, in a normal condition without a flood, only 15.6% of respondents are able to set aside the yield for saving. For others, the harvest is only enough for daily living and the cost of the next growing season.

Table 6.7 *The 2007 flood-based loss of the respondent's field*

Class	Loss (%)	Frequency	Percentage
Normal	< 20	5	15.6
Moderately Severe	20 - 49	6	18.8
Severe	50 - 79	11	34.4
Very Severe	≥ 80	10	31.3

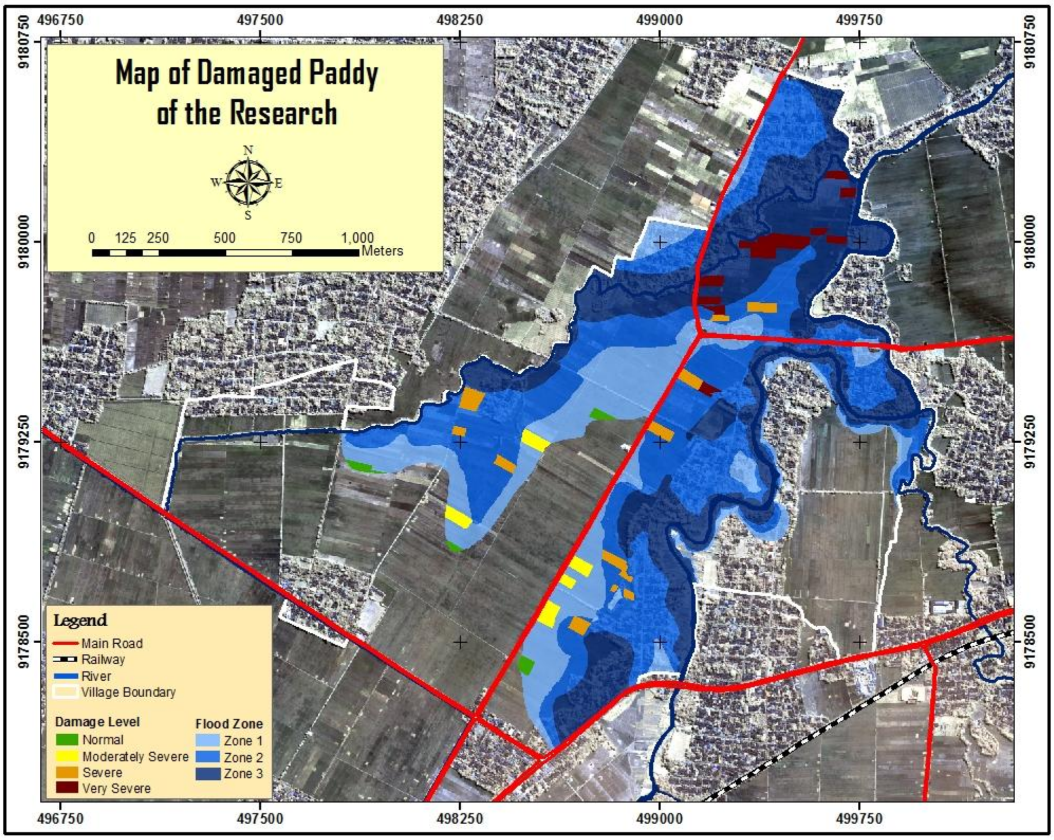

Figure 6.1. *Map of damaged paddy of the respondent by the flood zone*

Table 6.4 shows the constellation of the respondents based on the extent of damage of rice. The classification is made by the farmers themselves in the FGD. They assessed that the less-than-20% damage is considered as a normal condition and has no significant impact on farmers. It is the usual condition they experienced though no flood event. There are 15.6% of respondents in the class, meaning that the 2007 flood hit their fields could be no impact on rice production. Meanwhile, 34.4% and 31.3% of them had severe and very severe damage respectively.

The situation is influenced by the location of their fields. As noted earlier, respondents were proportionally randomized to each flood zone determined based on the flood depth. Figure 6.1 shows clearly that the deeper the immersion, the higher the damaged paddy. At zone 1 shown as the light blue zone, which has a depth of up to 0.5 meters, the paddies are in normal and moderately severe condition, which are almost equal in number between them. There is neither severe nor very severe damage in rice at this zone. At Zone 2 which is signed with the blue zone, almost all paddies are in severe condition and a few of them are very severely damaged. Meanwhile, all of the paddies are very severely damaged at Zone 3, the dark blue zone in the map, which has a depth of inundation over 1.5 meters.

Further, the farmers also said that their losses apart of agricultural production also influence the level of resilience. In particular they mention the breakdown to their houses. The cost that should be utilized as the capital for the next cropping must be used to repair the breakage. The level of damage was not specifically studied because on average they suffered similar breakage such as broken doors and collapsed fences, while the valuable properties could be saved by them. Other consequences that need no cost such as house and environment cleanup are not counted as a loss. Most of the farmer's houses in Sidoharjo village were damaged during the flood in 2007.

Table 6.8 *The respondent constellation by damaged house*

Another Loss	Frequency	Percentage
No	5	15.6
Yes	27	84.4

6.2.4. Source of Next Cropping Budget

This is the most influencing factor to the resilience according to the FGD result. They said that the farmer capability on continuing the cropping depends on the used finance resource. Of the farmers who have savings, they are ready to proceed as if does not happen anything. Slightly different condition occurs of the farmers who still have outcomes, either yields of the other fields in a secure area or those could be still harvested from flood-affected field. They also can continue their cultivation using the remaining proceeds even though there is a little change in meeting the other household needs. There are also some farmers who from the beginning of the growing season should indebt in form of fertilizers, and pay off using the harvest. They are actually difficult to continue the farming. So, those who still have access to borrow must indebt much more, and those who are not able to get a loan have to sell their property.

Table 6.9 *The financing resource of the respondents*

Next Cropping Budget	Frequency	Percentage
Saving	5	15.6
Save harvest	7	21.9
Lending	19	59.4
Selling Property	1	3.1

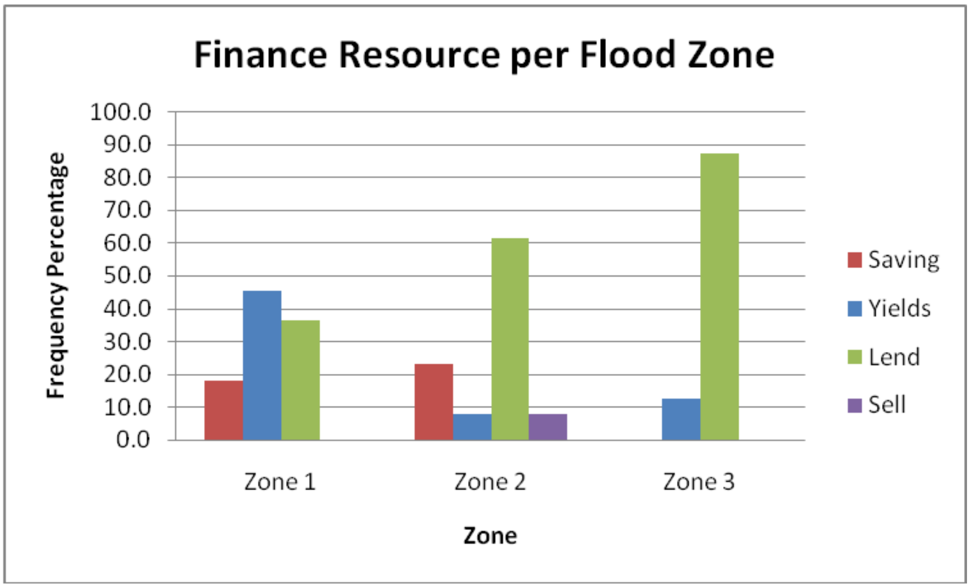

Figure 6.2. *Graph of correlation between finance resource of next cropping and the flood zone*

As seen in Table 6.6, most of the farmers in the village (59.4%) use the loan for the next season finance. There are two fertilizer distributors in the village cooperating with the farmer groups to sell their products by postpaid system.

The graph in Figure 6.2 shows the pattern of farmer behavior in the use of funding sources for the next planting based on the flood zone. *"Saving"* means farmers use their saving as the sources, *"Yields"* means they use the harvest as the source, *"Lend"* means they go into debt for the next cropping, while *"Sell"* means they have to sell their property as the source. For *saving*, the difference in zone does not show the influence. It is more influenced by socio-economic conditions like the number of income sources of the household. Of particular interest is of the *yields* and *lend* in which their frequency are likely to be affected by the zone. In *yields*, the deeper the immersion, the less the farmers using harvest as the financing source of the next cultivation. Associated with the appearance of *"yields"* in Zone 3, the results questionnaire result shows that the farmer uses harvest from another field in a safe area as mentioned in section 6.2.1.

The next question is whether the phenomenon is also influenced by the damage level of paddy, given the graph in Figure 6.1 shows the tendency of the correlation between the zone and the damage level.

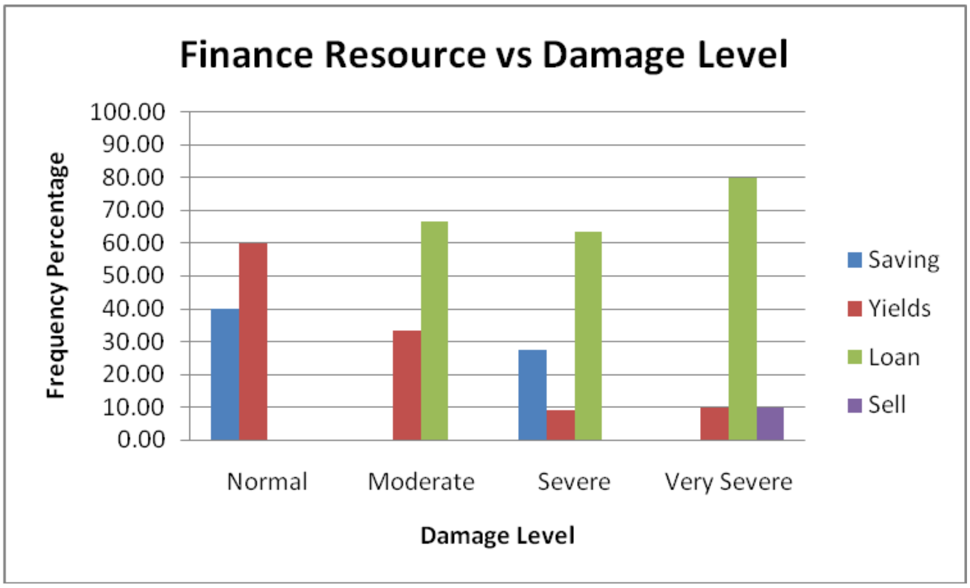

Figure 6.3. *Graph of correlation between finance resource of next cropping and the damage level of paddy*

As seen in Figure 6.3, the farmers who have normal damage level of paddy use either yields or savings as the funding resource of the next growing season. The use of these two sources has a tendency to fall with the increasing of the damage level. Conversely, the farmers using loans as the source tend to increase with the increasing of the level.

6.3. ASSESSING THE FARMER RESILIENCE

The resilience level is determined based on the resilience value of each respondent. It is calculated using weighting value and score of each influencing factor. All of them; the weighting value, the score, and the influencing factors, were decided by the farmer representatives through FGD, as displayed in the following table.

Table 6.10. *The weighting value and score of resilience in Sidoharjo Village*

Capital Form	Factor	Sub Factor	Classification	Score
1. Human Capital *(WV : 0.20)*	1. Farming Experience *(WV : 1.00)*		a. < 5 years	0.25
			b. 5 -10 years	0.50
			c. 11 - 20 years	0.75
			d. > 20 years	1.00
2. Economic Capital *(WV : 0.80)*	1. Dependent Number *(WV : 0.10)*		a. > 4	0.20
			b. 3 - 4	0.50
			c. 2	0.80
			d. 1	1.00
	2. Financing Resource *(WV : 0.50)*		a. Selling Property	0.10
			b. Loan	0.20
			c. Yields	0.60
			d. Saving	1.00
	3. Household Income *(WV : 0.20)*	1. Income Source *(WV : 0.80)*	a. Single Source	0.20
			b. Have Another	0.60
			c. Have Others	1.00
		2. Farmer Status *(WV : 0.20)*	a. Tenant	0.50
			b. Owner	1.00
	4. Losses *(WV : 0.20)*	1. Lost Production *(WV : 0.80)*	a. > 80 %	0.10
			b. 51 - 80 %	0.40
			c. 20 - 50 %	0.80
			d. < 20 %	1.00
		2. Other Losses *(WV : 0.20)*	a. Yes	0.20
			b. No	1.00

WV : Weighting Value

According to the weighting values of the influencing factors, the resilience value of the farmers in Sidoharjo village can be calculated using this following formula.

$$RES = (0.2)FE + (0.08)DN + (0.4)FR + (0.128)IS + (0.032)FS + (0.128)LP + (0.032)OL$$

in which,

RES	:	Resilience Value
FE	:	Farming Experience
DN	:	Dependent Number
FR	:	Financing Resource
IS	:	Income Source
FS	:	Farmer Status
LP	:	Lost Production
OL	:	Other Losses

The results show that the resilience values of the farmers in Sidoharjo village vary between 0.21 and 0.92. The average value is 0.52. Meanwhile, the average values of zone 1, zone 2, and zone 3 are 0.62, 0.50, and 0.40 respectively. Based on these averages there seems to be a trend of which the deeper the flood immerse the field, the smaller the resilience value of the farmers cultivating it. In order to more obviously see the relationship between the resilience values and the flood zone, those values are classified into three classes, namely low, moderate, and high. Interval of the resilience scale, which is 0 to 1, is divided equally to obtain the class interval. Yet it seems almost impossible that there is a zero value of resilience, so that the smallest value of the resilience scale is considered 0.1, with a class interval of 0.3.

Table 6.11. *The resilience level of the farmer in Sidoharjo Village*

Interval Class	Resilience Level	Frequency	Percentage
< 0.4	Low	9	28.1
> 0.4 - 0.7	Moderate	18	56.3
> 0.7	High	5	15.6

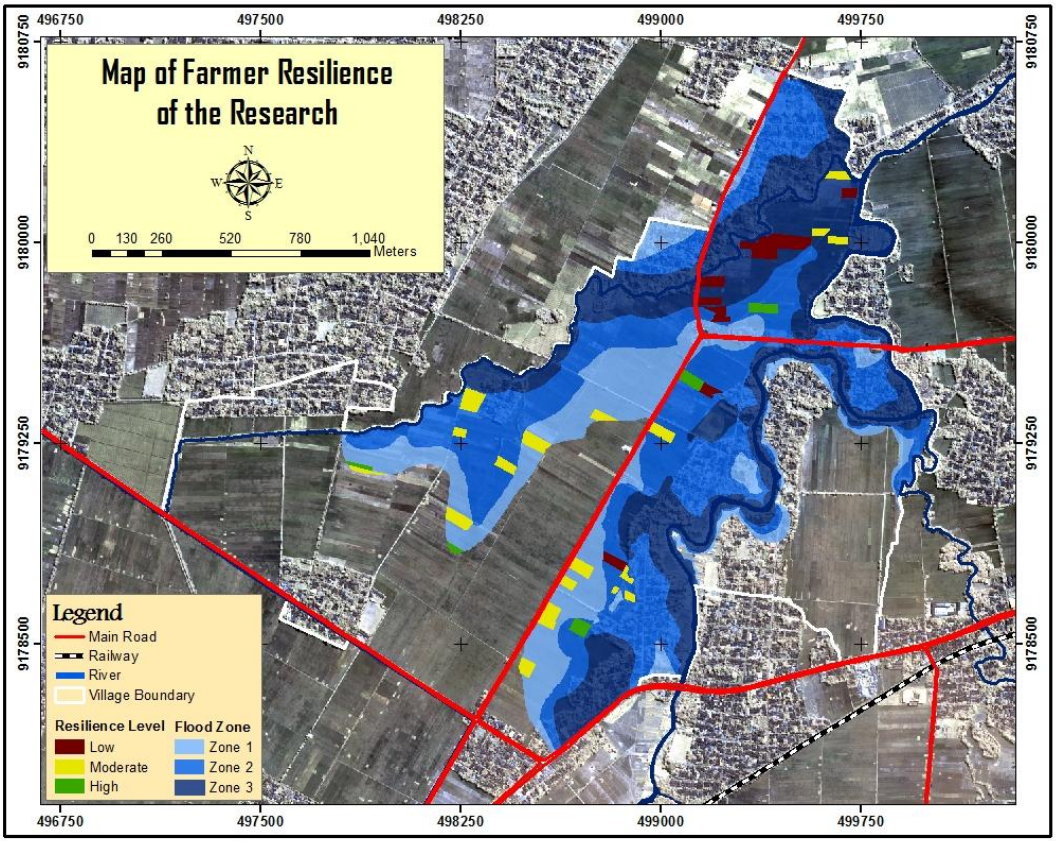

Figure 6.4. *Map of resilience level of the farmer by the flood zone*

Overall, most of the farmers in Sidoharjo village are categorized in moderate resilience level as displayed in table 6.11. Further, according to the Figure 6.4, there seems to be an effect of the flood zone toward the resilience level. From zone 1 to zone 3, which means the inundation is getting deeper, there are number increase of low-level and number decrease of moderate-level. Nevertheless, the socioeconomic condition of the farmer also has an influence on those levels. It is seen from the slight rise of high-level number from zone 1 to zone 2 which has a deeper immersion.

6.4. ACHIEVING RESILIENT FARMERS

"A resilient farm can cope effectively with climate shocks such as droughts or floods, continuing to produce and sustain its capacity for future responsiveness and production". (Oxam International, 2009)

That condition can be achieved by increasing the resilience level of. In the case of farmers in Sidoharjo village, it can be done by rising the score of each factor mentioned in table 6.10. In terms of farming experience, the farmers in this village have no doubt. Table 6.3 says that almost all of them are very experienced. Furthermore, the dependent numbers seem to be factor that can not be changed. Related to the financing source and household income, there are eight farmer groups which coordinate the peasants and act as the bridge between the farmers and the government. The groups can be empowered to undertake programs that strengthen both factors such as saving habit and business diversification to increase the source of household income. To support the program, a synergy between farmers, farmer groups, and governments are necessary. However, based on the questionnaire results, half of the respondents said that they did not feel the role of farmer groups. And even, 93.75% of them stated that they did not feel the role of government. Ironically, the government has done a lot of things like normalization of Mungkung River as the main source of flooding in the area, monitoring and controlling the extraordinary events such as flood and pests, and fertilizer supplies. They, both the farmer and the government, should be more active in dissemination of any undertaken program, to improve the confidence of farmers toward these two institutions.

Factor relevant to be scientifically discussed is the losses. The farmer perceptions against future loss are investigated through FGD. In 2011, the road crossing through the middle of the rice fields, shown as yellow line in Figure 6.5, was raised about 80 cm. Participants were asked to predict the losses if the flood with a 2007-flood-like magnitude happened again after the road raising. All the participants said that the losses will be much greater. Flood still hit the region on the west and north of the road, despite the depth and the extent will be reduced. However, the area on the east and south of the road will be damaged very badly since the main flood water flow, which is indicated as black arrow in Figure 4.10, will be restrained by the elevated road. The farmers predict that the flood depth will increase around 80 cm as the level of road rising. They also believe that the length of inundation will also increase. Both the depth and duration will significantly affect the damage level of paddy. In addition, Figure 4.1 shows that most of the settlements are also found in the area, so that the other losses also potentially increase. There should be a regular monitoring and normalization of the Mungkung River to guarantee that the river is able to accommodate the water discharge.

The paddy vulnerability for each phase was previously discussed in section 5.1. When the timing of the flood can be predicted based on the event catalog, then the cropping calendars can be adjusted with respect to the possibility of flooding (FAO, 2012), to reduce the risk. Another strategy can be done is to use flood-resistant variety in the growing season of which the flood potentially occurs. The International Rice Research Institute (IRRI) found a new variety of rice which is not only resistant to two-week flood immersion but also quality maintained (Balitbang-Pertanian, 2006). The questionnaire results said that all respondents stated that they did not know about the variety. Fortunately, they all expressed a willingness to plant it. This means that the strategy becomes something realistic to do.

7. CONCLUSION

7.1. FINAL REMARK

This research gives a real description about 2007 flood event in Sidoharjo village, including flood extent and flood depth. Several important attributes that are useful on disaster risk reduction specifically related to the paddy production such as paddy vulnerability, loss calculation method and its value, resilience level of the farmers, as well as farmer perception about the resilience, are also measured.

The flood extent and the flood depth are built by integrating DTM and local knowledge. The DTM is created based on sampled points measured applying DGPS and RTK-GPS methods. The points are interpolated by ArcGIS 9.3 assistance. The most appropriate interpolation method in this area is natural neigbour. The society knowledge provides information about flood depth in several locations which is then converted into a raster of flood level. There are three flood sources in this region i.e. rising of water level of the Mungkung River, accumulation of the run off which is restrained by the rising water, and *"water jump"* due to the influence of centripetal force on the river bends, as presented in figure 4.10. There are 54.22% flooded areas of the village. The depth of the immersion on the paddy fields reaches approximately 3 meters.

The flood depth, together with the variety and growth stage of paddy are considered on the vulnerability of paddy. Actually, there are a few farmers stating about the mud effect, but it can not be identified spatially. Also, most of them agree that the amount of mud deposited is not significant, so it does not affect the damage of paddy. There are four varieties cultivated at the time of 2007 flood i.e. *Ciherang, IR-64, Wayapo Buru*, and *Situ Bagendit*. However, the diversity has no effect on the generated synthetic damage data. Thus, only the depth and the growth stage are accounted to build the vulnerability. There are three growth stages i.e. vegetative, generative, and graining phases.

The integration of the vulnerability and the 2007 flood depth results production loss of paddy as a consequence of the flood. In 2007, flood hit the area when the rice was in graining stage. It was planted simultaneously, so as to have the same stage during the flood. A grid-based GIS method is used in the loss calculation which produces a value of

Rp. 1,137,350,000.00 (one billion, a hundred and thirty-seven million three hundred and fifty thousand rupiahs). This result is different from the value published by local government using a loss index based on the production cost in a single growing season. Both methods are equally able to be used, but in different cases. If the flood hit the paddy at the vegetative phase and the farmers must replant to obtain the results of the season, the loss is calculated based on the cost of production which is considered as lost investment. On the other hand, when the flood hit the ready-to-harvest paddy, the loss is calculated as lost production.

The losses have impacts on farmer households, including the ability to continue the cultivation in the next season, which in this study is defined as resilience. To determine the level of resilience, 32 respondents were proportionally randomized to each flood zone. There are three zones were created based on the flood depth i.e. Zone 1 with a depth of less than 0.5 meters, Zone 2 with a depth of between 0.5 - 1.5 meters, and Zone 3 which has a depth of more than 1.5 meters, see figure 3.12. The influencing factors of the resilience and its weights and scores were determined by farmer representatives via FGD. As a result, most of the farmers in the village (56.3%) are categorized in moderate level. There seems to be an effect of the flood zone toward the resilience level. Yet, the socioeconomic condition of the farmer also has influences on the level.

7.2. FUTURE RESEARCH

This study only focused on the agricultural sector, in particular on rice production. There are many things associated with the losses to be investigated, both in agriculture and other fields. In addition, the mud effect on the damage level of paddy could be a concern for the future research, especially for areas having a longer duration of inundation due to the deposition process. Farmer perception about the risk associated with road rising also investigated in this study. However, a hydrodynamic model is necessary to know exactly the effect of the elevating. Furthermore, the normalization of Mungkung River periodically be a strategy to reduce losses in this area. Thus, a study of the rate of sedimentation in the river will likely give a clear picture of the normalization period.

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APPENDIX

APPENDIX 1. *Questionnaire for production loss of paddy and farmer resilience in Sidoharjo Village*

Questionnaire No.	:	Date	: ....
Interviewer	:	Time	: ....

1. Information of Respondent

(1). Name : .... (2). Field Location : .... *(code as in the map)*

(3). Age : .... years (4). Sex : Male ☐ Female ☐

(5). Education : .... (6). Year of cropping in this location : .... years

(7). Address : ....

....

2. Information of Household

Name	Sex (F/M)	Age	Position	Education and Job
1.	....	....	....	....
2.	....	....	....	....
3.	....	....	....	....
4.	....	....	....	....
5.	....	....	....	....
6.	....	....	....	....
7.	....	....	....	....
8.	....	....	....	....

Household Income (per month)

Amount (rupiahs)	***Source***
(1)	....
(2)	....
(3)	....
(4)	....
(5)	....

Household Expense (rupiahs per month)

(1) Dinning needs
- ☐ < 300.000
- ☐ 300.000 – 500.000
- ☐ 500.000 – 700.000
- ☐ 700.000 – 900.000
- ☐ > 900.000

(2) Social needs
- ☐ < 200.000
- ☐ 200.000 – 350.000
- ☐ 350.000 – 500.000
- ☐ > 500.000

Others

(3) ....

(4) ....

(5) ....

3. Information about Cropping

Size of paddy field on flooded area : ………………………………..				
Cropping Time	**Paddy Variety**	**Total Production Cost**	**Harvest**	
			Ton	**Rupiahs**
1. ………………………………..	………………………………..	………………………………..	……………	…………………
2. ………………………………..	………………………………..	………………………………..	……………	…………………
3. ………………………………..	………………………………..	………………………………..	……………	…………………
4. ………………………………..	………………………………..	………………………………..	……………	…………………

Utilization of the harvest :

☐ Daily Life ☐ Next Cropping ☐ Others 1. ………………………………

☐ Saving ☐ Other Business 2. ………………………………

.

4. Information about Flood Impact *(conditions at the time of flooding)*

(1). Paddy variety : ………………………………………… (2). Plant age : ……………………………………………

(3). Plant phase : ………………………………………… (4). Plant height : ……………………………………………

(5). Costs incurred :

Process	***Cost***
a. ………………………………………………………………	………………………………………………………………………
b. ………………………………………………………………	………………………………………………………………………
c. ………………………………………………………………	………………………………………………………………………
d. ………………………………………………………………	………………………………………………………………………
e. ………………………………………………………………	………………………………………………………………………
f. ………………………………………………………………	………………………………………………………………………
g. ………………………………………………………………	………………………………………………………………………
h. ………………………………………………………………	………………………………………………………………………
i. ………………………………………………………………	………………………………………………………………………
j. ………………………………………………………………	………………………………………………………………………

(6). Began to be submerged at : day ………………… (7). Immersion length : ……………… days

(8). Percentage of flooded paddy field
- a. completely submerged : …………….. %
- b. partially submerged : …………….. %
- c. no submerged : …………….. %

(9). Plant condition after flood
- ☐ crop failure
- ☐ partly survive, harvest obtained : ……………………………… ton
  ……………………………… rupiahs

(10). Field condition after flood
- ☐ normal
- ☐ damaged but need no repair
- ☐ damaged and need repair ……………………………… rupiahs

(11). Other significant impacts on domesticity

☐ nothing ☐ loans for living ☐ others, ………………………………

☐ drop out (of school) ☐ property selling for living

(12). Is the location of the field effect on the damage?

☐ No ☐ Yes, related to ☐ water depth
☐ water (relative) velocity
☐ length of inundation
☐ others : ……………………………………………

5. Information about Recovery Process

(1). Do you have a field in a safe area?

☐ No ☐ Yes, flood effect on rice price of the saved area ☐ stable
☐ increase ……….. %
☐ decrease ………. %

(2). Do you have any savings when flood occur?

☐ No ☐ Yes, in form of ☐ money ………………………. rupiahs
☐ dried paddy ……………………… ton
☐ rice (beras) ……………………… ton

(3). Is your home also affected by flood?

☐ No ☐ Yes, with damage and loss ☐ Yes, without any damage and loss

(4). Does the condition above affect replanting effort?

☐ No ☐ Yes, in term of ………………………………………………………………………………………

(5). When you start to replant?

☐ ……….. days after the flood recede ☐ wait for the next planting season

(6). If you wait until the following growing season, what do you do during that period?

☐ Just wait ☐ Doing other businesses, such as …………………………………………………………

(7). What sources do you use as the capital to replant?

☐ Saving ☐ Loans, from ………………………… ☐ Others, …………………………………
☐ Property Selling ☐ Aid, from ……………………………

(8). Is there anything else that affects the process of replanting

☐ No ☐ Yes, such as ☐ certain infrastructure : …………………………………………
☐ government program : …………………………………………
☐ join the community : …………………………………………
☐ others : …………………………………………

(9). Is improvement effort need to be done before re-cultivating the field?

☐ No ☐ Yes, done by ☐ you yourself
☐ *gotong royong*
☐ support staff
☐ others, ………………………………………

6. Information about the Strategy

(1). Do you feel the role of government in agriculture associated with flood?

☐ No ☐ Yes, in form of
- ☐ stabilizing rice prices
- ☐ providing seeds and fertilizer
- ☐ others, ………………………………………………….

(2). Have you ever heard of the flood-resistant rice varieties?

☐ No ☐ Yes, from
- ☐ government
- ☐ colleague
- ☐ others, ………………………………………………….

(3). Will you plant varieties that during the rainy season?

☐ Yes ☐ No, because ……………………………………………………………………………….
……………………………………………………………………………….
……………………………………………………………………………….

(4). Is there any preparation to anticipate the flood impact in term of the agriculture sustainability?

☐ No ☐ Yes, in form of
- ☐ setting aside money every harvest
- ☐ storing crops before the rainy season
- ☐ others, ………………………………………………….

APPENDIX 2. *List of detailed spot height as results of RTK-GPS measurement*

No	X	Y	Z
1	499557.606	9179305.934	78.707
2	499573.360	9179333.056	78.939
3	499536.765	9179295.163	79.590
4	499679.798	9179393.921	73.002
5	499688.029	9179383.424	72.705
6	499671.434	9179389.140	78.537
7	499657.427	9179395.472	78.395
8	499407.034	9179499.103	77.827
9	499260.175	9179680.423	78.012
10	499259.204	9179680.980	77.521
11	499386.497	9179783.780	77.763
12	499387.522	9179783.174	77.152
13	499384.788	9179785.439	77.078
14	499512.792	9179914.255	77.507
15	499511.795	9179915.418	76.807
16	499513.938	9179913.301	76.753
17	499414.703	9179917.992	76.411
18	499565.393	9179976.334	77.544
19	499563.102	9179976.651	76.701
20	499568.630	9179977.181	76.726
21	499494.703	9180065.558	75.835
22	499676.496	9179968.140	75.177
23	499680.723	9179962.179	77.575
24	499709.724	9179967.251	71.454
25	499779.405	9180017.483	76.601
26	499863.973	9180006.070	71.586
27	499862.932	9180032.788	71.539
28	499852.755	9180034.723	76.204
29	499819.670	9180067.406	71.576
30	499706.559	9180027.825	75.206
31	499714.331	9180101.454	75.534
32	499655.523	9180101.248	77.451
33	499658.274	9180101.463	76.449
34	499654.062	9180102.157	76.535
35	499603.854	9179627.819	77.330
36	499776.633	9179616.212	77.829
37	499776.689	9179616.222	77.859
38	499875.849	9179525.257	71.966
39	499856.103	9179521.273	76.673
40	499950.157	9179393.574	71.372
41	499950.616	9179393.454	71.957
42	499934.456	9179398.532	76.332
43	499710.534	9179393.328	76.517
44	499711.018	9179393.712	77.747
45	499693.113	9179396.741	71.954
46	499749.283	9179609.094	77.815
47	498732.952	9179477.586	77.620
48	498729.546	9179479.435	77.598
49	498694.845	9179423.729	77.652
50	498698.554	9179420.135	77.900
51	498804.374	9179350.867	78.059
52	498626.582	9179306.796	77.834
53	498631.151	9179306.769	77.916
54	498720.375	9179258.147	78.121
55	498480.182	9179052.653	78.769
56	498477.955	9179053.427	78.381
57	498481.767	9179052.196	78.413
58	498572.018	9179005.701	78.522
59	498318.680	9178948.848	77.376
60	498392.083	9178904.320	78.535
61	498223.230	9178746.770	78.126
62	498277.820	9178713.331	78.688
63	498376.254	9178658.565	79.056
64	498669.435	9179377.378	77.720
65	498672.130	9179375.824	78.051
66	498573.201	9179211.836	78.634
67	498572.324	9179212.332	78.154
68	498579.962	9179217.312	78.233
69	498589.165	9179199.709	79.623
70	498587.082	9179195.775	78.276

No	X	Y	Z
71	498597.113	9179206.829	78.270
72	498680.736	9179153.855	78.513
73	498673.594	9179145.693	79.870
74	498675.634	9179147.223	78.508
75	498780.396	9179089.922	80.120
76	498782.931	9179094.631	78.744
77	498775.456	9179082.434	78.717
78	497703.032	9178842.797	79.088
79	497709.511	9178842.599	79.788
80	497715.500	9178842.122	79.164
81	497817.543	9178825.126	79.240
82	497754.257	9179046.418	79.144
83	497749.104	9179046.299	78.695
84	497761.548	9179052.209	78.657
85	497799.903	9179263.721	78.872
86	497808.556	9179261.131	77.619
87	497823.557	9179284.661	77.645
88	497824.382	9179288.077	76.061
89	497826.226	9179291.800	76.078
90	497827.050	9179294.909	77.917
91	497869.865	9179285.847	76.825
92	497860.508	9179558.294	80.647
93	497860.529	9179556.496	79.802
94	497860.529	9179554.287	79.291
95	497860.256	9179553.099	80.035
96	498042.754	9179502.367	78.243
97	498058.306	9179325.872	77.010
98	498057.563	9179321.875	74.975
99	498055.797	9179318.343	77.297
100	498013.137	9179363.699	77.471
101	499474.596	9179590.040	73.195
102	499473.696	9179586.769	73.954
103	499485.859	9179582.014	74.556
104	499487.389	9179583.779	73.008
105	499496.303	9179576.019	75.192
106	499498.346	9179578.790	72.933
107	499515.241	9179565.894	75.249
108	499514.594	9179569.695	72.971
109	499542.450	9179556.471	73.960
110	499543.944	9179562.117	72.982
111	499586.589	9179564.006	73.011
112	499586.543	9179558.647	73.220
113	499590.281	9179547.473	76.626
114	499555.785	9179544.580	78.572
115	499529.571	9179549.858	78.515
116	499496.266	9179562.114	78.119
117	499455.821	9179563.978	77.794
118	499426.827	9179548.751	78.152
119	499417.799	9179562.588	74.452
120	499419.732	9179566.724	73.020
121	499450.112	9179578.610	73.841
122	499450.121	9179578.621	73.841
123	499447.901	9179580.128	73.086
124	499397.471	9179540.631	78.099
125	499388.311	9179545.768	74.342
126	499393.049	9179501.678	78.383
127	499373.987	9179503.264	73.389
128	499367.920	9179502.130	73.075
129	499477.603	9179477.557	78.728
130	499406.572	9179442.680	78.977
131	499379.755	9179461.548	72.937
132	499386.286	9179467.573	79.428
133	499148.324	9179666.769	78.499
134	499456.007	9180611.049	77.305
135	499456.006	9180611.060	77.309
136	499588.372	9180551.756	76.489
137	499685.393	9180525.002	76.330
138	499688.731	9180521.599	77.957
139	499690.618	9180520.980	77.616
140	499704.732	9180566.549	74.479

No	X	Y	Z
141	499668.286	9180589.733	76.548
142	499667.672	9180590.487	74.976
143	499669.010	9180564.169	76.082
144	499581.487	9180435.305	76.898
145	499652.595	9180435.386	76.374
146	499671.664	9180434.070	74.963
147	499672.030	9180436.720	73.095
148	499654.096	9180372.174	76.490
149	499719.045	9180369.644	75.905
150	499719.494	9180370.461	74.784
151	499687.624	9180312.534	75.598
152	499580.842	9180374.606	76.990
153	499567.720	9180249.093	76.595
154	499589.143	9180223.663	74.932
155	499590.242	9180223.700	72.137
156	499592.954	9180223.128	75.334
157	499602.637	9180225.034	75.169
158	499619.227	9180248.760	75.890
159	499616.289	9180251.823	72.196
160	499612.874	9180253.341	75.493
161	499639.561	9180253.341	75.527
162	499642.597	9180311.016	72.249
163	499648.668	9180306.463	75.631
164	499659.933	9180265.883	76.032
165	499682.058	9180295.838	75.827
166	499684.082	9180302.921	71.974
167	499712.445	9180239.503	75.943
168	499709.981	9180216.188	76.039
169	499590.641	9180171.304	75.746
170	499580.015	9180167.161	72.585
171	499575.841	9180169.058	75.413
172	499543.209	9180186.892	75.746
173	499606.221	9180119.328	75.833
174	499605.221	9180120.228	76.532
175	499603.776	9180120.531	75.788
176	499517.424	9180126.834	76.027
177	499516.296	9180126.896	75.463
178	499530.189	9180163.904	75.546
179	499478.301	9180209.132	75.161
180	499479.819	9180204.579	72.983
181	499481.336	9180196.484	75.674
182	499482.498	9180170.196	75.228
183	499528.598	9180160.009	73.458
184	499528.730	9180158.401	75.602
185	499433.543	9180285.766	76.225
186	499311.469	9180321.106	77.865
187	499347.872	9180396.048	77.707
188	499371.943	9180444.894	77.603
189	499429.790	9180561.139	77.248
190	499254.728	9180208.967	77.829
191	499370.189	9180174.699	76.634
192	499411.925	9180162.810	74.539
193	499415.435	9180162.407	72.876
194	499417.597	9180158.948	75.184
195	499421.914	9180145.696	75.276
196	499390.634	9180104.209	75.653
197	499390.924	9180104.363	75.216
198	499370.167	9180104.308	75.261
199	499367.132	9180105.447	73.019
200	499361.061	9180105.422	75.692
201	499404.317	9180047.392	75.536
202	499408.870	9180048.151	73.122
203	499412.285	9180044.357	75.204
204	499203.683	9180079.946	76.988
205	499285.570	9180054.912	75.723
206	499358.322	9180014.831	74.361
207	499361.847	9180013.361	73.362
208	499363.517	9180010.667	75.519
209	499320.528	9180009.502	75.497
210	499320.961	9180012.538	73.341

No	X	Y	Z
211	499318.359	9180016.875	74.608
212	499293.206	9180028.813	74.476
213	499291.471	9180020.344	73.292
214	499289.302	9180016.441	75.803
215	499268.919	9180038.992	75.766
216	499265.016	9180039.860	73.338
217	499263.715	9180043.329	75.547
218	499267.644	9180007.767	75.803
219	499262.414	9180007.724	73.617
220	499268.052	9180006.900	75.390
221	499285.570	9179957.460	75.088
222	499294.940	9179957.894	73.573
223	499289.302	9179960.496	75.402
224	498816.592	9179814.854	75.218
225	499349.432	9179997.319	75.347
226	499300.459	9180002.920	75.462
227	499300.573	9180002.621	75.261
228	499112.534	9180056.249	77.879
229	498964.433	9180085.813	78.178
230	499160.794	9179971.856	76.532
231	499069.118	9179988.951	77.423
232	499226.900	9179919.007	74.826
233	499193.506	9179892.986	74.503
234	499189.603	9179895.154	73.164
235	499190.037	9179897.756	74.730
236	499144.934	9179878.240	74.366
237	499144.500	9179873.904	72.949
238	499145.368	9179868.699	74.412
239	499220.242	9179924.032	74.400
240	499221.069	9179923.425	73.337
241	499137.027	9179878.713	76.800
242	499137.037	9179878.713	76.786
243	499016.553	9179905.099	77.166
244	498890.552	9179930.511	77.603
245	498888.501	9179931.550	77.487
246	499023.400	9179829.906	75.511
247	499024.281	9179826.759	73.187
248	499028.310	9179824.241	75.400
249	499060.033	9179823.234	75.272
250	499059.530	9179829.276	73.215
251	499058.019	9179834.816	75.593
252	499092.764	9179849.922	75.544
253	499095.785	9179845.390	73.009
254	499101.324	9179841.865	75.337
255	498871.728	9179829.193	75.349
256	498867.509	9179825.507	73.724
257	498864.963	9179818.395	75.211
258	499148.540	9179660.721	79.220
259	499137.465	9179616.675	77.706
260	499062.675	9179486.934	77.700
261	498900.049	9179212.747	78.684
262	498901.343	9179211.978	78.352
263	498743.313	9178945.579	79.290
264	498744.409	9178945.334	78.889
265	498602.061	9178708.198	79.889
266	498603.037	9178703.445	79.330
267	498487.268	9178508.562	80.099
268	498489.543	9178508.493	79.635
269	498407.595	9178373.292	80.674
270	498409.408	9178373.146	80.020
271	498431.881	9178441.927	80.264
272	498430.733	9178443.031	79.675
273	498535.696	9178617.749	80.616
274	498535.705	9178621.108	79.381
275	498626.257	9178773.167	79.867
276	498624.050	9178774.279	79.145
277	498507.733	9178847.308	78.938
278	498720.484	9178933.584	79.354
279	498717.093	9178932.631	78.736
280	498801.106	9179070.649	79.280

No	X	Y	Z
281	498798.394	9179068.692	78.684
282	498902.796	9179243.126	78.881
283	498900.360	9179243.724	78.242
284	498774.934	9179303.804	78.147
285	499046.828	9179492.365	77.987
286	499101.422	9179588.519	77.692
287	499138.712	9179648.490	77.570
288	497570.371	9178705.837	80.333
289	497568.093	9178710.752	79.083
290	497575.710	9178829.184	80.070
291	497581.495	9178828.070	79.244
292	497571.482	9178828.170	79.455
293	497578.464	9178928.484	79.868
294	497582.680	9178927.910	79.113
295	497581.219	9179026.556	79.709
296	497586.405	9179026.766	78.948
297	497576.767	9179026.677	79.034
298	497480.782	9179029.739	79.004
299	497584.706	9179125.690	79.155
300	497581.542	9179125.081	78.795
301	497468.502	9179130.597	78.781
302	497589.253	9179119.982	78.683
303	497589.430	9179267.995	78.745
304	497590.463	9179343.984	79.455
305	497595.149	9179344.910	78.703
306	497586.998	9179344.118	78.617
307	497592.193	9179414.754	79.998
308	497591.815	9179401.845	79.994
309	497589.898	9179479.653	80.905
310	497589.229	9179477.041	79.641
311	497589.489	9179475.656	79.682
312	497590.669	9179471.721	80.651
313	497696.321	9179466.943	79.220
314	497472.958	9179415.758	80.275
315	497673.862	9179412.009	79.442
316	497474.882	9179346.605	79.857
317	497669.570	9179352.784	79.207
318	499784.318	9178460.396	81.049
319	499784.708	9178454.775	81.996
320	499674.280	9178430.029	81.441
321	499674.448	9178434.567	80.137
322	499669.394	9178433.409	80.375
323	499527.756	9178532.348	79.032
324	499515.346	9178528.297	79.622
325	499487.914	9178661.452	78.540
326	499488.291	9178663.460	78.882
327	499487.789	9178665.468	78.453
328	499486.638	9178650.590	78.795
329	499498.732	9178644.202	78.546
330	499498.133	9178643.452	78.930
331	499525.851	9178629.219	78.585
332	499524.802	9178628.919	79.131
333	499464.104	9178667.323	78.406
334	499418.271	9178674.500	79.776
335	499232.541	9178685.708	79.673
336	499146.567	9178706.545	78.791
337	499135.898	9178707.906	73.776
338	499142.860	9178642.682	78.992
339	499135.395	9178635.766	73.936
340	499120.442	9178786.060	78.471
341	499114.538	9178785.372	74.033
342	499170.983	9178783.280	79.104
343	499220.801	9178770.075	79.987
344	499206.332	9178887.784	78.493
345	499164.927	9178839.274	78.710
346	499161.237	9178855.080	73.602
347	499056.812	9178908.359	80.622
348	499051.665	9178936.245	73.543
349	499078.157	9178851.153	80.891
350	499320.045	9178815.827	79.815

No	X	Y	Z
351	499471.934	9178808.850	78.069
352	499586.473	9178806.835	78.999
353	499462.421	9178811.387	78.898
354	499467.971	9179061.333	78.370
355	499447.006	9179069.819	79.317
356	499436.283	9179073.694	74.366
357	497812.965	9178480.228	80.413
358	499525.062	9179061.972	78.745
359	497570.836	9178591.921	80.376
360	499634.376	9179056.911	78.635
361	499634.909	9179061.439	79.211
362	499634.642	9179065.435	78.545
363	499833.558	9179053.027	79.375
364	499838.353	9179056.023	80.049
365	499838.552	9179065.213	78.806
366	499836.155	9179065.013	79.689
367	499833.159	9179063.415	79.184
368	499843.347	9179055.424	79.327
369	499866.554	9179059.752	80.197
370	499879.241	9179054.403	78.289
371	499884.461	9179049.181	77.694
372	499904.334	9179059.756	73.845
373	499898.139	9179032.655	77.502
374	499901.380	9179000.086	77.826
375	499889.950	9178924.296	78.828
376	499853.039	9178816.254	79.783
377	499826.273	9178788.331	79.701
378	499822.630	9178787.600	80.651
379	499817.284	9178786.131	79.772
380	499711.195	9178652.470	80.136
381	499707.965	9178650.168	80.730
382	499667.724	9178649.656	79.890
383	499808.171	9178645.819	80.317
384	499812.776	9178643.517	81.079
385	499814.936	9178605.644	80.443
386	499809.356	9178580.004	81.690
387	499805.578	9178582.203	80.556
388	499826.447	9178800.378	79.811
389	499823.314	9178801.821	80.635
390	499819.731	9178803.178	79.784
391	499839.963	9179151.302	79.712
392	499838.564	9179151.467	79.052
393	499842.392	9179150.852	78.602
394	499918.153	9179173.546	77.715
395	499935.186	9179181.354	77.386
396	499944.529	9179178.735	73.722
397	499941.023	9179181.118	75.485
398	499938.543	9179233.422	77.853
399	500008.593	9179330.845	77.615
400	500017.656	9179345.069	77.737
401	500022.068	9179363.711	72.867
402	499977.807	9179341.200	77.377
403	499965.038	9179352.417	73.315
404	499965.034	9179352.373	72.794
405	499864.003	9179302.636	78.251
406	499849.381	9179307.498	78.082
407	499847.886	9179312.276	77.546
408	499846.823	9179330.162	72.530
409	499709.185	9179301.655	78.128
410	499697.684	9179346.483	77.598
411	499695.724	9179302.506	78.134
412	499719.760	9179214.543	78.695
413	499143.789	9179656.618	77.504
414	499142.477	9179647.493	78.415
415	499146.164	9179631.779	78.384
416	499145.270	9179627.669	77.536
417	499197.353	9179598.733	77.569
418	499201.889	9179604.133	77.427
419	499327.090	9179523.031	77.248
420	499328.520	9179529.317	77.293

No	X	Y	Z
421	499330.507	9179524.944	77.870
422	499353.736	9179521.019	72.095
423	499309.817	9179466.558	76.868
424	499307.287	9179467.335	77.608
425	499303.131	9179466.819	77.150
426	499300.970	9179458.408	77.893
427	499297.031	9179424.624	77.234
428	499283.906	9179386.241	76.914
429	499251.581	9179397.546	77.305
430	499249.849	9179398.628	77.281
431	499247.933	9179397.139	76.699
432	499238.025	9179424.916	77.706
433	499236.366	9179426.167	77.109
434	499292.481	9179364.061	77.325
435	499285.931	9179361.411	76.612
436	499281.563	9179330.485	76.945
437	499287.607	9179325.968	78.035
438	499332.275	9179309.752	77.249
439	499345.041	9179317.921	72.494
440	499267.142	9179265.297	78.029
441	499363.001	9179167.707	78.160
442	499381.406	9179171.560	72.234
443	499118.308	9179198.972	78.003
444	499116.078	9179200.971	77.525
445	499043.170	9179099.630	78.046
446	499040.224	9179102.040	77.465
447	499155.739	9179042.608	77.943
448	499189.487	9179014.948	77.210
449	499194.554	9178998.917	72.501
450	499042.462	9179092.550	78.041
451	498983.616	9179032.402	76.815
452	498989.348	9179038.525	77.989
453	499011.770	9179055.564	77.035
454	498923.189	9179069.452	78.953
455	498922.056	9179065.298	77.174
456	498836.279	9179104.860	78.522
457	498835.847	9179107.176	79.400
458	498862.476	9179148.785	78.476
459	498860.842	9179149.460	79.103
460	498852.529	9179154.140	78.956
461	498980.130	9179347.891	77.797
462	498986.123	9179357.286	77.689
463	499127.209	9179272.572	77.112
464	499129.687	9179270.722	77.977
465	499132.817	9179273.339	78.081
466	499135.894	9179276.817	77.269
467	499181.035	9179256.082	76.572
468	499176.067	9179252.194	78.018
469	498971.706	9179363.118	78.083
470	498968.304	9179354.695	78.030
471	498851.154	9179416.446	77.908
472	498850.635	9179425.052	77.887
473	498736.114	9179484.884	77.713
474	498905.133	9179804.344	75.352
475	498732.611	9179485.160	77.591
476	498799.143	9179592.487	77.656
477	498796.992	9179595.520	77.446
478	498910.573	9179532.524	77.829
479	498874.195	9179723.554	76.871
480	498873.302	9179724.779	76.613
481	499011.559	9179649.104	77.295
482	499567.680	9180060.119	75.988
483	498905.921	9179785.306	75.579
484	498907.197	9179777.299	75.389
485	498906.103	9179793.415	73.159
486	498929.608	9179794.921	75.105
487	498929.852	9179800.042	73.946
488	498977.480	9179758.220	76.168
489	498973.644	9179760.393	75.478
490	498995.529	9179803.545	75.218

No	X	Y	Z
491	498995.025	9179808.077	73.088
492	498994.018	9179816.134	75.326
493	498960.028	9179812.987	75.294
494	498963.427	9179806.944	73.245
495	498960.784	9179802.412	75.443
496	498878.967	9179801.328	75.171
497	498879.966	9179807.594	73.719
498	498886.321	9179816.101	75.276
499	498847.194	9179830.421	75.547
500	498848.083	9179837.872	73.777
501	498856.692	9179846.201	75.472
502	498809.191	9179862.661	76.305
503	498804.018	9179827.389	75.513
504	498807.780	9179821.275	73.814
505	498815.680	9179800.913	75.903
506	498786.158	9179803.829	75.575
507	498786.704	9179808.567	73.839
508	498786.733	9179816.032	75.382
509	498769.847	9179802.007	74.769
510	498770.626	9179834.443	75.520
511	498775.329	9179841.498	73.873
512	498781.443	9179842.438	75.579
513	498767.028	9179858.085	75.274
514	498769.162	9179861.141	73.951
515	498767.201	9179871.174	75.562
516	498737.705	9179851.845	75.446
517	498733.943	9179856.548	74.116
518	498744.289	9179875.830	75.288
519	498719.213	9179818.280	75.502
520	498715.905	9179826.908	74.081
521	498686.268	9179726.010	75.817
522	498686.610	9179722.182	76.129
523	498692.829	9179698.322	76.872
524	498664.940	9179611.340	77.015
525	498660.534	9179614.779	74.124
526	498612.755	9179551.133	76.659
527	498595.764	9179546.712	75.860
528	498596.110	9179555.899	76.010
529	498592.881	9179566.048	75.688
530	498523.334	9179512.327	76.141
531	498523.939	9179508.233	76.524
532	498522.065	9179520.775	75.470
533	498498.155	9179483.519	76.038
534	498451.961	9179478.968	76.348
535	498457.727	9179498.458	73.492
536	498408.967	9179402.162	77.084
537	498371.790	9179331.095	76.470
538	498373.495	9179332.190	77.084
539	498299.782	9179444.689	76.772
540	498301.189	9179448.319	77.680
541	498302.414	9179451.858	76.355
542	498271.423	9179447.683	76.719
543	498269.880	9179450.996	77.112
544	498239.322	9179388.024	77.498
545	498243.308	9179385.990	77.546
546	498245.905	9179381.805	77.240
547	498187.000	9179167.835	77.940
548	498195.201	9179163.606	77.710
549	498272.554	9179143.254	77.420
550	498363.106	9179122.796	76.505
551	498034.780	9179211.393	77.774
552	498168.083	9179127.409	78.636
553	498692.318	9179506.739	77.536
554	498687.923	9179501.044	77.166
555	498934.519	9179015.446	76.826
556	498935.652	9179012.047	77.138
557	498968.774	9178998.677	76.802
558	498970.662	9178993.834	77.910
559	498946.320	9178904.776	78.259
560	498896.469	9178931.212	77.304

No	X	Y	Z
561	498884.762	9178931.590	76.781
562	498945.187	9178846.994	78.196
563	499025.979	9178930.285	72.536
564	498889.664	9178865.560	78.337
565	498878.676	9178872.019	76.707
566	498821.126	9178929.229	78.285
567	498832.739	9178901.754	78.822
568	498844.918	9178895.240	78.217
569	498850.300	9178893.540	76.904
570	498853.416	9178878.812	76.918
571	498850.017	9178879.661	78.240
572	498842.086	9178877.962	78.573
573	498847.562	9178849.354	78.292
574	498878.908	9178831.226	77.834
575	499089.866	9178746.920	77.329
576	499110.638	9178755.246	73.041
577	498942.474	9178741.025	78.682
578	498907.940	9178739.217	78.047
579	498882.307	9178761.264	78.471
580	498923.640	9178346.373	79.277
581	499005.953	9178479.961	78.868
582	499083.993	9178468.145	76.053
583	499110.454	9178472.918	73.256
584	498729.191	9178552.844	78.865
585	498726.075	9178543.893	78.573
586	498731.457	9178549.275	78.262
587	498702.181	9178505.858	78.317
588	498935.193	9178559.058	79.122
589	498849.087	9178570.639	79.382
590	498745.985	9178577.714	79.048
591	498753.990	9178580.161	79.413
592	498768.306	9178617.782	79.175
593	498765.755	9178610.668	78.966
594	498765.798	9178616.506	79.603
595	498553.676	9178620.069	79.495
596	498608.384	9178711.553	79.289
597	498843.878	9178577.370	78.419
598	498904.980	9178649.193	78.337
599	498873.257	9178661.782	78.411
600	498866.207	9178663.796	79.035
601	498864.193	9178725.733	78.268
602	498859.661	9178723.215	79.292
603	498853.618	9178723.221	78.855
604	498855.115	9178762.681	78.928
605	498832.937	9178667.321	79.558
606	498825.420	9178666.314	78.974
607	498810.313	9178626.533	79.620
608	498806.385	9178628.366	79.061
609	498818.370	9178613.832	79.109
610	498816.859	9178607.399	78.664
611	499065.436	9178366.220	79.435
612	498835.817	9178294.526	77.395
613	498824.321	9178440.608	77.226
614	498634.193	9178257.735	77.585
615	498504.121	9178211.943	79.824
616	498579.419	9178291.978	78.952
617	498580.081	9178308.344	79.440
618	498617.997	9178357.692	79.334
619	498667.871	9178447.656	79.185
620	498809.298	9178483.592	77.318
621	498594.277	9178316.564	78.960
622	498629.620	9178116.451	78.232
623	498558.219	9178063.390	81.357
624	498440.489	9178424.796	79.751
625	498422.060	9178448.076	79.633
626	498419.922	9178446.962	80.119
627	498418.646	9178445.046	79.680
628	498280.547	9178541.945	79.052
629	498278.825	9178540.438	79.529
630	498275.597	9178540.653	79.104

No	X	Y	Z
631	498150.537	9178628.584	78.409
632	498147.969	9178627.999	78.873
633	498148.468	9178624.648	78.364
634	497941.205	9178765.651	79.527
635	497942.373	9178767.601	79.091
636	497939.882	9178764.056	79.173
637	497936.025	9178768.942	80.041
638	497933.510	9178770.619	79.371
639	498098.258	9179010.825	78.603
640	498094.613	9179016.081	79.341
641	498092.831	9179017.924	78.586
642	499155.583	9179940.164	76.400
643	497156.461	9178980.190	79.098
644	497151.476	9178985.988	77.826
645	497150.012	9178991.304	77.831
646	497144.163	9178993.655	80.000
647	497140.939	9179020.115	81.394
648	497138.786	9179023.131	80.381
649	497163.963	9179134.979	80.229
650	497167.561	9179134.133	81.361
651	497178.560	9179137.232	77.234
652	497185.060	9179136.592	79.485
653	497191.355	9179258.589	80.245
654	497194.461	9179257.037	81.230
655	497202.659	9179271.478	79.052
656	497209.757	9179341.393	80.358
657	497213.019	9179343.394	81.314
658	497222.788	9179345.243	80.603
659	497224.890	9179348.253	79.997
660	497220.249	9179341.746	79.392
661	497448.109	9179347.109	79.778
662	497448.228	9179342.869	78.767
663	497445.223	9179295.752	78.714
664	497472.522	9179421.089	80.498
665	497468.527	9179451.652	79.586
666	497470.609	9179451.546	80.930
667	497392.250	9179417.155	80.593
668	497320.563	9179417.198	79.705
669	497323.625	9179413.391	80.775
670	497222.095	9179398.764	80.161
671	497226.096	9179399.753	81.342
672	497231.636	9179400.567	80.729
673	497157.304	9178974.206	79.910
674	497316.211	9178870.523	80.263
675	497563.701	9178708.116	80.428
676	497450.037	9178787.547	79.730
677	497569.150	9178774.033	79.691
678	497572.484	9178765.259	80.123
679	497582.240	9178857.665	79.208
680	497576.741	9178860.372	80.159
681	497572.522	9178866.875	79.414
682	497490.337	9178865.285	79.500
683	497359.849	9178863.684	79.425
684	497313.344	9178875.971	79.539
685	497185.566	9178958.651	79.441
686	497361.850	9178956.792	79.203
687	497259.019	9179068.521	78.804
688	497366.862	9179047.290	78.975
689	497252.153	9178959.406	79.035
690	497369.212	9179130.687	78.803
691	497372.628	9179233.876	78.614
692	497285.209	9179234.800	78.496
693	497285.006	9179148.489	78.702
694	497436.937	9179232.840	78.688
695	497582.311	9179229.719	78.729
696	497990.627	9179044.859	78.530
697	498031.108	9178915.894	79.668
698	498024.801	9178914.633	78.912
699	498033.631	9178913.539	78.834
700	497887.668	9178939.862	79.820

No	X	Y	Z
701	498157.116	9178840.131	78.359
702	498040.813	9178698.970	79.028
703	498042.942	9178698.704	78.762
704	498042.143	9178695.511	78.804
705	497574.493	9178962.707	79.107
706	497466.389	9178962.487	79.172
707	497578.879	9178960.684	79.868
708	498276.479	9178246.360	80.622
709	498211.934	9178288.783	80.440
710	498107.571	9178357.177	80.286
711	498023.509	9178412.857	80.076
712	497899.990	9178494.331	79.823
713	497785.365	9178570.264	80.390
714	497665.872	9178647.878	80.534
715	497690.601	9178752.307	80.097
716	497898.658	9178670.382	80.092
717	497929.949	9178724.316	79.568
718	497973.880	9178615.490	79.632
719	498006.195	9178577.810	79.399
720	498058.418	9178537.646	79.552
721	498127.267	9178519.731	79.697
722	498226.952	9178442.865	80.015
723	498330.773	9178260.600	81.545
724	499842.415	9179419.180	77.047
725	499760.669	9179439.083	77.352
726	499739.343	9179532.203	77.538
727	497990.414	9179377.044	78.198
728	499076.789	9178385.956	73.493
729	499075.066	9178421.291	77.824
730	499085.407	9178422.153	73.357
731	499102.644	9178516.435	77.015
732	499115.571	9178517.297	73.238
733	499092.302	9178576.762	76.983
734	499111.262	9178570.729	73.214
735	499078.513	9178634.504	77.112
736	499117.294	9178631.918	73.196
737	499100.058	9178708.620	76.964
738	499113.847	9178705.173	73.177
739	499121.604	9178751.940	73.068
740	499128.498	9178749.355	78.643
741	499098.335	9178791.584	73.011
742	499070.756	9178788.137	76.825
743	499077.651	9178816.577	73.003
744	499085.407	9178816.572	78.527
745	499064.724	9178810.544	73.015
746	499039.731	9178807.958	76.797
747	499056.860	9178853.635	78.392
748	499049.103	9178851.696	72.994
749	499036.822	9178852.988	73.006
750	499012.261	9178854.927	76.812
751	499028.420	9178904.051	72.983
752	499036.822	9178902.112	77.804
753	499018.078	9178900.819	73.018
754	498994.809	9178897.587	77.025
755	499043.286	9178926.027	77.912
756	499018.078	9178933.396	72.977
757	498985.760	9178937.920	76.904
758	499049.103	9178945.676	72.918
759	499054.921	9178959.250	77.109
760	499078.190	9178907.541	77.431
761	499085.946	9178911.419	73.228
762	499095.641	9178920.468	73.173
763	499100.812	9178920.457	76.620
764	499093.702	9178871.345	78.029
765	499116.971	9178875.223	73.316
766	499125.374	9178881.040	73.140
767	499154.460	9178869.406	73.028
768	499132.807	9178821.144	79.845
769	499136.254	9178937.489	76.952
770	499188.717	9178893.968	72.910

No	X	Y	Z
771	499179.668	9178903.017	73.142
772	499172.558	9178906.895	77.083
773	499186.778	9178956.018	72.951
774	499175.790	9178964.421	77.106
775	499198.413	9178956.665	72.826
776	499211.340	9178952.786	78.193
777	499205.523	9178996.739	72.646
778	499230.085	9179001.910	77.920
779	499236.225	9179026.256	72.571
780	499309.086	9178927.902	79.048
781	499224.655	9179042.631	72.632
782	499231.550	9179054.122	77.805
783	499296.401	9179007.598	77.951
784	499309.328	9179016.001	72.463
785	499307.389	9179030.221	72.517
786	499314.499	9179034.099	77.185
787	499379.459	9179009.106	72.436
788	499380.320	9179012.553	77.256
789	499359.637	9179079.775	77.934
790	499416.517	9179022.033	72.371
791	499430.306	9179026.342	78.862
792	499419.102	9179072.019	72.286
793	499408.760	9179073.742	77.318
794	499419.102	9179158.890	72.188
795	499438.062	9179163.199	78.249
796	499361.212	9179260.362	72.206
797	499378.805	9179258.229	78.153
798	499347.350	9179247.567	72.258
799	499333.489	9179247.034	77.415
800	499367.076	9179327.963	72.181
801	499387.335	9179330.095	78.824
802	499376.140	9179394.604	72.143
803	499365.477	9179396.737	77.390
804	499395.865	9179420.194	72.203
805	499409.194	9179419.128	78.711
806	499368.143	9179463.378	72.186
807	499358.546	9179459.646	76.552
808	499352.349	9179493.939	72.154
809	499343.152	9179501.337	76.427
810	499347.151	9179530.126	72.045
811	499342.752	9179528.926	76.443
812	499367.143	9179556.116	72.021
813	499364.344	9179559.315	76.215
814	499385.536	9179558.915	72.044
815	499416.724	9179585.145	72.109
816	499417.924	9179597.140	76.199
817	499465.026	9179601.983	72.072
818	499457.029	9179609.136	77.083
819	499507.010	9179587.944	72.046
820	499523.403	9179593.142	77.119
821	499590.498	9179576.348	72.026
822	499594.096	9179586.744	77.251
823	499634.814	9179567.018	72.157
824	499633.748	9179545.160	76.711
825	499656.875	9179575.948	72.208
826	499661.671	9179578.747	76.842
827	499663.603	9179517.117	72.015
828	499656.139	9179518.184	76.523
829	499681.197	9179519.783	72.079
830	499690.260	9179518.184	76.803
831	499605.492	9179441.946	78.803
832	499664.136	9179443.012	71.982
833	499650.808	9179443.108	77.714
834	499675.865	9179443.546	71.975
835	499695.591	9179438.747	76.629
836	499719.653	9179349.715	72.024
837	499744.692	9179349.181	71.409
838	499754.289	9179357.178	76.513
839	499783.943	9179353.645	76.472
840	499788.788	9179345.193	71.419

No	X	Y	Z
841	499791.791	9179333.724	71.520
842	499787.565	9179319.055	77.554
843	499828.394	9179341.718	71.881
844	499819.864	9179350.248	76.294
845	499934.824	9179356.626	71.620
846	499911.367	9179363.734	76.283
847	499923.096	9179467.327	71.812
848	499912.670	9179462.588	76.304
849	499851.064	9179597.743	71.354
850	499846.325	9179592.056	76.470
851	499823.578	9179598.690	78.816
852	499841.704	9179653.314	71.493
853	499829.762	9179649.192	77.116
854	499753.702	9179687.577	71.198
855	499749.437	9179677.625	76.921
856	499696.835	9179706.770	71.265
857	499692.570	9179701.083	77.126
858	499592.342	9179697.529	71.138
859	499596.607	9179681.890	77.307
860	499556.888	9179717.219	71.164
861	499556.557	9179723.617	77.419
862	499541.872	9179739.374	76.570
863	499587.366	9179810.031	71.174
864	499561.065	9179796.525	77.208
865	499549.691	9179801.501	76.425
866	499642.456	9179873.770	71.028
867	499639.612	9179881.352	76.822
868	499638.665	9179888.934	76.267
869	499802.632	9179961.914	71.193
870	499807.371	9179973.287	76.214
871	499796.945	9180053.470	76.311
872	499728.704	9180086.643	71.447
873	499740.818	9180153.035	72.038
874	499726.424	9180158.366	75.315
875	499749.348	9180225.541	71.171
876	499734.954	9180219.143	75.159
877	498335.103	9178253.464	80.826
878	498337.021	9178250.325	80.203
879	498345.614	9178286.344	81.520
880	498352.073	9178282.753	80.805
881	498354.139	9178279.446	80.218
882	498362.664	9178317.778	80.703
883	498358.944	9178317.776	80.114
884	498368.061	9178310.484	80.684
885	498371.374	9178308.916	80.202

No	X	Y	Z
886	498384.076	9178337.936	80.710
887	498388.086	9178335.321	80.218
888	498377.589	9178342.122	80.739
889	498375.496	9178343.865	80.198
890	498397.468	9178376.613	80.805
891	498394.503	9178378.357	80.206
892	498437.085	9178427.334	80.483
893	498474.983	9178509.997	80.195
894	498473.123	9178511.159	79.527
895	498539.115	9178601.577	80.418
896	498543.145	9178600.027	79.502
897	498588.274	9178907.425	78.882
898	498639.070	9178772.003	79.970
899	498642.383	9178770.259	79.211
900	498676.735	9178853.279	79.893
901	498674.643	9178854.154	79.296
902	498687.355	9178855.200	79.820
903	498690.319	9178852.933	79.188
904	498769.584	9179012.895	79.412
905	498766.794	9179014.129	78.926
906	498780.124	9179012.579	79.207
907	498782.914	9179011.649	78.784
908	498812.675	9179067.801	79.042
909	498812.155	9179067.181	78.625
910	498830.858	9179115.647	79.380
911	498829.190	9179117.510	78.662
912	498850.420	9179153.413	78.508
913	498871.861	9179186.269	79.010
914	498869.667	9179186.271	78.380
915	498932.585	9179289.488	78.829
916	498929.661	9179290.138	78.203
917	498943.958	9179290.788	78.740
918	498945.908	9179287.214	78.124
919	499004.001	9179418.210	78.020
920	499019.355	9179416.013	77.695
921	499084.994	9179526.684	77.694
922	499172.846	9179647.198	78.185
923	499254.625	9179641.726	78.037
924	499339.886	9179642.719	77.922
925	499344.854	9179636.427	77.894
926	499475.604	9179635.765	77.478
927	499480.572	9179628.148	77.420
928	499602.647	9179620.531	77.261
929	499817.652	9179612.915	78.305
930	499825.931	9179606.623	78.418