Guidelines for Disaster Risk Management Using Geospatial Information and Services

Eruption of Pinatubo Volcano (left) and Pinatubo Crater at normal time (upper and lower right)
Photos by PHIVOLCS-DOST, the Philippines

**Working Group on Disaster Risk Management (WG2),
Regional Committee of the United Nations
Global Geospatial Information Management
for Asia and the Pacific (UN-GGIM-AP)**

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Preface

This document was prepared by Working Group on Disaster Risk Management (WG2) of the Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific (UN-GGIM-AP) to assist National Geospatial Information Authorities (NGIAs) in the Asia-Pacific region as their Guidelines in contributing to disaster risk reduction through taking practical actions against natural disasters by fully employing geospatial information technology.

These Guidelines have been compiled in accordance with Strategic Framework on Geospatial Information and Services for Disasters (SFGISD), to provide NGIAs in the Asia-Pacific region with materials for launching and enhancing their works for disaster risk management.

Chapter one provides introduction to understand international trend in utilization of geospatial information for disaster risk management and the context in which the Guidelines were developed.

Chapter two summarizes SFGISD, which is an international policy guidance document adopted by UN-GGIM and endorsed by ECOSOC, and explores strategic viewpoint of NGIAs to manage disaster risk, as well as disaster cycle and its three phases: before, during and after disasters.

In Chapter three through five, policy and measures NGIAs can take before, during and after disasters are examined in detail. NGIAs staff readers can examine these proposed policy and measures, while taking their organizational objectives and available resources into account.

The collection of Best Practices and actions taken by Geospatial Information Authority of Japan in response to 2016 Kumamoto Earthquake are introduced in Annex two and three respectively. They are notable as specific cases useful for NGIAs to develop policy and measures.

Furthermore, these Guidelines will be of great help in the Asia-Pacific and all the other regions. Also, they are instrumental not only for NGIAs but also all organizations conducting disaster response using geospatial information at present and in future.

I am very grateful to all members of WG2 listed in Annex 1 for their extensive contribution in preparing this document, and sincerely hope, on their behalf, that these Guidelines will contribute to disaster risk reduction in the region through active engagement of NGIAs with relevant applications of geospatial information technology.

November, 2018

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Acronyms and Abbreviations

CORS	Continuously Operating Reference Station
DRM	Disaster Risk Management
ECOSOC	Economic and Social Council
ESCAP	Economic and Social Commission for Asia and the Pacific
GIS	Geographic Information Systems
GNSS	Global Navigation Satellite System
GSGF	Global Statistical Geospatial Framework
ICT	Information and Communication Technology
NGIAs	National Geospatial Information Authorities
SAR	Synthetic Aperture Radar
SDGs	Sustainable Development Goals
SFDRR	Sendai Framework for Disaster Risk Reduction 2015-2030
SFGISD	Strategic Framework on Geospatial Information and Services for Disasters
SNS	Social Network Service
UAVs	Unmanned Aerial Vehicles
UN EG-ISGI	United Nations Expert Group on the Integration of Statistical and Geospatial Information
UN-GGIM	United Nations Committee of Experts on Global Geospatial Information Management
UN-GGIM-AP	Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific
UNISDR	United Nations Secretariat for International Strategy for Disaster Reduction
VGI	Voluntary Geographic Information
WG2	UN-GGIM-AP Working Group on Disaster Risk Management
WG-Disasters	Working Group on Geospatial Information and Services for Disasters

Chapter 1: Introduction

1-1) International Context

Many countries in the Asia-Pacific region are located along the Alpine-Himalayan orogenic belt and the circum-Pacific orogenic belt, and are prone to considerable impacts of natural hazards, including earthquakes, tsunamis, and volcanic eruptions that are frequently caused by their persistent tectonic activities. Typhoons and floods resulting from extreme weather events, presumably intensified by recent climate change, have repeatedly caused much damage in this region as well. Statistics in fact highlights that the Asia-Pacific (Asia and Oceania) region accounted for over 50 percent of the total impacts of natural disasters in the world in 2016 as shown in Table 1 (ADRC, 2016).

Table 1 Impacts of natural disasters by region 2016

Region	Impact							
	Occurrence (share in %)		Killed (share in %)		Affected (share in %)		Damage (million US$) (share in %)	
Africa	63	(18.0%)	2,554	(24.9%)	13,760,813	(6.7%)	867	(0.6%)
Americas	85	(24.3%)	2,062	(20.1%)	95,038,986	(46.6%)	57,148	(38.8%)
Asia	158	(45.1%)	5,186	(50.5%)	94,718,029	(46.4%)	73,017	(49.5%)
Europe	28	(8.0%)	415	(4.0%)	93,426	(0.0%)	11,179	(7.6%)
Oceania	16	(4.6%)	56	(0.5%)	490,911	(0.2%)	5,160	(3.5%)
Total	350	(100.0%)	10,273	(100.0%)	204,102,165	(100.0%)	147,371	(100.0%)

Source: ADRC (2016)

In light of such inherent high risk of natural hazards in the region, the National Geospatial Information Authorities (NGIAs) in some countries have been successfully taking advantage of geospatial information technology as well as ICT and space technology to prepare risk maps of vulnerable areas, quickly respond to disasters with timely provision of accurate geospatial information of the damaged areas, and widely share them on web maps. These efforts have significantly contributed to the accurate and timely understanding of both potential risks and actual damages caused by disasters in their countries. These experiences have been repeatedly shared through regional and international conferences. The Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific (UN-GGIM-AP), in particular, has long been engaged in finding the way in which the geospatial information technology can be best employed by NGIAs in disaster risk reduction by setting up working groups and conducting a number of pilot studies in cooperation with NGIAs in the region. The result of such studies is found at Knowledge Base of UN-GGIM-AP website (UN-GGIM-AP, 2016a).

In the meantime, the Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR) was adopted at the Third United Nations World Conference on Disaster Risk Reduction in 2015 (UNISDR, 2015). SFDRR recognizes that “Disasters, many of which are exacerbated by climate change and which are increasing in frequency and intensity, significantly impede progress towards sustainable development.” (paragraph 4), and aims to achieve the outcome of “The substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries” (paragraph 16) by 2030. In order to attain this outcome, SFDRR lists a number of key actions for disaster risk reduction and requests the member states and other relevant stakeholders to implement them. One of the outstanding features included in these actions is the application of geospatial information technology for disaster risk reduction.

In response to this call, the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) established the Working Group on Geospatial Information and Services for Disasters (WG-Disasters) in 2015 to discuss the overall framework of the application of geospatial information and services for disaster risk reduction. As one of its outcomes, WG-Disasters drafted a Strategic Framework on Geospatial Information and Services for Disasters (SFGISD), which was adopted at the seventh session of UN-GGIM in August 2017 (WG-Disasters, 2017). Furthermore, the resolution on SFGISD was adopted by the Economic and Social Council (ECOSOC) on 2 July 2018 as a guide for member states to ensure the availability and accessibility of quality geospatial information and services across all phases of disaster risk reduction and management (ECOSOC, 2018).

1-2) About the Guidelines

In parallel to abovementioned global endeavor for disaster risk reduction with geospatial information technology, and given the fact that the Asia-Pacific region is especially prone to natural disasters, UN-GGIM-AP established the Working Group on Disaster Risk Management (WG2) at its fourth plenary meeting in 2015 to explore potential roles of NGIAs for disaster risk reduction. The primary goal of WG2, during its three-year term (2015-2018), is to develop guidelines that assist NGIAs in the region in applying the geospatial information technology for disaster risk reduction.

Figure 1 shows the conceptual relationships between the Guidelines and the relevant frameworks and activities. The Guidelines, which introduce specific geospatial activities for NGIAs, complements SFGISD which is a policy guidance document for applying geospatial information and services for disaster risk reduction. With the help of these two documents, NGIAs are expected to enhance their capability of applying geospatial information technology and services in their responses to disasters, and contributing to disaster risk reduction at national level. The collective efforts of NGIAs will significantly contribute to disaster risk reduction in the Asia-Pacific region, which will contribute to the implementation of the Sustainable Development Goals (SDGs) and the SFDRR.

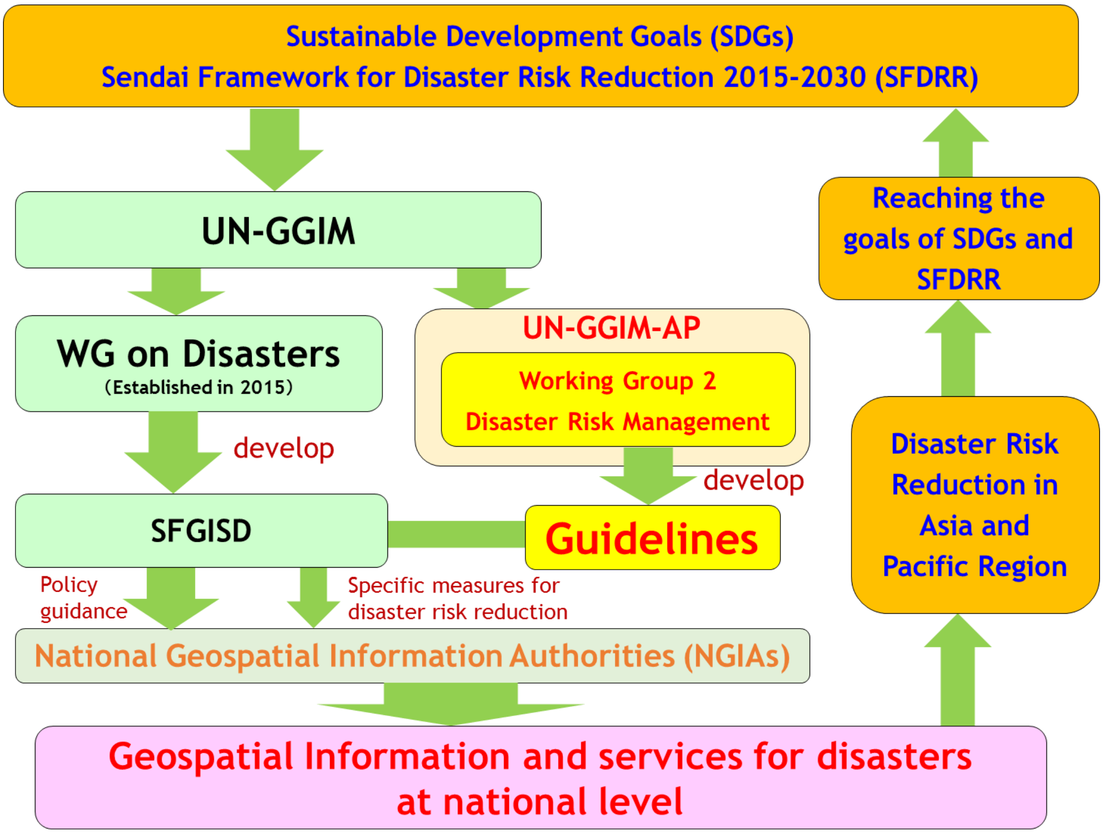


Figure 1 Relationships between the Guidelines and the relevant frameworks and activities

Prior to developing the Guidelines, WG2 conducted a questionnaire survey to understand what NGIAs in the region have been doing against natural disasters with geospatial information and services (UN-GGIM-AP, 2016b), and collected the best practices of NGIAs in the region for applying geospatial information, attached as Annex 2 to the Guidelines. The results of the survey and the best practice collection were analyzed to identify practical actions NGIAs can take at each phase of “Disaster Cycle” with geospatial information technology. The outcomes of the Special Session of the 6th Plenary of UN-GGIM-AP, which discussed the potential roles of NGIAs by analyzing a specific case of what Geospatial Information Authority of Japan (GSI) did in response to 2016 Kumamoto Earthquake, were also incorporated into the Guidelines. Furthermore, the comments and insights made by the members of WG2 as well as UN-GGIM-AP member NGIAs were also incorporated into the Guidelines.

WG2 also worked closely with WG-Disasters of UN-GGIM and incorporated the priority policy of SFGISD into the Guidelines to assist NGIAs in implementing SFGISD's goals so that they will facilitate the adaptation of SFGISD in each country as illustrated in Figure 1.

The Guidelines consist of the following chapters. Following this introductory chapter (Chapter 1), Chapter 2 describes the roles of geospatial information and NGIAs in DRM. Then, Chapters 3, 4 and 5 introduce measures before, during and after disasters, respectively. These measures would be potentially engaged by NGIAs based on the roles described in Chapter 2. In addition, there are three annexes. Annex 1 is the list of WG2 members. Annex 2 is the summary of the best practices on the use of geospatial information for disaster risk reduction. Annex 3 includes the GSI's case story of response activities to 2016 Kumamoto Earthquake.

Targeted readers of the Guidelines are primarily senior staff members of NGIAs. However, the Guidelines will also benefit other users in geospatial information field who work for disaster risk reduction in both public and private sectors. In this sense, the Guidelines are also expected to develop a common understanding on the benefit of employing geospatial information technology between NGIAs and relevant stakeholders that engage in disaster risk reduction.

While there are a number of different types of natural hazards in the region, most methodologies of applying geospatial information technology in DRM by NGIAs are commonly applicable to different types of hazards. Therefore, the Guidelines do not address specific geospatial information technologies that are only applicable for a specific type of hazard. Rather, the Guidelines, mainly in Chapter 4, focus on how different types of geospatial information technology can be applied in disaster risk reduction in general. In addition, since the Guidelines are intended to cover as many measures for NGIAs as possible, some of them may not be suitable or practical for specific disasters or in some countries. NGIAs, therefore, are requested to select those measures that are applicable in their countries, and modify them, if needed, so that they may be best suited for their needs in DRM.

Chapter 2: Roles of Geospatial Information Technology and NGIAs in DRM

2-1) Roles of Geospatial Information Technology and NGIAs

Disaster Risk Management (DRM) refers to the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses (UN General Assembly Resolution A/RES/69/283 (Unites Nations, 2015)). While many different measures are to be employed in DRM, SFGISD stresses that geospatial information has been widely recognized as an important aspect of DRM, and that the availability and accessibility of quality geospatial data and information from authoritative sources ensure decision makers and other concerned stakeholders of an accurate common operational picture of critical scenarios before, during and after disasters (paragraph 2 of SFGISD). Based on this understanding, SFGISD aims to achieve the following outcome:

The human, socioeconomic and environmental risks and impacts of disasters are prevented or reduced through the use of geospatial information and services (paragraph 8).

In order to attain this outcome, the following goal is set in SFGISD to take full advantage of the geospatial information technology:

Quality geospatial information and services are available and accessible in a timely and coordinated way to support decision-making and operations within and across all sectors and phases of disaster risk management (paragraph 9).

Furthermore, SFGISD proposes the following targets to achieve the above outcome and goal (paragraph 10):

a. Awareness is raised among policy makers and concerned entities on the importance of geospatial information and services to the DRM process; regular assessment, monitoring and evaluation of risks and disaster situations are conducted; and a comprehensive plan is developed to implement the five priorities for action identified in this framework;
b. Policies on collaboration, coordination and sharing are established, issued and implemented;
c. Geospatial databases and information products are developed, maintained and updated based on common standards, protocols and processes as important tools in every decision-making process across all phases of the DRM;
d. Common geospatial information facilities and services are established for all key stakeholders to have a common operational picture of disaster events;
e. Information, education and communications capacities and mechanisms are built and strengthened; and
f. Resources are made available to sustain all the activities for the enhancement of the use of geospatial information in DRM.

SFGISD proposes major activities to achieve its outcome and goal, taking into account of the fact finding analysis of existing policy frameworks in the world. The activities are classified into one of the following five priorities for action.

Priority 1: Governance and Policies;
Priority 2: Awareness Raising and Capacity Building;
Priority 3: Data Management;
Priority 4: Common Infrastructure and Services; and
Priority 5: Resource Mobilization.

Among many organizations which conduct DRM activities, it is obvious that NGIAs should take a central role in promoting geospatial information for effective DRM, by communicating and collaborating with the other organizations. NGIAs have a unique position in national institutional framework, by providing authoritative geospatial information as framework data to the society, advocating and promoting appropriate and/or state-of-the-art geospatial information technology to solve the problems that are common in DRM operations by relevant organizations.

In order to confirm the roles and function of the NGIA within national DRM framework, the NGIA, particularly its senior officials are recommended to check the following points to further enhance its strengths and to avoid duplications within the framework.

- Figure out the NGIA's position in the national DRM framework or "eco-system", by mapping the DRM community structure, the member organizations and their roles. (Figure 2 shows a schematic relationship diagram between the NGIA and stakeholders.)
- Recognize the technical strengths of their organization and others contributing to DRM outcomes.
- Understand the needs of end users of the NGIA's outputs and identify gaps to be closed.
- Scope and plan the development or maintenance of applicable datasets and services.
- Prioritize engagement with strategic delivery partners in national and local government, academia, private sector and NGOs, that will be needed to meet end user needs,
- Invest in organizational capability, capital expenditure, workforce development.
- Streamline the work process to meet user needs at appropriate time and occasion.
- Ensure the organization's efforts not to duplicate those of others in the framework.
- Specify the role of the NGIA before, during and after disaster in communication geospatial information and services.
- Advocate the importance of geospatial function in the DRM framework.

While some specific points in the above list will be touched in the following chapters, a schematic communication diagram is proposed in Figure 2 to reconfirm the position of the NGIA in national DRM framework consisting of stakeholders in the society.

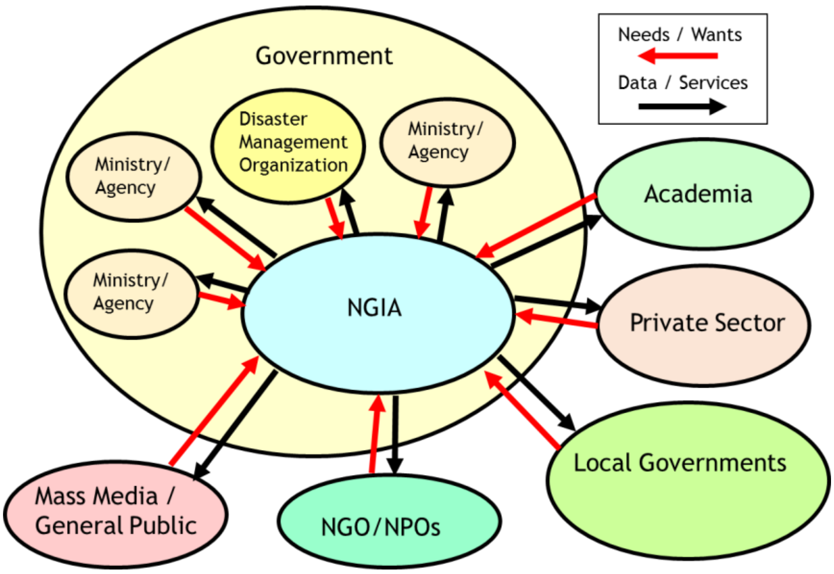


Figure 2 Diagram for geospatial communication between the NGIA & stakeholders

2-2) Disaster cycle phases

Although NGIAs are expected to employ geospatial information and its enabling technology as mentioned above to contribute to DRM, they need to adjust their activities through "Disaster Cycle" to provide appropriate information and services in a timely manner. While there are some variations in the names of disaster cycle phases and their definitions, the Guidelines adopt those used by SFGISD, which divides the whole disaster cycle into three phases of before, during and after disasters, in each of which the measures need to be conducted as shown in Table 2. The concept of disaster cycle is illustrated in Figure 3.

Table 2 DRM measures before, during and after disasters

Phase	Measures
Before Disaster	Preparation to prevent or reduce disaster damage before disasters occur
During Disaster	Lifesaving and emergency assistance to disaster victims (e.g., medical activities, procurement of food, clothes and other relief supplies, and securement of evacuation centers)
After Disaster	Restoration of the functions and services of public facilities and infrastructures in the affected areas to bring them back to normal conditions or better than before

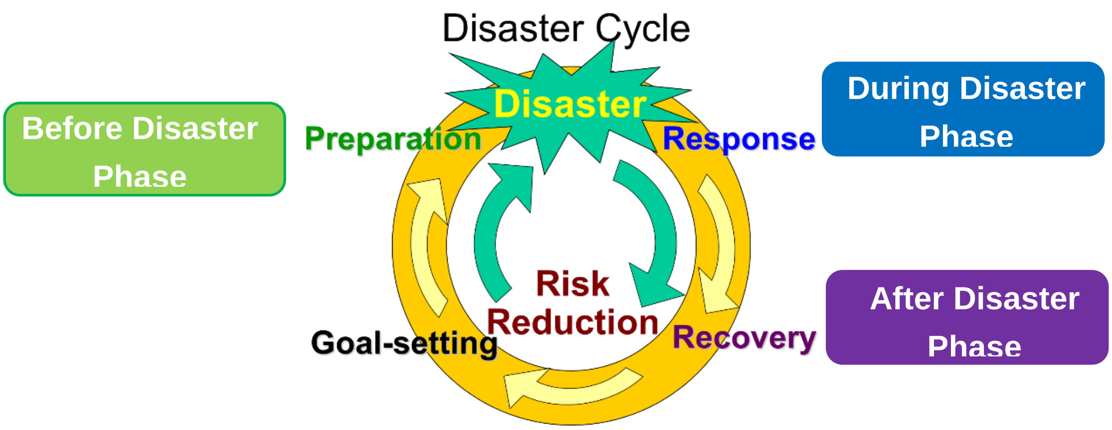


Figure 3 Disaster cycle

In order to contribute to implementing DRM measures throughout the disaster cycle shown in Table 2, NGIAs should engage in the following activities at each of the phases[1]:

Before disasters:

i) Development and update of geospatial databases of the country to enable all stakeholders to easily get access to the latest geospatial information including disaster risk information before disasters take place;
ii) Policy development and organizational arrangements at national level and within NGIAs, defining the roles and activities of NGIAs throughout the disaster cycle.
iii) Building cooperative relationships with stakeholders that potentially benefit from the applications of geospatial information in their response to disasters so that they will be able to use the latest geospatial information, and to provide NGIAs with the information on their needs, including feature attribution quality requirement, and so that NGIAs will be able to build partnerships with the industry and international bodies to meet the sudden surge of demand at the outbreak of disasters;
iv) Conducting regular drills within NGIAs to quickly respond to emergency situations with adequate resources and capacity; and
v) Raising awareness among relevant stakeholders by explaining policy makers about the usefulness of products NGIAs can provide, participating in their disaster response drills, conducting public relations and educational activities.

During disasters:

i) Launching initial response activities including the assessment of disaster impacts to set the level of priority and engagement of the organization; setting up the disaster management meeting; and safety check of the NGIA staff members.
ii) Convening the first and the subsequent disaster management meetings to mobilize necessary resources and personnel to implement the determined measures;
iii) Activation of cooperative relationships and partnerships with relevant

[1] In addition to the three phases in the disaster emergency cycle, disaster mitigation policy and measures are one of the major field for geospatial application. The guidelines, however, does not touch upon geospatial application for mitigation due to lack of best practice examples and available information.

stakeholders to inquire their needs and provide the latest geospatial information that shows disaster situations in a timely manner;

iv) Acquisition of the latest geospatial information in disaster situations by employing available geospatial information technology effective for particular disasters occurred; and

v) Dissemination of the latest geospatial information that shows disaster situations to the relevant organization as well as the general public.

After disasters:

i) Providing the revision of the coordinates of geodetic control points after large earthquakes, ortho-rectified image maps and line maps of affected to relevant stakeholders, particularly the public works organizations; and

ii) Reviewing the whole process of disaster response activities to make necessary improvements and revisions in the NGIAs' measures including their policy, organizational arrangements and methodologies.

The recommended specific measures that may be taken by NGIAs for DRM will be presented in Chapter 3 (before disaster), Chapter 4 (during disaster) and Chapter 5 (after disaster).

Chapter 3: NGIAs' measures before disasters

Measures of NGIAs on DRM start well before the outbreak of disasters. Sections below explore activities NGIAs should engage before disasters including development/update of geospatial databases, organizational arrangements, establishment of communication channels with stakeholders, and raising awareness among relevant stakeholders on the benefits of using the NGIAs' products for their disaster response operations. Figure 4 shows the relationships of measures introduced in this Chapter.

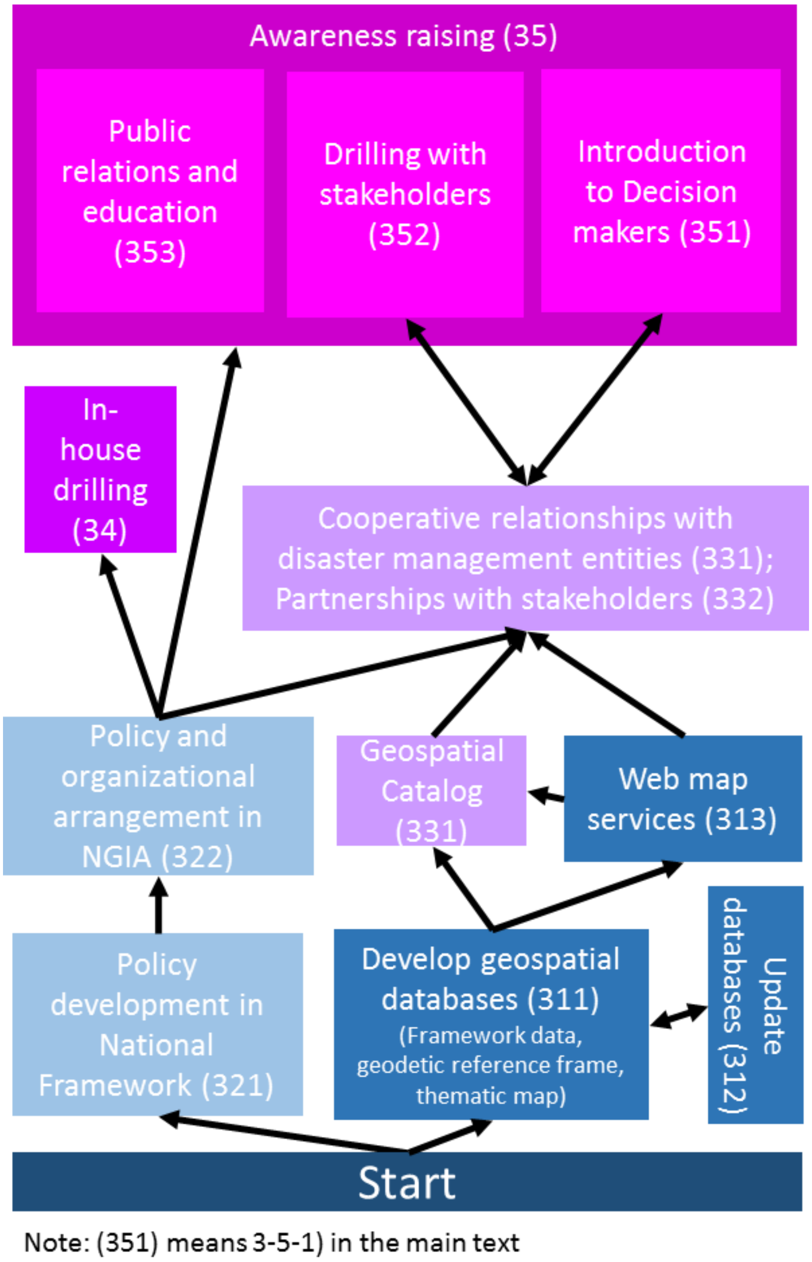


Figure 4 NGIAs' measures to be taken before disasters

3-1) Development, update and dissemination of geospatial databases

The following measures are regularly conducted by NGIAs, and are not recognized as specific activities solely for DRM. However, it is important to understand that the continuous implementation of these measures is the prerequisite for NGIAs' successful contribution to DRM, particularly during disasters.

3-1-1) Development of geospatial databases

Developing geospatial databases of the country and making them accessible by the government and the general public are the "raison d'être" of an NGIA. This responsibility becomes even more prominent when the government agencies and relevant stakeholders are engaged in emergency response activities in the affected areas hit by a large disaster. If the geospatial databases do not exist or are not made readily available, people will have much difficulty in even knowing and sharing important information on disasters, including the location where disasters have taken place and the number of people who live in the affected areas, and in making timely responses to them. Therefore, the geospatial databases need to be prepared well before disasters take place and widely made available in the country.

Since lives, livelihoods, the environment and culture are all potentially at risk from natural hazards, it is important for NGIAs to enable as much geospatial information as possible for supporting disaster-related decision. Particularly, the fundamental geospatial databases produced by NGIAs are prerequisite to support risk / impact analyses either at local, provincial or national scales, for mitigation purposes. Important data or information products should be:

- Robustly and sustainably developed and managed;
- As consistent, reliable, current and complete as possible;
- Enabled for interpretation, integration, value-adding and further analysis;
- Discoverable, accessible, consumable and easily understood; and
- Openly available for use and re-use.

It goes without saying that a geodetic reference frame is to be established and well maintained for the whole country before developing geospatial databases. This is particularly important when the country is located in a region of active tectonic movements. In the current era of accurate satellite positioning, increasing amount of locational information for various location-based services is acquired through the signals from Global Navigation Satellite System (GNSS) while the country itself keeps slowly moving due to the tectonic movements. Such locational information always needs to be accurately overlaid on existing geospatial databases by adjusting the location in accordance with the tectonic movements. Therefore, NGIAs need to provide transformation parameters between different epochs of GNSS to ensure that GNSS measurements fit accurately in their geospatial databases.

Some NGIAs are mandated to prepare thematic geospatial information based on hazard history and potential risk of hazards for disaster risk reduction, including the extent of lavas formed in the past volcanic eruptions and the location of active faults, as well as the location of shelters. It is desirable that such information is integrated in the basic geospatial databases and widely shared with other organizations before disasters.

If NGIAs do not have full coverage of national geospatial databases, VGI (voluntary geographic information) may be an option for DRM application by the end users or NGIAs themselves. While VGI sometimes include valuable information for effective disaster response activities, the data should be applied carefully because they are not authoritative ones and their accuracy and quality are not usually officially validated.

Column 1　Global Statistical Geospatial Framework (GSGF)

Proposed under UN-GGIM framework, the GSGF recommends five principles as a standard for the integration of statistical and geospatial information, focused on the use of fundamental geospatial infrastructure, using and managing geocoded unit record data in a data management environment, developing common geographies for dissemination of statistics, statistical and geospatial interoperability, and accessibility of geospatially enabled statistics. The implementation of GSGF at the country level would enable production of geospatial data from official statistics and vice versa, and enables value-adding of both geospatial and statistical information. NGIAs can play a key role in ensuring statistical information is enabled in this way, which would open greater opportunities to gain insights about the physical and human geography for the benefit of DRR policy and decision making. (For more information , please see http://ggim.un.org/UNGGIM-expert-group/ (UN EG-ISGI, 2018))

3-1-2) Update of geospatial databases

Keeping geospatial databases as current as possible is also crucial for successful preparation for disasters in order to enable users to know the latest features on the ground, particularly transportation networks. In case of large disasters, the local public organizations often become dysfunctional and incapable of making appropriate responses by themselves as they themselves might have been affected by the disasters. That means that many people including rescue teams, who would be deployed to the affected areas, might not be familiar with the local geography and would heavily depend on available geospatial databases even to find the suitable route to get there. If the transportation networks are not well updated, however, they may take an unnecessary detour to reach the affected areas by, for example, not being able to take advantage of the newly built road networks. Since disasters may take place anytime and anywhere, NGIAs need to make sure that their databases are updated and usable even in case of disasters.

Another important aspect of updating geospatial databases is that they provide the basic information that shows the situations before the disaster to be compared with those acquired after the disaster. Most people who are involved in disaster operations may not be familiar with the areas affected by the disaster, which sometimes means that many external people may not fully understand the impact of disaster by just looking only at the geospatial information acquired after the disaster. However, if people can compare the geospatial information between before and after the disaster, they can easily and quickly comprehend the impact by simply comparing the information acquired at two occasions.

3-1-3) Web maps for sharing the latest geospatial information

Once disasters take place, the geospatial information that shows the disaster situations of the affected areas need to be instantly shared in the government and with the general public to facilitate the timely response activities by relevant organizations. When printed maps were the primary media of geospatial information, preparation of the geospatial information of affected areas required a number of days before the disaster information is actually shared with other organizations. While printed maps are still useful and important media for keeping the records of what has happened in disasters, they cannot meet the immediate need of other organizations that need to know the latest disaster situations to appropriately respond to them in a timely manner, including to save people’s lives and properties and to rebuild damaged infrastructures.

Distributing data in digital form via the internet is another way of sharing the latest geospatial information with other organizations. In most cases, however, other organizations are so busy for their response activities that they have no time to access the data and virtually no capacity/tools to process it by themselves. In such cases, the geospatial information prepared by NGIAs may not contribute much to their activities at the early phase of disasters.

Web maps, however, provide a very convenient way of instantaneously sharing a lot of different layers of geospatial information on the same basic map on the web without employing additional tools to process the data and building the capacity to use them. Furthermore, many organization has introduced decision support tools for emergency planning and response, which requires the latest geospatial information provided by NGIAs via the Internet in many cases. In this connection, it is recommended that NGIAs develop a web map service based on NGIAs' geospatial databases for relevant organizations and the general public before disasters. Services that are operated at normal time will allow NGIAs to seamlessly distribute geospatial information even in case of disasters, contributing much to disaster risk reduction. NGIAs may also be able to provide a suite of 'standby' static maps to end users that mirror the basic layers available in a web mapping application upon consultation with the users. This measure may be a useful contingency in case of disruptions to utilities during emergencies.

Column 2 Providing man-made slope distribution through webmap services (Hong Kong)

Lands Department (LandsD) in Hong Kong Special Administrative Region (HK) provides registered man-made slopes through a website (http://www1.slope.landsd.gov.hk/smris/map) in cooperation with Civil Engineering and Development Department (CEDD). This map enables readers to identify location, responsible party, maintenance agent and others of the specific slope. Location and maintenance responsibility of the landslip are identified in the first instance. Geospatial information of the disaster scene is captured for investigation and restoration purposes. (For details, please see Best Practice No.5 in Annex 2)

3-2) Policy development and organizational arrangements

3-2-1) Policy development within national framework

Without appropriate DRM policies that define the role and proper implementation strategy, the NGIA's activities will be easily disarrayed and may not be able to contribute well to the overall DRM of the country, even though the NGIA is capable of employing sophisticated geospatial information technology and have capable staff members and adequate resources to provide timely geospatial information to other organizations.

The first and important thing for the NGIA to do is to incorporate its disaster response policy into national policy framework on DRM.

Usually, the framework is provided in a legal document that defines how the government bodies should prepare and respond to disasters. The NGIA needs to make its disaster response policy be consistent with the national framework through cooperation with other government institutions, particularly the disaster management organization. Since many other organizations need to engage in DRM, the policies of NGIAs should be harmonized with those of other organizations.

3-2-2) Policy and organizational arrangements within NGIAs

Based on the national framework in which NGIAs' disaster response policy is incorporated, the NGIAs should arrange their policy and organization in preparation for disasters. Normally, this arrangement is summarized in in-house documents like disaster management plan and/or disaster response manual. Two kinds of documents may be formulated: one for policy guidance and the other for operational manual.

Although the circumstances around NGIAs are different by countries, the following points are provided as important options of organizational arrangements for the disaster response activities of NGIAs. Applicable options out of these points should be well incorporated into the documents that govern the disaster response activities of NGIAs.

a) Disaster response measures and activities need to be developed for each of three disaster cycle phases, namely, before, during and after disasters, for their effective implementation.
b) The organizational structure that is to be set up to oversee disaster response activities should be defined. Responsibility of the members within the structure should also be made clear. A special team composed of senior staff members should be designated to manage disaster response activities (This team is called "the headquarters" throughout these Guidelines).
c) The level of engagement of the organization, depending on the severity of the magnitude and impact of disasters, needs to be specified. The triggering criteria determining the level of engagement may be different according to hazard types including earthquake, tsunami, volcanic eruption, drought and flood.
d) Once a disaster happens, finding the safety status of their staff members and the family is also a priority for the NGIA. In this connection, it is often helpful to have a service of automatically inquiring the well-being of the staff members and their families via their pre-registered mobile devices including cell phones and smartphones to quickly find who needs help and is available for service.
e) At the outbreak of a disaster, the NGIA needs to be immediately ready for setting up a DRM meeting of the senior management (the headquarters meeting). The primary role of the meeting is to share the information on the latest disaster situations among the senior management and to make decisions on the activities the NGIA should engage with clear priority.
f) Designation of functional teams under the headquarters needs to be defined beforehand. The responsibility of such designated teams may vary depending on

the role of the NGIA in the government, and may include provision of latest geospatial information to other organizations, communications with relevant organizations on their specific geospatial information needs, preparation of map products, and public relations.

g) Communication arrangement is also an important element. In order to quickly initiate the DRM activities and arrange the necessary structure in the organization, it is very important that all senior staff members are immediately informed of the disaster outbreak and summoned to participate in the first headquarters meeting during office hours or tele/video conference meeting during non-office hours in order to put them all on the same page. Therefore, arrangements should be made before disasters so that every senior staff member always carries a mobile phone and can be informed of emergencies anytime even during non-office hours.

h) In case a disaster hits the main office and/or the regional branch offices, NGIAs need to be ready for implementing its business continuation plan that has been developed before disasters to ensure that their minimum services are continually in operation, and a minimum number of staff members are available to respond to the disaster.

i) The policies and organizational arrangements should be reviewed and revised as needed once a series of DRM activities are completed for a particular disaster or when some changes are made on the mandate and other responsibilities.

Once the organizational structure is arranged before disasters, the staff members need to be frequently reminded of their responsibilities and how they need to respond in case of a disaster. Regular drills, described in 3-4), are also effective and prerequisite to make the arrangements quickly in case of a disaster.

3-3) Building cooperative relationships and partnerships

3-3-1) Building cooperative relationships with disaster management entities

Geospatial information, which shows the latest disaster situations, is valuable *per se* to understand the impacts of disasters including quantitative analyses of the size of flooded areas and the volume of land mass moved by a landslide. At the same time, however, geospatial information will be also useful for other organizations that engage in disaster response activities including rescuing people from the affected areas, distributing water and foods to the people in shelters, and the repairing of damaged infrastructures. These organizations, mostly public ones, have their own specific needs on the timing of acquisition and the extent of data that is provided by NGIAs.

In this connection, it is important for NGIAs to build good cooperative relationships with these organizations before disasters to understand their needs so that NGIAs will be able to acquire geospatial information that meets them once disasters take place. Since their needs may be subject to change as the situations move from one phase to another in disaster cycle, it is important for NGIAs to always keep the good relationships with them.

Possible partner organizations for emergency response activities include; a) civil defense force and police; b) national and local governments; c) private sector which assesses their damage; and d) mass media. While possible partner organizations for impact and risk analysis include: a) science or technical agencies; b) academia and experts; c) administrative agencies; d) the agency responsible for the analyses.

Preparing a catalog of geospatial information and products prepared by NGIAs in the past disasters will help the staff of disaster management organizations understand when and what types of geospatial information will be made available to them and make them ready to incorporate such products in making their decisions. The description of the catalog should be as easy as possible, because the readers may not be familiar with technical terms of geospatial information. It is also important that the catalog will clarify what types of media or format are to be used for dissemination or delivery.

Column 3 Multi-hazard mapping of 28 priority provinces and the greater metro Manila area (Philippines)

Aiming to have a safer and disaster resilient communities, National Mapping and Resource Information Authority (NAMRIA) implemented multi-hazard mapping of the 28 high risk provinces to map out areas exposed to natural hazards. NAMRIA provided base maps, capacitated local government units on the use of GIS technology, engaged technical staff in the integration of hazard maps for use by the local government units and national government agencies. The output of this activity will facilitate evidence-based decision-making by local and national authorities (For details, please see Best Practice No.13 in Annex 2)

3-3-2) Building partnerships with stakeholders

The typical timeframe of ordinary activities of NGIAs including the development and update of geospatial databases is mostly months and years, not hours or days, which means that NGIAs usually may not have adequate resources to meet the surge of demand, including mobilizing a number of survey teams in the affected areas and sending many airplanes to take their aerial photographs, immediately after the outbreak of disasters.

Obviously, NGIAs need to depend on external resources to meet such a sudden surge of demand of surveying and mapping in case of disaster.

One way to overcome such a challenge is to build a partnership with the surveying and mapping industry before disasters, including signing a memorandum of cooperation, to enable NGIAs to request the industry at the outbreak of disasters to deploy their resources to the affected areas to acquire their latest geospatial information without going through a formal bidding process. Such partnership arrangements have to be made before disasters and need to be tested through regular drills to see if they work well.

If sufficient resources are not available domestically, it may be necessary to request assistance through bilateral or multilateral cooperation programs supported by international organizations including aid agencies. In this respect, it is noteworthy that there are prominent international frameworks, including the International Charter on Space and Major Disasters (Charter on Cooperation to Achieve the Coordinated Use of Space Facilities in the Event of Natural or Technological Disasters) (See Column 4), and Sentinel Asia (International cooperative project aiming for the online sharing of disaster-related information in the Asia-Pacific region obtained by earth observation satellites and other space technologies, thereby preventing and mitigating damage caused by natural disasters), both of which enable NGIAs to acquire latest earth observation data provided by space agencies in the world. These international assistance frameworks also need to be tested before disasters to see how they work in reality through drills.

Column 4　International Charter on Space and Major Disasters

The International Charter on Space and Major Disasters is an international collaboration between the owners and operators of earth observation missions and the data users to provide rapid access to satellite data to assist rescue authorities in the event of a natural or man-made disaster. Although its mandate only requires the provision of satellite data quickly and at no cost, the members of the Charter often collaborate with other value-adding agencies for data analysis and interpretation. Each member organization has committed its resources to supporting the provisions of the Charter and thus is helping to mitigate the effects of disasters on human life and property. (ESCAP, 2017)

The relevant websites are:

- International Charter on Space and Major Disasters https://disasterscharter.org/en/web/guest/home
- Sentinel Asia https://sentinel.tksc.jaxa.jp/sentinel2/topControl.jsp

The following guidelines published by ESCAP are also helpful in applying space application to geospatial support activities in DRM.

- Innovations in Disaster Rapid Assessment: a Framework for Early Recovery in ASEAN Countries http://www.unescap.org/publications/innovations-disaster-rapid-assessment-framework-early-recovery-asean-countries
- Specific Hazards: Handbook on Geospatial Decision Support in ASEAN Countries http://www.unescap.org/publications/specific-hazards-handbook-geospatial-decision-support-asean-countries-0
- Sharing Space-based Information: Procedural Guidelines for Disaster Emergency Response in ASEAN Countries http://www.unescap.org/publications/sharing-space-based-information-procedural-guidelines-disaster-emergency-response-asean

3-4) Drilling within NGIAs

It is very important that policy and organizational arrangement, described in 3-2-2), are shared among all staff members of NGIAs. More specifically, all relevant staff members are needed to be frequently reminded of their responsibilities and how they need to respond in case of a disaster. In this connection, NGIAs should have a program of conducting regular drills on DRM to ensure their planned activities are flawlessly carried out. The possible menu of drills are: safety check response drill; tele/video conference participation drill; the first disaster management meeting setting up drill; imagery acquisition, processing, and interpretation drill; and web-map publishing drill. Regular drills are particularly important for those NGIAs that have frequent personnel changes, so that all staff members are always kept updated on their roles in DRM. It is also recommended that an annual drilling plan be established to sustain the capability of staff members for disaster response and to prepare them for seasonal disasters like typhoons and heavy rains.

Participation in drills conducted by other organizations is described in 3-5-2).

3-5) Raising awareness

3-5-1) Introduction of geospatial products to decision makers of stakeholders

Some policy makers and decision makers of other government organizations are often unaware of the potential role of geospatial information in their disaster responses and what NGIAs can provide throughout the disaster cycle. They may also have difficulty in keeping up with the emerging new geospatial information technologies including airborne laser scanning, Synthetic Aperture Radar (SAR) and Continuously Operating Reference Station (CORS) network that detect very minute changes of ground surface caused by earthquakes and volcanic activities and delineate flooded areas even under uncooperative weather. This means that even if NGIAs successfully provide the latest disaster situations in a timely manner to these important people, they may understand neither what the information means for them nor how it can assist them in making their decisions.

In this connection, it is very important for NGIAs to reach out to these people before disasters to inform them of the geospatial products NGIAs will be able to provide throughout disaster cycle. Geospatial catalog described in 3-3-1) as well as examples of geospatial information which were effective at past disasters can be used to keep decision makers and senior officials well informed of the real value and the effectiveness of geospatial information.

3-5-2) Participating in drills of relevant stakeholders

In addition to decision makers, the staff of relevant organizations are to be informed of the geospatial products of NGIAs as they will be the ones who actually use the products in their respective response operations. While explaining them about the catalog mentioned in above section is helpful, participating in their drills will give more practical opportunity for NGIAs to demonstrate how geospatial products they provide will help the staff in taking advantage of geospatial information in their operations. Most organizations use maps in some way or other once disasters take place. However, they may not be familiar with taking advantage of digital map data and web map in their operations in sharing the latest situations within their organization and with other organizations. Such interaction will also benefit NGIAs in getting deeper insight on the need of other organizations and on the improvement NGIAs may need to make for their future products.

3-5-3) Public relations and educational activities

The general public is another important user of NGIA products throughout the disaster cycle as they should be well aware of potential risk and damage caused by disasters of where they live and work. The question is how best NGIAs can reach out to them. While NGIAs may have capacity to visit them, including local community schools to provide lectures and even organize a seminar for the local community, the most effective way is to use existing news media including TV and newspapers as well as commonly used Social Network Services (SNSs). It is important for NGIAs to have opportunities to brief media about the latest products and services so that the general public will be widely informed of the information they can depend on before future disasters. Comments returned from the followers of SNSs will also be helpful for NGIAs to better understand the user needs to improve their products and services.

Another category of people to whom NGIAs may want to reach out is school children. Generally speaking, school children are more receptive than adults in learning new concepts and new type of information and applying them in their real life. On the other hand, school teachers may not be keeping up well with the latest geospatial information technology and new products of NGIAs that are useful for reducing disaster risk of school children. It is, therefore, helpful for both school children and their teachers that NGIA staff members visit and show and tell them how the geospatial products of NGIAs will help reduce their future disaster risk as well as how the geospatial information technology benefits their daily life.

Chapter 4: NGIAs' measures during disasters

This chapter elaborates on the potential measures of NGIAs to be taken during disasters. Figure 5 shows the relationships of measures introduced in this Chapter.

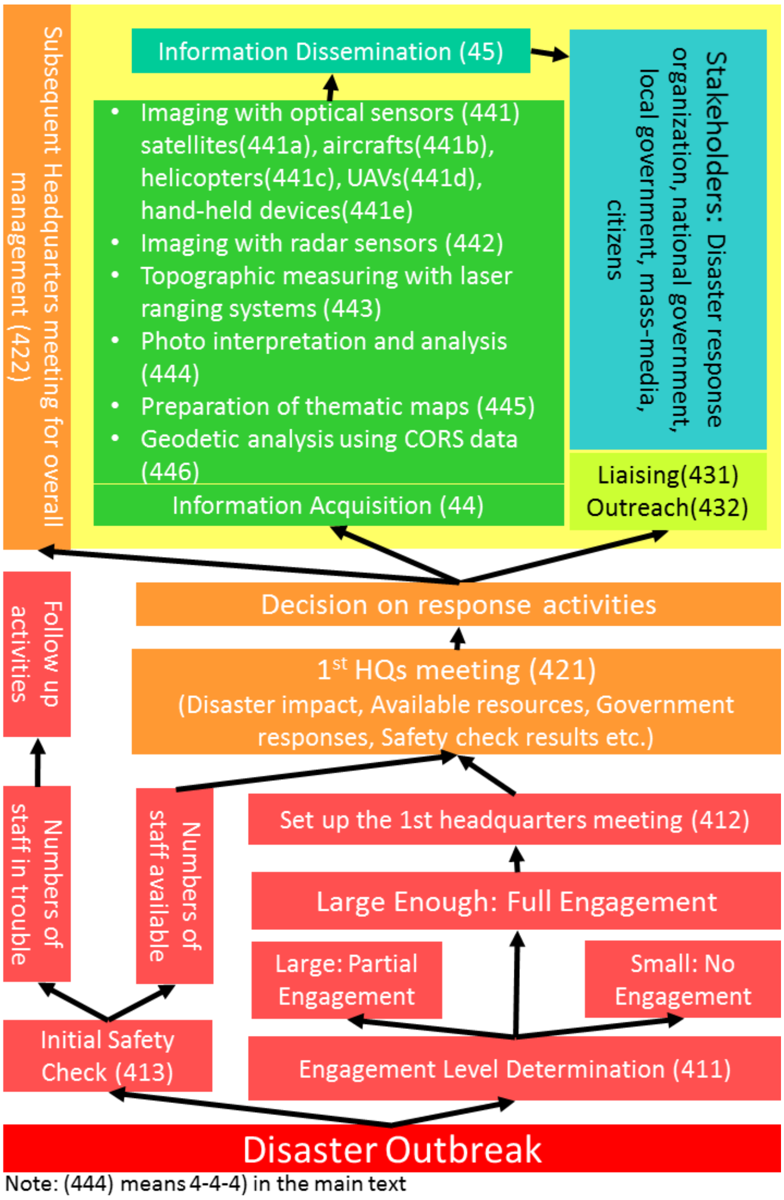


Figure 5 NGIAs' measures to be taken during disasters

4-1) Launching of disaster response activities

Once the preparation before disasters has been well set in place, the initial activities after the outbreak of a disaster are supposed to be conducted without much difficulty in most cases, although a number of activities are to be conducted in parallel. There are, however, a number of critical decisions that have to be made immediately after the outbreak including: i) to decide whether the NGIA should engage in response activities for the particular disaster; ii) to decide on the level of engagement of the NGIA, in other words how much resource should be engaged; and iii) to decide on when and how the initial DRM meeting should be convened to discuss the steps to be taken in response to the disaster. Furthermore, the NGIA needs to know whether staff members and their family members are safe or get injured if a disaster occurs close to their offices. Activities necessary for such decision making is described in the following sections.

4-1-1) Determination of engagement level

Decisions on i) and ii) above are in most cases straightforward as their decisions should be made automatically based on predetermined criteria without human intervention. In the case of an earthquake, for example, the largest seismic intensity observed on the ground announced by the government agency in charge of earthquake monitoring can be used to determine whether the NGIA should initiate the response activities and how much resource should be engaged. In the case of other disasters caused by floods and landslides, it may be difficult to develop criteria before disasters. In such cases, these decisions may need to be made by assessing the magnitude of the disaster impacts, the level of engagement of other government agencies and requests from the organizations in the affected areas.

4-1-2) Setting up the first headquarters meeting

If the disaster is so large that severe damage affects an extensive part of the country, the NGIA should make an immediate decision to initiate disaster response activities with the highest priority and to convene an emergency headquarters meeting soon (Figure 6). When the disaster takes place during the office hours, the first headquarters meeting should be immediately convened at the office. The attendance of the senior staff members is a must. In case of non-office hours, the senior staff members should be immediately informed via an email message to their cell phones, requesting immediate acknowledgement to find out who is available for the first headquarters meeting in the form of tele/video conference (Figure 7), which should be convened as soon as possible once the availability of members has been confirmed. If the NGIA has regional branch offices, it is desirable that the senior staff members in all those offices join the headquarters meeting via tele/video conferencing since those offices, even far from the affected areas, may be requested to mobilize their resources to assist the office nearest to the most affected areas.

Figure 6 An image of the headquarters meeting

Figure 7 Teleconference

4-1-3) Safety check of staff members

It is highly recommended that safety checks should be carried out when a disaster happens, by employing a service which automatically sends messages to the staff members via telephone calls and/or emails, and reports the number of responses received to the headquarters (Figure 8). This check is particularly important when the disaster takes place near one of the offices of NGIA or in case some staff members and their family members are traveling nearby. The result will tell the NGIA about the number of staff members available for disaster response activities as well as the number of staff members affected by the disaster who may need a certain care. Safety checks should be carried out while disaster response activities are on-going, because the safety of the staff members and their family must be the primary concern of the NGIA.

Figure 8 Safety check service for NGIA staff and their family members

4-2) Headquarters meeting for DRM

Since the NGIA needs to fully commit itself to disaster response activities in case of a large disaster, a different organizational structure (called the DRM headquarters for instance) needs to be set up in order to make necessary decisions promptly. Timeliness and appropriate agenda setting in conducting the headquarters meetings is crucial for the NGIA's engagement in disaster response.

4-2-1) Agenda of the first headquarters meeting for DRM

The first thing the meeting needs to do is to share among the members what has happened to understand the impact and extent of the disaster. At the same time, by the time of this meeting, the senior staff members should be ready to report on the available resources they take charge of and the conditions of their equipment including the location of their airplanes as well as the initial results of observation including the amount of crustal movement if the disaster is caused by an earthquake. Initial activities of major national government offices including disaster management organizations as well as instructions of top government officials should be shared. The result of initial safety check should also be reported to the meeting participants.

Based on the information on the impact of disaster and available resources of NGIA, and the actions of relevant government institutions, the meeting should decide on which tasks the NGIA should engage in and immediately start taking actions by mobilizing their resources. If the disaster impact is too large for the existing resources of NGIA to meet the demand of surveying and mapping, the decision should be made at this meeting to request private companies to provide their support in accordance with the memorandum of cooperation, so that the companies will also be able to quickly mobilize their resources to the affected areas.

In parallel to deciding on these immediate actions to acquire the latest information on the disaster, the first headquarters meeting should also decide to set up a number of functional teams that have been designated to accomplish specific tasks, including communications with relevant organizations to meet their geospatial information needs, preparation of map products and public relations, and to appoint staff members to work for them.

In closing the meeting, the time and the form (face-to-face or tele/video conferencing) of the next headquarters meeting should be confirmed for better time management of disaster response activities.

4-2-2) Subsequent headquarters meetings during disasters

Once initial decisions are made, the NGIA needs to convene subsequent headquarters meetings to monitor the progress of the activities as well as to share the latest situations among the senior staff members, and to adjust the activities to respond to new situations. The frequency of meetings may be initially as high as even three or four times a day to catch up with rapidly changing situations, and then it becomes lower as the disaster response operations are shifting from the initial emergency phase to the recovery phase that focuses on the rebuilding of the damaged areas.

4-3) Liaising with different stakeholders and conducting outreach activities

4-3-1) Liaising with different stakeholders

The central government generally conducts disaster response management when a large disaster takes place. The NGIA is supposed to be a part of the government-wide disaster management framework and play specific roles as a national institution. For example, the NGIA may be requested to report its activities and outcomes to the disaster management meetings convened by the government. Attending these meetings is also important just after the outbreak of the disaster to get the latest information on the disaster. Generally, available information on the impact and extent of the disaster, usually brought by news media, may be very limited. Therefore, NGIAs should make sure to attend these meetings to get necessary information for better decision making and resource mobilization.

The Government may also set up a local office to liaise with the local governments to provide timely support to the local people and facilitate the recovery from the damage. The NGIA has an important role in such a local office by meeting their geospatial needs, including printing large format maps for rescue operations and food delivery to shelters.

Cooperative relationships that have been built before disasters with relevant organizations including local governments assist the NGIA in receiving the latest information on the disaster situations and understanding specific needs they have on geospatial information. Being knowledgeable about specific geospatial needs of stakeholders, the NGIA can make necessary adjustments in its activities during disasters to better meet user needs in a timely manner. In this connection, it is important that the NGIA contacts other organizations, particularly local governments that are hit by the disaster, soon after the outbreak to keep good communications with them. When it becomes practical, deploying its staff members to these organizations to liaise with them will further facilitate the communications. For concerted communication activities, it is also effective to set up a designated geospatial provision support team. The team interfaces with different stakeholders to discover their geospatial information needs and conveying their needs back to the appropriate offices in the NGIA for both short-term and long-term improvement of the products.

Column 5 Real Time Crisis Response Mapping for Government Officials (Australia)

Geoscience Australia (GA) is supporting the Attorney-General's Department (AGD)'s - Australian Government Crisis Coordination Centre- by establishing a spatial mapping capability. The collaboration between GA and AGD is supporting the ability of executive decision makers in government to make informed decisions on the coordination of the Australian Government's response to domestic disaster events (For details, please see Best Practice No.1 in Annex 2)

4-3-2) Conducting outreach activities

The geospatial information acquired by the NGIA is useful not only for relevant government organizations, but also for the general public to understand the impact of disaster.

In order to reach out to them, the NGIA should also communicate well with the news media so that they will be able to provide timely information to the people through them. Practically, it is recommended to hold briefing sessions for the media. Briefing sessions provide the media with detailed technical explanation about the products to assist them in writing a good article based on proper understanding. That is why it is important to set up a functional team that works on public relations.

As for the outreach to the general public, the combination of web maps and media coverage is effective. Also, SNSs, such as Twitter and Facebook enables citizens to get direct access to and browse geospatial products of the NGIA. In short, so-called cross-media strategy is required to make ordinary citizens familiar with the NGIA's geospatial products for the disaster. Some citizens have a special interest in the disaster affected area as they might have their houses, relatives and friends there. Provision of imagery through web map by the NGIA helps them understand the latest situations of the areas they are concerned with.

These important communication activities described in 4-3-1) and 4-3-2) are illustrated in the schematic diagram of Figure 9.

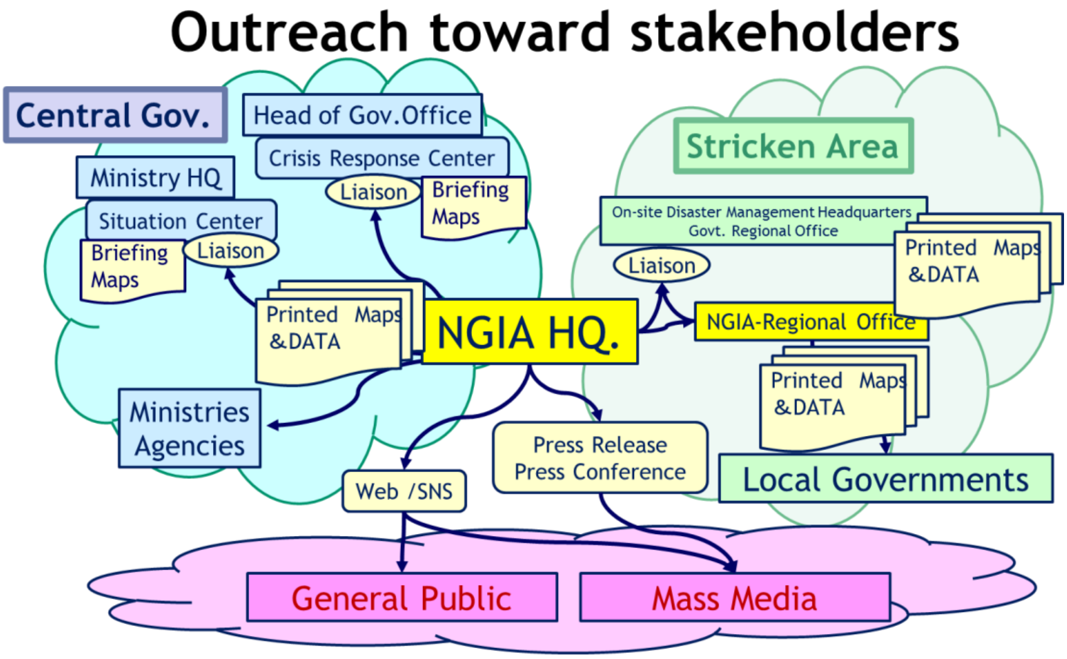


Figure 9 Outreach activities of NGIAs to different stakeholders

4-4) Acquisition of the latest geospatial information on disaster situations

There are a number of techniques the NGIA can employ to acquire the latest geospatial information of the areas affected by the disaster. Although they are complementary to each other, some of them are suitable for particular types of disasters and others are more fitted to different ones. Since each of the techniques has both advantages and disadvantages, the NGIA needs to select the suitable techniques or combine different techniques to acquire valuable information as quickly as possible by assessing the disaster situations. This section lists some of the commonly used techniques by NGIAs with their brief descriptions, including their advantages and disadvantages.

4-4-1) Imaging of the ground with optical sensors

Imaging the ground with optical sensors such as optical camera is one of the most commonly used techniques to acquire the geospatial information of the areas affected by disasters, including the areas inundated by floods or tsunamis, those devastated by landslides and those damaged by earthquakes. Recent digital processing technology has streamlined the acquisition, processing (including the development of ortho-rectified imagery), analysis and timely dissemination of acquired data including ortho-rectified imagery to different stakeholders including the general public via the internet. Having had the long history and been widely used in different applications, these images allow most people to visually and easily understand the disaster situations. When compared with those images taken before the disaster, the impact and extent of the disaster will become evident for many people. It is, therefore, the first option out of many techniques NGIAs should consider for their initial response to disasters.

Major disadvantage of imaging with optical sensors, however, is its dependency on weather conditions. Disasters often break out during severe weather conditions including tropical storms or during night time, which prevent optical sensors from capturing images of the ground and from timely provision of imagery of disaster situations.

There are a wide variety of platforms that carry optical sensors for imaging the ground: a) Satellites; b) Aircrafts; c) Helicopters; d) Unmanned aerial vehicles (UAVs); and e) Hand-held devices.

a) Satellites

Images acquired by the optical sensors onboard artificial satellites generally have relatively lower spatial resolution without stereo viewing capability than those acquired by other platforms, and may not reveal detailed disaster situations. The frequency and timing of acquiring imagery of target areas are also largely constrained by its predetermined orbital configuration, the swath width and the sensor pointing capability as well as weather conditions. These conditions hamper the acquisition of requested images when they are needed. Nevertheless, they are suitable for understanding the disaster impacts of large areas since they can cover broad areas of ground per path. In addition, for those NGIAs that have no platforms including aircrafts for optical sensors, satellite imagery provides a promising option for quickly acquiring imagery of the areas affected by disasters as the International Charter on Space and Major Disasters (See Column 4) allows those countries that are hit by disasters to receive satellite imagery at no cost.

b) Aircrafts

Aircrafts have larger flexibility than satellites or UAVs in accessing targeted areas, and are most commonly used by NGIAs in acquiring images of the areas hit by disasters (Figure 10). Since airborne photo-taking has a long history of application, the technology has been well established, and the results do not fail to meet the expectations. Fixed-wing aircrafts need to be deployed to acquire images of the whole affected areas to understand the total impact of disaster, even though clouds often prevent timely deployment of aircrafts. If clouds do not allow to capture vertical photo images from the aircraft, capturing oblique-view (or bird’s eye view) photo images with an optical camera is a viable option to see the disaster situations. (Figure 10, right)

Many NGIAs have their own aircrafts for their prompt deployment to target areas (Figure 11). If they have no aircraft or the affected areas are too large to be covered quickly enough by their own aircrafts, prior arrangements with private companies before disasters may help NGIAs acquire the images of target areas quickly without going through a lengthy bidding process.

Figure 10 Images acquired by aircraft (left: vertical photo, right: oblique view photo)

Figure 11 Surveying aircraft

c) Helicopters

When clouds are one of the major impediments for aircrafts, helicopters are a better option to acquire images of the target areas, on the condition that the altitude of clouds is not too low. They are flexible in approaching and observing the target areas because they fly at variable speed and direction. Comparing with aircrafts, however, they cannot sweep wider areas for image capturing.

d) Unmanned aerial vehicles (UAVs)

UAVs or so-called drones provide very detailed images of the areas that may not be easily accessible by people, including craters of active volcanos and top part of landslides, and are very useful for understanding the disaster situations in detail. UAVs have two types: multicopter and fixed-wing. Both types should be operated by a team of well trained and experienced people who can not only pilot UAVs well, but also understand the risk of losing their control over the equipment and the importance of prioritizing the safety of the team at any time.

Multicopters allow the pilots to have flexible maneuvering to capture images of the areas they would like to see, though they may not be operable under the conditions of strong winds and/or interfering radio waves. Their limited battery capacity is also another constraint that prevents long flights. As the result, the pilot needs to be deployed very close to the target areas such as landslide sites and flooded areas, which may not be easily accessible, and much care needs to be taken on the safety of the deployed team.

Fixed-wing UAVs fly along pre-programmed flight paths in an autonomous manner, and do not allow the pilots to have control over where they go while flying. Since fixed-wing UAVs have a longer flight range than multicopters, they can be operated from safer areas that are not affected by disasters to acquire images of very remote and inaccessible areas like a remote active volcano island more than 100km away from the nearest land.

It is important to note that the technology associated with UAVs has been and will be improving very rapidly and the current technical capabilities of UAVs may be quickly outdated. NGIAs are encouraged to keep an eye on their technical development and make necessary adjustments to their strategy of employing UAVs for their DRM activities.

In addition, many countries have different regulations on the use of UAVs, and NGIAs need to study the latest regulations and always comply with them.

Column 6 The Use of Unmanned Aerial Vehicle (UAV) to Monitor the Flood and Its Impact (Malaysia)

The 2014-year end downpour and floods has been the worst ever in the country's history, affecting more than half a million people. The video and aerial photo captured using UAV have been used to provide information about the areas that were susceptible to the floods and locations where people can be evacuated to. The data have been used for making post flood damage assessments and identifying the facilities need to be repaired urgently such as roads, bridges, water treatment plant, etc. (For details, please see Best Practice No.11 in Annex 2)

e) Hand-held devices

The capability of commercially available hand-held digital cameras, including their spatial resolution, has evolved significantly during the last decade, and the high quality of images taken by these cameras greatly assists NGIAs in quickly providing the latest disaster situations including landslides and floods, when they are taken from aircrafts.

When they are carried into the areas affected by disasters to acquire in-situ images, those images will provide very detailed information on the ground including active faults appearing on the ground and the buildings and houses damaged by earthquakes, which may not be clearly seen from the air. If the captured images are sufficient and well overlapped, 3-D models of objects such as buildings and houses can be made, employing the SfM (Structure from Motion) technique.

4-4-2) Imaging of the ground with radar sensors

Radar sensors, usually equipped with a Synthetic Aperture Radar (SAR) on satellites or aircrafts, provide range images, which may not be as easily understood by many people as those images acquired by optical sensors. Their biggest advantage over optical sensors, however, is that they can acquire images of the ground both day and night time, even through clouds and smoke that is emanating from volcanos. In other words, radar sensors can be used under any weather conditions even during nights, which makes radar sensors very useful when a disaster breaks out under severe conditions, including tropical storms and volcanic eruptions. Since still water surface returns virtually no back scatter against radar signals released from the sensors, range images acquired by radar sensors are also useful for delineating inundated areas caused by floods and tsunamis. In the case of volcanic eruptions, when smoke emanating from the crater prevents optical sensors from acquiring images inside the crater, range images acquired by radar sensors reveal how much lava has been discharged and filling the crater to understand if the lava will be soon spilling out of the crater.

Besides range images, radar sensors provide topographic data of the ground by conducting interferometric analyses of the return pulses that are back-scattered from the ground in response to radar signals emitted from an antenna and detected by two antennas equipped on an aircraft. Most airborne SAR sensors have this capability and provide useful topographic data including the amount of lava flow caused by volcanic eruptions.

In addition, when observations are made on the same area at two different occasions by SAR equipped on a satellite, interferometric analyses of these two observations can reveal subtle changes of even a few centimeters on the ground surface during the interval (Figure 12). These analyses help NGIAs detect geospatial distribution of ground surface movement, and allow NGIAs to: i) find the control points that need resurveying after large earthquakes; ii) estimate the volume of magma moving inside a volcano, and iii) decide whether additional surveying of bench marks is necessary in the areas of subsidence.

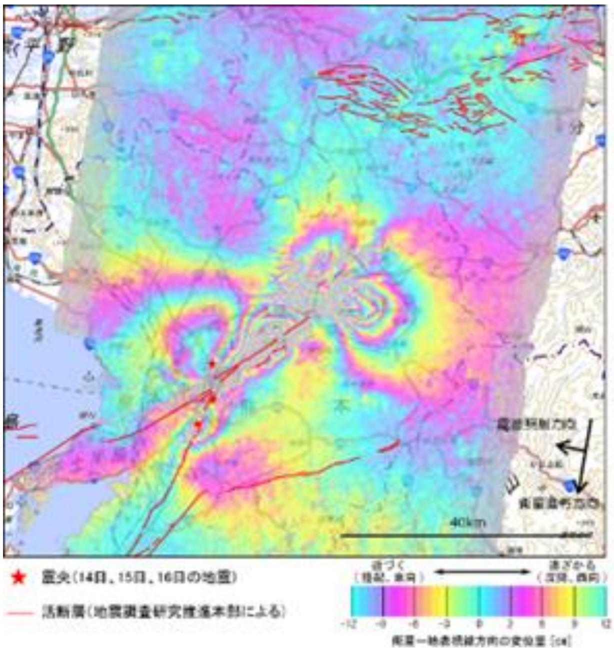


Figure 12 Example of interferometric SAR analysis of crustal movement caused by an earthquake (2016 Kumamoto Earthquake, Japan)

4-4-3) Measuring topographic changes with airborne laser ranging systems

Airborne laser ranging systems provide most accurate elevation data with a remote sensing platform and allow NGIAs to detect the detailed topographic features of the area and estimate the volume of topographic changes caused by disasters including landslides and earthquakes when there exist elevation data that have been acquired before the disasters. Laser ranging systems can be equipped on different platforms including aircrafts, UAVs, and automobiles as well as those used on a tripod. Most of them are used in combination with optical cameras to develop a three-dimensional model of a target area. As for the characteristics of each platform, reference should be made to those used for optical sensors described above.

4-4-4) Interpretation and analysis of aerial photographs

Images acquired by optical sensors including cameras help people easily understand the impact and extent of disasters in a qualitative manner. In order to estimate, for example, the number of people and vehicles that need to be deployed to recover from the damage caused by disasters, however, the impact of disasters needs to be translated into more quantitative figures, including the total area of inundation caused by floods and the volume of sediment moved by landslides. Such quantitative analyses usually start with photo interpretation, generally using aerial photographs, to identify the changes of geospatial features and man-made structures caused by disasters. Since photo interpretation still heavily relies on skilled photo interpreters who need to manually look at images, the time required to complete the interpretation and analyses of all acquired images depends on the number of skilled interpreters (Figure 13).

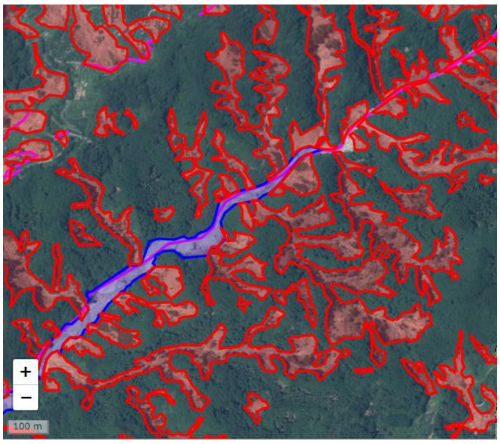


Figure 13 An example of airphoto interpretation (Left: ortho-rectified image; Right: interpretation (red: landslides, blue: debris flows) for floods in July 2017 in Fukuoka prefecture, Japan.)

4-4-5) Preparation of thematic maps describing disaster situation

Understanding the geospatial context of disaster affected areas is useful for better response activities. Taking advantage of being specialized in cartography and geography, the NGIA may prepare thematic maps that describe the geospatial context and disaster damages (including predicted ones) to provide the geospatial perspective of the affected area to relevant organizations and the general public. Besides paper maps, 3-D landform models made by 3-D printer may help people understand the geospatial context. The NGIA needs to keep assessing the geospatial needs of the stakeholders in order to make valuable thematic maps at the appropriate timing.

Column 7　Rapid Mapping of Kelud Volcanic Mountain (Indonesia)

On February 13, 2014 Mount Kelud erupted. The Centre of Thematic Mapping and Integration of Geospatial Information Agency (BIG), together with some institutions and local governments, have provided the Disaster Susceptibility Map of Mount Kelud, Evacuation Sites and Routes, and Ash Distribution of Mount Kelud. The above products have been published on internet so that many people in Blitar and Kediri Regencies could be saved. (For details, please see Best Practice No.6 in Annex 2)

Column 8　Mapping of Track of Typhoon Lawin (Haima) (Philippines)

In 19 October 2016, Typhoon Lawin (Haima) classified as extremely dangerous by the state's weather agency affected the provinces in the northern part of the country. National Mapping and Resource Information Authority (NAMRIA) prepared a map layout showing the track of Typhoon Lawin (Haima), the likely affected provinces and population, integrating data from various relevant institutions. The public is able to visualize the track of the typhoon and is made aware of the areas and population likely to be affected by it. (For details, please see Best Practice No.16 in Annex 2)

4-4-6) Analysis of Continuously Operating Reference Station (CORS) data

Earthquakes are often accompanied with large crustal movement that requires NGIAs of resurveying some of their control points as their coordinates may have been significantly changed. In case the extent of movement is large enough to affect nearly whole country, the geodetic reference frame may have to be revised. While such movement needs to be detected quickly to provide accurate positional control to the recovery activities including infrastructure development, the conventional surveying method requires NGIAs to spend months or even years to find the amount and extent of crustal movement by resurveying the triangulation points and benchmarks that may have been potentially affected by earthquakes. If NGIAs have access to real-time data acquired by a CORS network system (Figure 14), they can analyze it to find the amount and extent of co-seismic crustal movement in a few hours, as well as continue monitoring the post-seismic crustal movement, to locate the control points that need to be resurveyed for prompt initiation of recovery activities. By looking at the result of CORS data analysis (see Figure 15), people will also understand the impact of the earthquake.

Figure 14 Photo of CORS

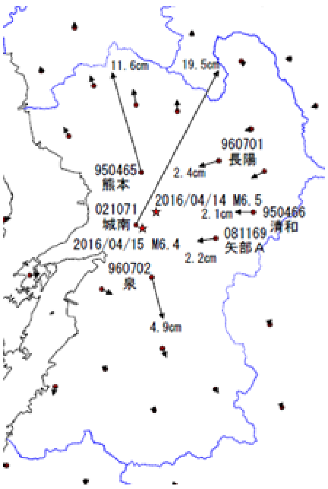


Figure 15 An example of crustal movement analysis

4-5) Dissemination of geospatial information

Once the latest geospatial information on the disaster situations is collected and analyzed, it needs to be promptly distributed to and shared with relevant organizations in the Government and local authorities for their immediate applications of the data. The same information, except the one that may need clearance from the Government, should also disseminated to the general public including news media to facilitate their proper understanding of the impact of the disaster. Otherwise, the efforts made by NGIAs during the disaster may be considered only meaningful for future archives, not for disaster response operations by other organizations.

Dissemination of geospatial information can take a number of different forms and formats, including printed maps and digital map data stored in digital media. In order to promptly provide disaster related information simultaneously to wider audience and share the information with the stakeholders and the general public, however, a web mapping system is the most useful platform (For details, please see **3-1-3**). It also allows users to overlay different map layers including risk information, ortho-rectified images, and results of photo interpretation and interferometric SAR analyses.

Chapter 5: NGIAs' measures after disasters

In parallel to emergency response activities to save people's lives and properties as well as to provide support to the evacuees immediately after the outbreak of a disaster, restoration of different infrastructure components, including electricity, waterworks, sewerage and transport network needs to proceed quickly to allow local residents to recover from the devastation and get back to a normal life. If the impact of the disaster is limited on the physical structures of the local community, additional surveying and mapping activities may not be necessary for NGIAs beyond those conducted during the disaster.

In case the damage is so big and widespread that significant parts of the physical structures of the community have become dysfunctional, however, total reconstruction work may be necessary for the whole damaged areas, while the local people remain in temporary shelters. In order to minimize the time the people have to spend in the temporary shelters, the reconstruction planning and its implementation need to get started very soon after or even in parallel to the initial emergency activities. The reconstruction planning obviously requires newly prepared maps after the disaster. In the case of a large earthquake, resurveying of geodetic control points may also need to be conducted first.

In this connection, NGIAs need to respond quickly to the reconstruction need of the community by resurveying and mapping. It is also very important for NGIAs, once their response to the disaster is completed, to review their activities during and after the disaster to find out any improvements for the future.

Figure 16 shows the relationships of measures introduced in Chapter 5.

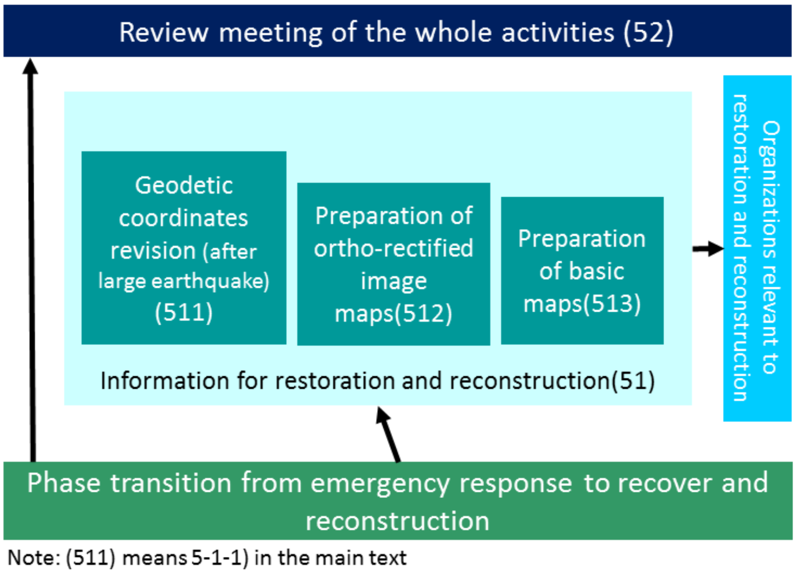


Figure 16 NGIAs' measures to be taken after disasters

5-1) Geospatial information for restoration and reconstruction

5-1-1) Revision of the coordinates of geodetic control points after large earthquakes

Large earthquakes are often accompanied by large crustal movement, which requires NGIAs to revise the coordinates of geodetic control points and even the geodetic reference frame. Since most reconstruction work starts with surveying for the reconstruction planning of the damaged areas, resurveying of geodetic control points is one of the earliest activities that need to be conducted after the disaster. The challenge the NGIA face when a big earthquake hits the country, however, is that the amount and extent of the crustal movement are not self-evident immediately after the earthquake until the geodetic control points are resurveyed.

If the NGIA has access to the data of a CORS network system, it can identify the amount of movement and the areas where geodetic control points need to resurveyed, and decide on when the resurvey should be conducted by monitoring the post-seismic movement with the CORS data. The result of the resurvey need to be widely informed to the relevant organizations in the Government and the local community so that the reconstruction plan is implemented based on the revised coordinates of geodetic control points.

5-1-2) Preparation of ortho-rectified image maps of affected areas

Large-scale ortho-rectified image maps are useful for most people to understand the latest situations of the areas damaged by the disaster (Figure 17). In addition, they are prepared earlier than basic maps (or line maps) that require map compilation. It is also important the once prepared, they are distributed quickly to the relevant organizations and local governments to assist them in their reconstruction planning.

5-1-3) Preparation of basic maps of affected areas

Large-scale basic maps are useful for post-disaster city planning and extensive reconstruction programs (Figure 18). For example, it will help city planners determine where to relocate public facilities that had been located in high risk areas and discuss countermeasures against potential disasters such as tsunamis and high tide water. NGIAs can contribute to the implementation of “Build Back Better” policy mentioned in SFDRR through the provision of basic maps for restoration and reconstruction.

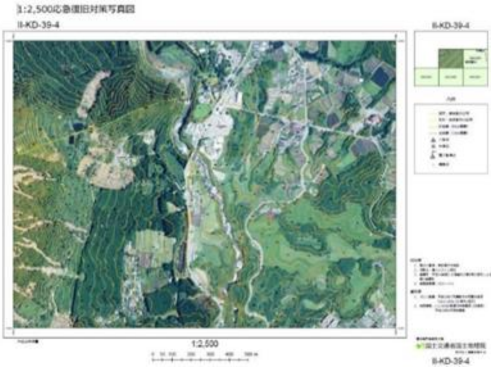


Figure 17 Large-scale ortho-rectified image map

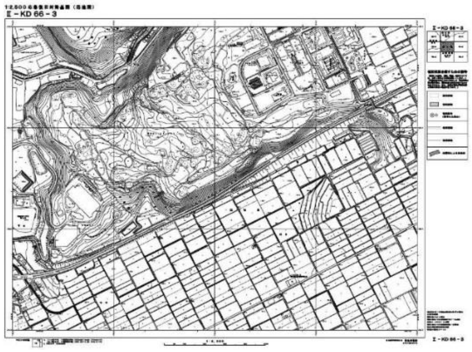
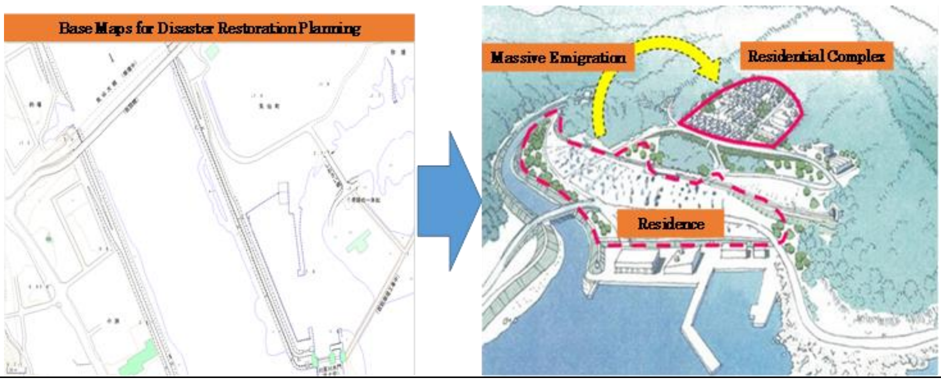


Figure 18 Large-scale basic map

Column 9 Case example of the Great East Japan Earthquake for "Build Back Better" (Japan)

During the Great East Japan Earthquake, which occurred at 14:46, 11 March 2011, the largest magnitude experienced in Japan, Mw (Moment Magnitude) of 9.0, was recorded. The earthquake triggered tsunamis that reached the height of more than ten meters that struck areas along Pacific coast of Tohoku region of Honshu Island. During recovery phase of the disaster, the Geospatial Information Authority of Japan developed "Basic Maps for Disaster Restoration Planning" that show transportation facilities, buildings and land use, as well as temporary houses, debris dumping sites, closed public facilities and inundated areas. These maps were provided to the local governments in the affected areas and were utilized to relocate residential places to a higher elevation areas to avoid tsunami disaster, and to explain restoration plans to the residents.



5-2) Review of activities for future improvement

One of the most important but also most underestimated steps in measures against disasters is to review the whole activities after the disaster, and find any improvements for the future. Although the NGIA should implement any emergent improvements that are found even during the on-going activities, it is important to have a review meeting after their disaster response is completed (Lower right corner of Figure 19).

In addition to the internal review meeting in the NGIA, it is highly recommended to have a meeting with relevant stakeholders to get their feedback to the geospatial information the NGIA provided at different phases of the disaster, which will add a wider perspective to the internal review process. In that respect, it is better to have a meeting with the stakeholders or at least to get their feedbacks to the delivered data before conducting an internal review meeting in NGIA. The outcomes of the review should be used to revise the NGIA's policy for future DRM.

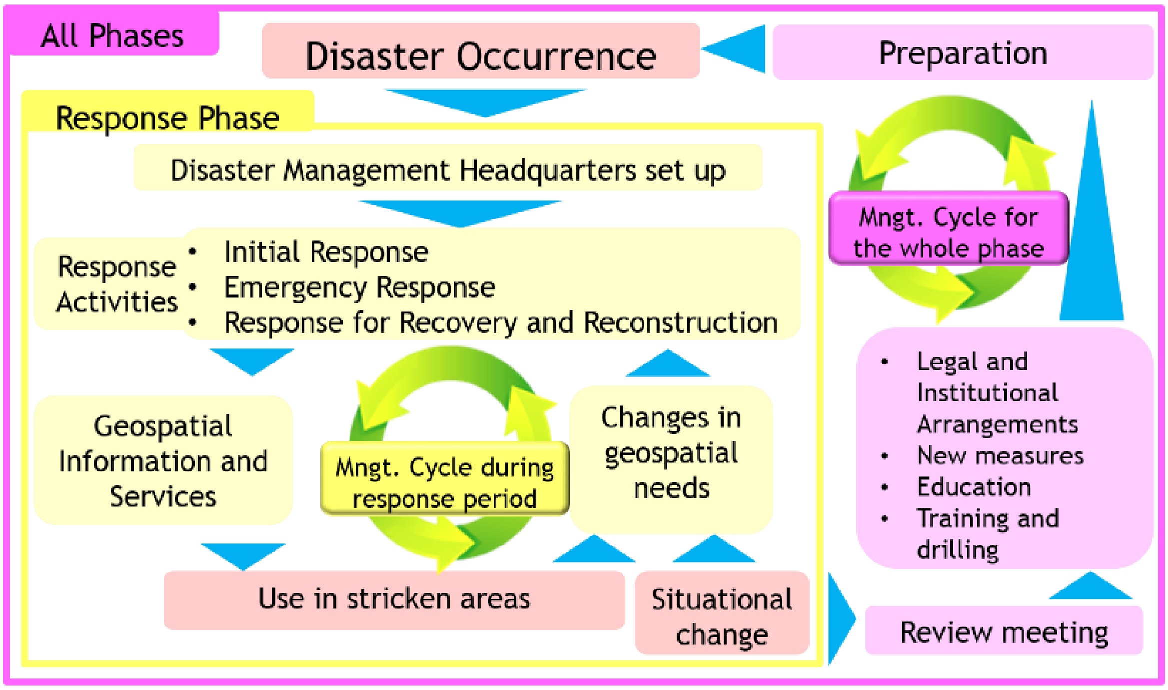


Figure 19 A model of NGIA disaster management cycle

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Annex 1

List of UN-GGIM-AP WG2 Members (2015-2018)

Chair; Japan
Mr. Toru Nagayama
Director of Planning Division
Geospatial Information Authority of Japan

Vice-Chair; China
Dr. Tang Xinming
Deputy Director General
Satellite Surveying and Mapping Application Center, NASG

Vice-Chair; Indonesia
Mr. Adi Rusmanto
Centre for Standardization and Institutional Aspect of Geospatial Information
Geospatial Information Agency (BIG)

Vice-Chair; Mongolia
Mrs. Munkhtsetseg Dalkhaa
Senior specialist of Administration and Cooperation Department, ALAGaC

Vice-Chair; New Zealand
Mr. Rob Deakin
Chief Steward, National Spatial Data Infrastructure
New Zealand Geospatial Office

Vice-Chair; Iran
Mr. Peyman Baktash
Deputy Director General's office, Public Relations and International Affairs Department
National Cartographic Center (NCC) of Iran

Vice-Chair; Philippines
Mr. John SF Fabic
Director, Geospatial Information System Management Branch
National Mapping and Resource Information Authority

Annex 2

Final Report

Collection of Best Practices on the use of geospatial information for disaster risk reduction

UN-GGIM-AP WG2

October 2017

Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific
(UN-GGIM-AP)

Contents

1. Overview of the Best Practice survey

(1) A Best Practice survey was conducted as a part of UN-GGIM-AP (United Nations Global Geospatial Information Management for Asia and the Pacific) WG2 (Disaster Risk Management, hereinafter WG2) (2015-2018)activities .

(2) NGIAs (National Geospatial Information Authorities) of Member States of UN-GGIM-AP were requested to submit at least one best practice, in conjunction with the questionnaire survey which was simultaneously conducted by WG2. Best Practice cases were invited twice on December 2015 and February 2017 from Member States.

(3) As of October 2017, 18 Best Practice cases have been collected from ten Member States.

2. Key findings of the Best Practice cases

(1) NGIAs in Asia Pacific region have already significantly committed to disaster risk reduction through implementing various kinds of activities.

(2) Kinds of disasters addressed reflect each Member State's circumstances.

(3) Best practices mainly focus on responses during the occurrence of disaster. On the other hand, a few practices focus on before the occurrence of disaster or after the occurrence of disaster.

(4) Geospatial information produced and provided according to each disaster phase is:

1) Before the occurrence of disaster: hazard maps or hazard-related geospatial information provided to stakeholders and citizens to enlighten disaster risk of a particular area. (No.2, 10, 13, 14)

2) During the occurrence of disaster: aerial photos, satellite imagery, UAV images, topographic maps showing damage situation, evacuation sitemap of victimised people, and geodetic data. (No. 1, 3, 4, 6, 7, 8, 9, 11, 12, 16, 17, 18)

3) After the occurrence of disaster: DEM data to consider relocation of victimised people and topographical survey after landslides. (No.5, 15)

(5) Outcomes of the best practice reported are recognized as follows:

1) NGIAs' data were used as a material for decision-making by government organizations and decision makers. (No.1, 2, 3,4, 5, 7, 8, 11, 12, 15, 17, 18)

2) Some cases indicated that data were provided to citizens and residents via the internet to facilitate evacuation activities. (No.6, 9, 14, 16)
3) Promotion of geospatial information application, enlightenment and capacity building of local governments were also reported. (No. 10, 13, 14)
4) A geospatial information catalogue for the provision in case of a disaster to help stakeholder quickly request required information to the NGIA. (No.10)
5) Provision of geospatial platforms (such as geoportal) enabling stakeholder and people to view the situation spatially and to overlay their particular information. (No.14)

(6) The future efforts mentioned are as follows:
1) Use of UAV which enables flexible and quick provision of information during disaster. (No.2, 5, 11, 18)
2) Quick dissemination of geospatial products (No.3, 11)
3) Development of geospatial information about the people vulnerable to disasters. (No.4)
4) Enrichment of data in coordination with other organizations (No. 6, 16)
5) Densification of CORS network (No.12, 17)

3. Conclusion

A variety of examples of Best Practices suggest that the collection be a valuable material for NGIAs in Asia and the Pacific to learn how to take a better action for Disaster Risk Reduction effectively.

4. Summary list of Best Practices introduced

No.	Member state	Disaster Type	Information and Service	Title	Activity Contents	Page
1	Australia: Geoscience Australia(GA)	Overall disaster	Location data	Real Time Crisis Response Mapping for Government Officials	Provided by Geoscience Australia to Government Emergency Crisis Coordination Centre and used by the government as a material for decision-making during disasters .	4
2	Bangladesh: Survey of Bangladesh(SOB)	Typhoon, Cyclone, Earthquake, etc.	Thematic map	Use of Geospatial information for DRR in Asia and the Pacific Region	Provided by Survey of Bangladesh to government organizations, and by integrating and sharing geospatial information in the government, contributed to mitigating disaster risks and saving of resources.	5
3	China: Satellite Surveying and Mapping Application Center (SASMAC)	Earthquake	Geospatial information	Earthquake	Used for emergency response during disasters.	6
4	Fiji: National Disaster Management Office	Typhoon, Flood	Geospatial information		Used for emergency response during disasters.	7
5	Hong Kong Special Administrative Region (HKSAR): Lands Department	Landslide	Location data	Contingency Plan for Natural Disasters	Provided by the system of the website and used to identify the location at the occurrence of landslides and for recovery activities after the occurrence.	8
6	Indonesia: Geospatial Information Agency(BIG)	Volcano	Topographic map	Rapid Mapping of Kelud Mountain	By releasing evacuation routes and distribution of volcanic ash on the topographic map on the Internet, provided the people living around the volcano with a material to make decision for evacuation.	9
7	Japan: Geospatial Information Authority of Japan(GSI)	Flood	Aerial photo, Inundated area map	Floods as a Result of Heavy Rain	Swiftly disclosing the disaster situation that specifies the inundation range on the Internet, contributed to initial restoration operations (placement of police, the numbers of pumper trucks and workers, placement positions and determining work hours). Government and media used the data provided by GSI as trustworthy official information for disaster response and for news coverage.	10
8	Japan: Geospatial Information Authority of Japan(GSI)	Tsunami	Aerial photo, Inundated area map	2011 Great East Japan Earthquake	Immediately after the disaster, GSI created figures to provide related organizations with the general situation of the inundation range, conducted emergency shoots of aerial photograph, and these resources were utilized in a wide range of fields, such as making the base map for disaster recovery planning. All of them are released on the Internet.	12
9	Japan: Geospatial Information Authority of Japan(GSI)	Overall Disaster	Thematic map	Evacuation Center Map for 2016 Kumamoto Earthquake Response	Creating Evacuation Center Map enabled on-site disaster response headquarters to understand information on evacuation centers and to support activities like providing supply goods to evacuation centers.	14
10	Japan: Geospatial Information Authority of Japan(GSI)	Overall Disaster	Creation of Disaster Geoinformation Catalog	Creation of Disaster Geoinformation Catalog	The national and local governments referred to the Catalog and understood what type of geospatial information GSI developed and owned. This preparation helped GSI meet their requests rapidly.	16
11	Malaysia: Department of Survey and Mapping Malaysia (DSMM)	Flood	Video by UAV	The Use of Unmanned Aerial Vehicle (UAV) to Monitor the Flood and Its Impact in Malaysia	Used to identify flooded areas and evacuation sites with video and aerial photo captured by UAVs. After the disaster, used to identify facilities for recovery of various infrastructures.	18
12	Malaysia: Department of Survey and Mapping Malaysia (DSMM)	Earthquake	GNSS data	Earthquake Struck Ranau in Sabah, Malaysia	By analyzing GNSS data before and after earthquakes and releasing them on the early warning system of earthquake, contributed to the citizen for an early planning.	19
13	Philippines: National Mapping and Resource Information Authority (NAMRIA)	Hydromet* and Seismic**	Hazard map	Multi-Hazard Mapping of 28 Priority Provinces and the Greater Metro Manila Area	By providing local government organizations with hazard maps on the Internet, used as a material for decision-making of the area at the time of disasters.	20
14	Philippines: National Mapping and Resource Information Authority (NAMRIA)	Hydromet and Seismic	Hazard map	The Philippine Geoportal	By providing hazard maps on the Internet, contributed to the citizen in visually identifying risk areas.	21
15	Philippines: National Mapping and Resource Information Authority (NAMRIA)	Typhoon	Digital topographic map data, Ortho image	Recovery and Rehabilitation after Typhoon Haiyan	Used by the government to determine the status of disaster-affected areas and to identify safe and risk zones.	22
16	Philippines: National Mapping and Resource Information Authority (NAMRIA)	Typhoon	Hazard map	Mapping of Track of Typhoon Lawin (International Name: Haima) and Affected Areas and Population	The track of the typhoon was visualized by obtaining information from meteorological and statistical organizations and creating and releasing a map layout which showed the track. Through this effort, residents in the area at high risk for the typhoon were able to prepare.	23
17	Philippines: National Mapping and Resource Information Authority (NAMRIA)	Earthquake	GNSS data	Philippine Active Geodetic Network (PageNet) – Surigao Earthquake	GNSS enabled to acquire data of crustal displacement before and after the earthquake. Collaboration of observation system with other organization was achieved by continuous observation.	25
18	Sri Lanka: Survey Department	Tsunami	Digital topographic map data		Expressing disaster-prone areas on the topographic map can make swift relief operations.	29

*Hydromet: flood, storm surge, rain-induced landslide, **Seismic: ground rupture, ground shaking, tsunami, earthquake-induced landslide, liquefaction

5. Best Practice cases

No.1

Country	Australia
Organization	Geoscience Australia(GA)
Title	Real Time Crisis Response Mapping for Government Officials
Outline of the subject natural disaster	Spatially enabling federal government to enhance decision making.
Response	Geoscience Australia is supporting the Attorney-General's Department's - Australian Government Crisis Coordination Centre - establish a spatial mapping capability as part of its crisis centre. Geoscience Australia also integrates fundamental and synthesised spatial data with statistical information for a given area of interest to estimate exposure. This information is provided in report form on request to the Australian Government Crisis Coordination Centre.
Effect	The collaboration between GA and AGD is supporting the ability of executive decision makers in government to make informed decisions on the coordination of the Australian Government's response to domestic disaster events, using location based data.
Future	Continuous development and improvement of the capability supporting a joint mission across agencies.

No.2

Country	Bangladesh
Organization	Survey of Bangladesh(SOB)
Title	Use of Geospatial information for DRR in Asia and the Pacific region
Outline of the subject natural disaster	Floods, Storm surge, Drought, Tornedo, Landslide and Cyclone are the main disaster. Beside these, country is in the risk of Earthquake and Sea Level Rise.
Response	Survey of Bangladesh is preparing thematic maps for the whole Bangladesh. Thematic maps will help the country to prepare an integrated, comprehensive and coordinated plan which is already underway.
Effect	By supplying geospatial information to the relevant agencies, the Government will be able to mitigate the natural disaster and can save our valuable resources.
Future	Our organization is planning to use UAV for capturing aerial photographs and making available live high resolution satellite images just after the disaster to prepare an integrated, comprehensive and coordinated post disaster plan.

No.3

Country	China
Organization	Satellite Surveying and Mapping Application Center (SASMAC)
Title	Earthquake
Outline of the subject natural disaster	In China, earthquakes happen quite often, In almost all earthquakes, SBSM provides the maps after earthquakes including previous, in situ, and after maps
Response	The response of emergency mechanism of government
Effect	good
Future	Accelerate the speed of response including all kinds of disasters such as storm, flooding. etc

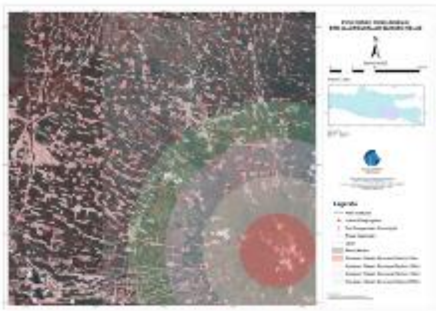
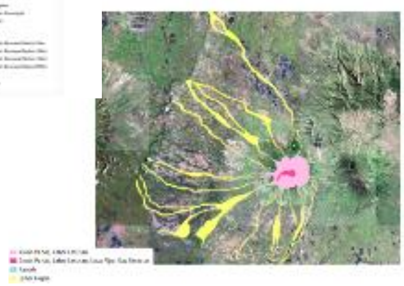
No.4

Country	Fiji
Organization	National Disaster Management Office
Title	
Outline of the subject natural disaster	Tropical Cyclone, Flooding
Response	The information provided by geospatial information assists in the coordination our response.
Effect	It really assists in the effectiveness and efficiency of response efforts.
Future	• Improve geospatial information • Mapping of people with disability

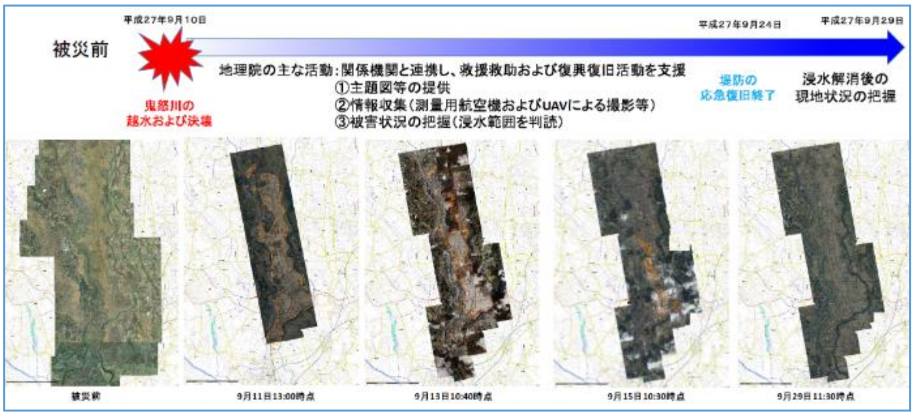
No.5

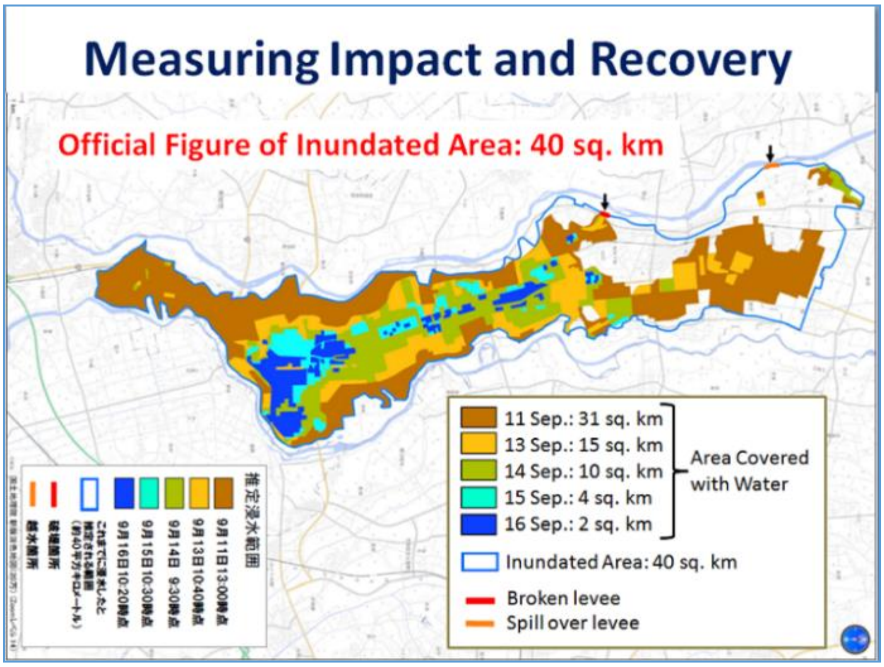
Country	Hong Kong Special Administrative Region (HKSAR)
Organization	Lands Department
Title	Contingency Plan for Natural Disasters
Outline of the subject natural disaster	A landslip is occurred affecting life and property.
Response	Lands Department (LandsD) is responsible for emergency and urgent repair works to landslips occurring on registered man-made slopes maintained by LandsD and to landslips that occur on man-made slopes on unleased and unallocated Government land not maintained by other departments and affecting life and property. LandsD works in conjunction with the Civil Engineering and Development Department (CEDD) in determining maintenance responsibilities of registered man-made slopes. The maintenance responsibilities of slopes having been determined are contained in the Slope Maintenance Responsibility Information System (SMRIS) and publicized on the LandsD's website (http://www.slope.landsd.gov.hk/smris/) and on CEDD's Slope Information System (SIS) accessible from http://hkss.cedd.gov.hk. LandsD will assist as necessary in emergency situations. The Survey and Mapping Office (SMO) of LandsD is responsible for providing existing maps, plans and aerial photos of the scene in conjunction with Government Flying Services (GFS) in an emergency situation. The SMO will also conduct topographical surveys after the disaster if necessary.
Effect	Location and maintenance responsibility of the landslip are identified in the first instance. Geospatial information of the disaster scene is captured for investigation and restoration purposes.
Future	UAV will be deployed as a part of the emergency survey operation in future disaster incidents.

No.6

Country	Indonesia
Organization	Geospatial Information Agency(BIG)
Title	Rapid Mapping of Kelud Mountain
Outline of the subject natural disaster	On February 13, 2014 mount Kelud erupted. The Centre of Thematic Mapping and Integration of Geospatial Information Agency (BIG) has conducted rapid mapping and analysis of Mount Kelud.
Response	BIG, together with some institutions and local governments, have provided the Disaster Susceptibility Map of Mount Kelud, Evacuation Sites and Routes, and Ash Distribution of Mount Kelud. EVACUATION SITES AND ROUTES  DISASTER SUSCEPTIBILITY MAP OF MOUNT KELUD  ASH DISTRIBUTION OF MOUNT KELUD 
Effect	The above products have been published on internet so that many people in Blitar and Kediri Regencies could be saved.
Future	Many additional important information from ministries, local governments, and private sectors could be enriched the above maps.

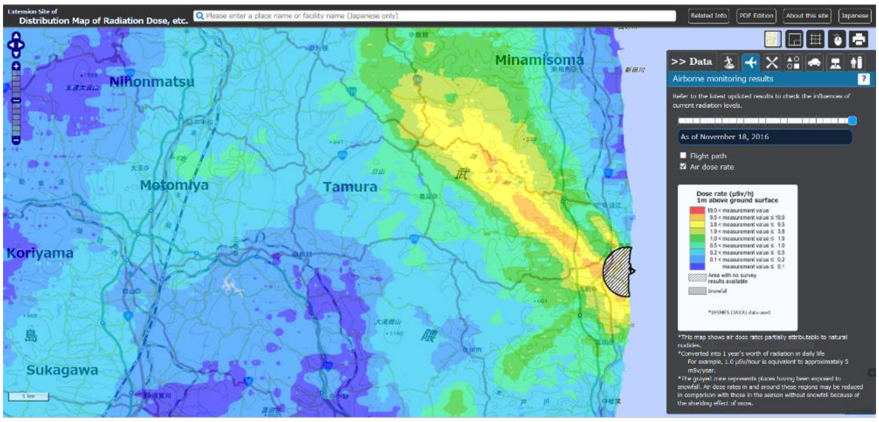
No.7

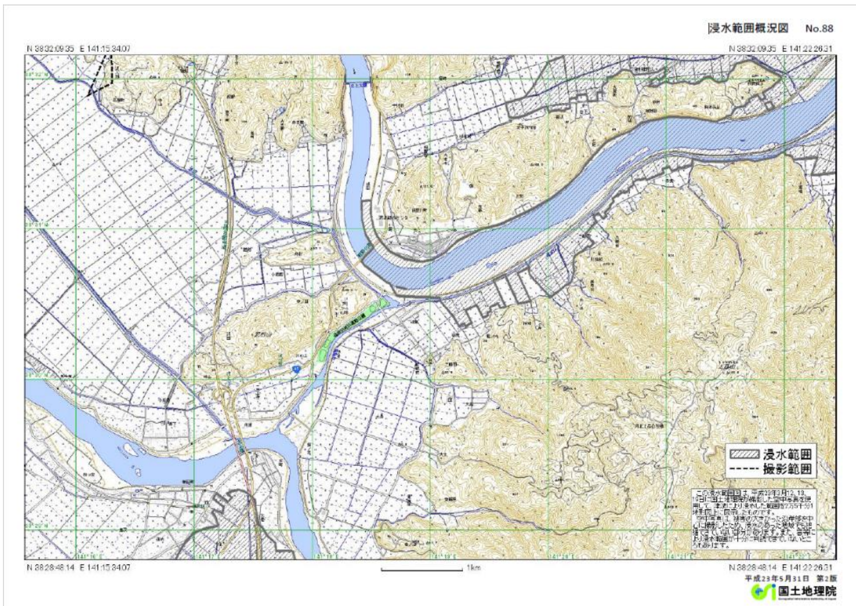
Country	Japan
Organization	Geospatial Information Authority of Japan (GSI)
Title	Floods as a Result of　Heavy Rain
Outline of the subject natural disaster	Due to the heavy rainfall from September 9 to 11 in 2015, the collapsing of levees, overtopping and leakage, inundation and the fracturing/breaking of levee slopes occurred in over 80 rivers. Immense damage was brought about as a result of this, including the loss of lives, injuries, and many incidents of houses being swept away and above the floor level inundation.
Response	Relief work and restoration activities were enforced in cooperation with related organizations after overtopping and damage occurred at the rivers. Specifically, aerial photos after the disaster were photographed, and photos before and after the disaster were provided to the government and disaster-stricken municipalities, while information was provided extensively to the nation on our homepage. By measuring the inundated area using photographic interpretations, the disaster effects and restoration situation after the disaster were monitored. Measurements of the inundated areas were updated daily and reported to the government until the inundated areas became small enough that drainage pump cars were no longer required. 



Effect	Swiftly disclosing the disaster situation that specifies the inundation range, contributed to initial restoration operations (placement of police, the numbers of pumper trucks and workers, placement positions and determining work hours). As well, the government and media utilized the data provided by GSI as trustworthy official information in their disaster response and news coverage, reaffirming the significance of GSI.
Future	It was possible to provide timely information to the government, as the government's needs were understood through frequent interactions with various government posts on a regular basis. In other words, it is important that the required needs for policy making are grasped. Furthermore, disaster simulations (hazard maps) of these rivers where levees broke had been released to the public until now. However, because a sense of danger was not clearly communicated to residents, it may also be believed that it didn't lead to their swift evacuations. It is important to also raise the awareness of residents towards disaster prevention.

No.8

Country	Japan
Organization	Geospatial Information Authority of Japan (GSI)
Title	2011 Great East Japan Earthquake
Outline of the subject natural disaster	The Great East Japan Earthquake that occurred at 14:46 on March 11 2011 with the largest Mw (moment magnitude) of 9.0 ever recorded in Japan, caused strong earthquake motions with an intensity over lower 6 on the Japanese scale of 7 in a wide area spanning eight prefectures from Iwate Prefecture to Chiba Prefecture, and triggered a powerful tsunami over 10-meters in height that hit the Pacific side of Japan's Tohoku region, destroying an area of 561km2 with its massive force, followed by an accident at the Tokyo Electric Power Company Fukushima Daiichi Nuclear Power Plant and resulting massive evacuation efforts, making it the most massive and multiple catastrophe our nation has ever experienced.
Response	Immediately after the disaster, Geospatial Information Authority of Japan created figures of the general situation of the inundation range, conducted emergency shoots of aerial photograph to provide to related organizations, and these resources were utilized in a wide range of fields. Specifically, figures of the general situation of the tsunami inundation and aerial photos were used for the creation of radiation dosimetry maps, the issuing duties of disaster victim certificates, and explanatory manuals for volunteer activities etc. Apart from these, the disaster recovery plan base map, provided by Geospatial Information Authority of Japan, was also utilized.  [Radiation dosimetry map (estimate)]

	 [Figure of the general situation of the inundation range]
Effect	Various resources to serve restoration/recovery were created and provided using the map provided by Geospatial Information Authority of Japan as its base. For example, in areas where massive emigration was conducted, the time and cost spent on the move was significantly reduced using the results of the cadastral survey results.
Future	Though most of the three months after the disaster was spent for grasping the damage situation, because the information gets complicated, the swift disclosure of “trustworthy maps” issued by the nation is indispensable for grasping damage situations towards their recovery. In the future, Geospatial Information Authority of Japan will continue to seriously maintain and provide geospatial information for restoration/recovery, and promote the utilization of information, while understanding the needs of each field.

No.9

Country	Japan
Organization	Geospatial Information Authority of Japan（GSI）
Title	Evacuation Center Map for 2016 Kumamoto Earthquake Response
Outline of the subject natural disaster	A Mw 6.2 earthquake occurred in Kumamoto district in southern Japan on April 14, 2016 at 21:26 (pre-shock). Subsequently, a Mw 7.0 earthquake occurred on April 16 (main shock) at 1:25. These earthquakes are referred to as “The 2016 Kumamoto Earthquake.” The earthquake left 98 people dead, 830 severely injured and 1,491 slightly injured, as well as 8,198 buildings totally collapsed, 29,761 half-collapsed and 138,102 partially damaged. The earthquake hit Kumamoto city with the population of 730 thousand and its suburban municipalities, causing 180 thousand people to be evacuated at peak period.
Response	・Affected people who took precautions against possible aftershocks and people whose houses were totally collapsed took shelter in evacuation centers. As a result, the number of evacuees far exceeded the capacity of evacuation centers. Additionally, some evacuation centers themselves were too damaged to use. Because of these, many people had to stay and sleep outside or in their own car. ・On April 17, the following day of the main shock, evacuees' living conditions became worse and their fatigue peaked due to rain and disruption of relief goods supply. However, the on-site disaster response headquarters, set up by the national government, did not have enough information about the location of the evacuation centers and the number of evacuees, which made the relief goods supply extremely difficult. ・Thus, the next day, on April 18, head of the on-site disaster response headquarters directed Geospatial Information Authority of Japan (GSI) to create a distribution map which showed the locations of the evacuation centers. In response, GSI mobilized disaster response staff, organized and compiled on-site information and existing materials, and created Evacuation Center Map (Figure 1). On April 20, GSI completed and provided the first map for the on-site disaster response headquarters.
Effects	Evacuation Center Map significantly contributed to the on-site disaster response headquarters for accessing evacuation centers and for assisting in relief supply. Since evacuation centers were re-organized and closed according to the change of number of evacuees, GSI had updated the map once a week for four months since the earthquake, until August 2016. The map played an important role in the operation and environmental management of the evacuation centers.
Future	The Basic Act on Disaster Control Measures of Japan (revised in 2013) stipulates that mayors of municipalities designate the emergency evacuation areas[*1] and evacuation centers [*2]. Public facilities such as schools are often designated as such evacuation facilities. Since designation of the facilities is subject to change as appropriate, their location information needs to be updated on a regular basis. GSI prepared the location information of emergency evacuation areas by establishing a framework of cooperation with Cabinet Office and Fire and Disaster Management Agency, as well as collaborating with prefectures, municipalities and the like. The location information of emergency evacuation areas became publicly available on GSI web map in February 2017, and GSI will continue to update the information (Figure 2).

*1 Emergency evacuation area: A place to evacuate residents and other people at immediate risk caused by tsunami, flood or other disasters, in order to secure safety of their lives

*2 Evacuation center: Facilities to accommodate residents and other people who have escaped from disaster up until there is no further disaster risk, or to temporally accommodate those who cannot return home due to disaster.

Figure 1 : Evacuation Center Map(east of kumamoto city) provided by GSI and utilized by on-site disaster response headquaters

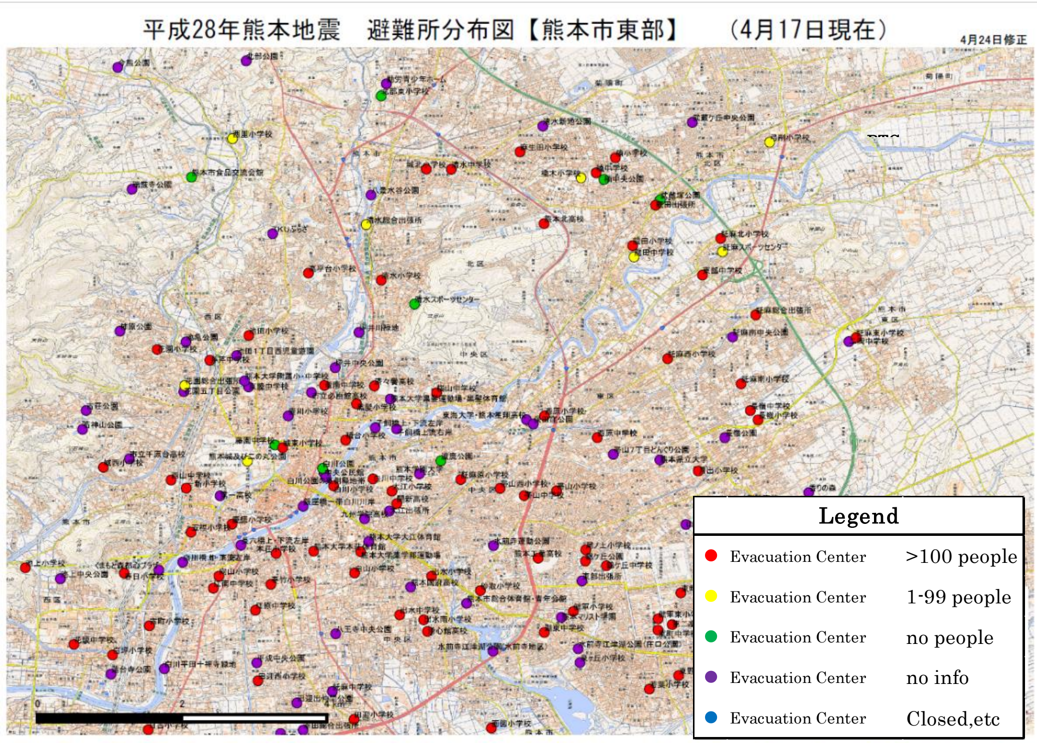
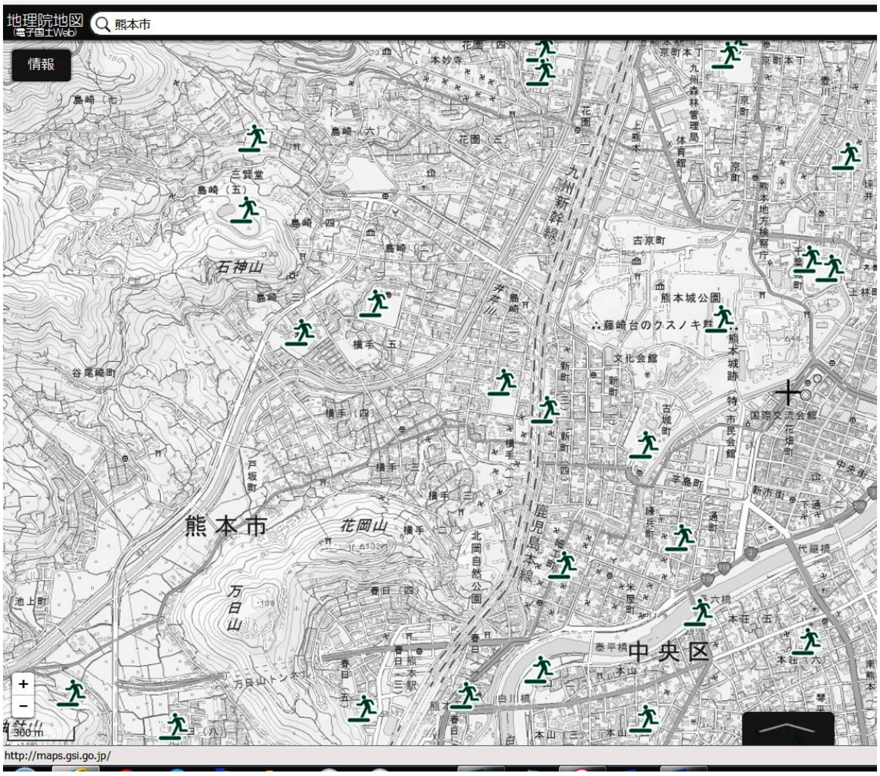


Figure 2: Emergency evacuation area provided in web map (Kumamoto city and its vicinity)



 Emergency evacuation area

No.10

Country	Japan
Organization	Geospatial Information Authority of Japan（GSI）
Title	Creation of Disaster Geoinformation Catalog
Outline of the response to natural disaster	Geospatial Information Authority of Japan (GSI) compiles and provides a catalog of disaster geoinformation, including type of geospatial information as well as timing of provision and data format, featured as "Disaster Geoinformation Catalog." This catalog aims at facilitating national and Local governments effectively utilizing disaster geoinformation provided by GSI.
Response	Japan experienced various natural disasters such as earthquakes, volcanic eruptions and floods. During these disasters, the national and local governments referred to the Catalog and requested GSI to provide geospatial information according to their particular needs for disaster response.
Effects	The national and local governments referred to the Catalog and understood what type of geospatial information GSI developed and owned. This preparation helped GSI meet their requests rapidly.
Future	Since the geospatial information developed and owned by GSI are expected to become more varied and wide-ranging, GSI intends to update the Catalog regularly and provide it for the related organizations.

Disaster Geoinformation Catalog (excerpt)

[関係機関限り]

(Available Disaster Geoinformation to be provided by GSI at disaster occasions)

災害時に国土地理院が提供する地理空間情報

(Disaster Geoinformation Catalog)

防災カタログ

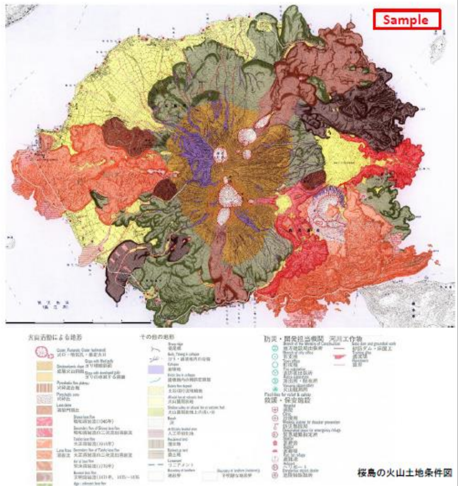
(As of 1.March 2016)

平成28年3月1日作成

国土地理院
Geospatial Information Authority of Japan

Cover Page

No. 5 火山土地条件図



桜島の火山土地条件図

火山土地条件図とは、火口分布や過去の噴出物の分布等の火山活動による地形のほか、防災関連施設などが記載された地図です。
過去の噴火と比較した災害対応をする際に有効な情報です。

注）現時点の整備状況は地理院地図からご確認ください。

提供できる時期と形式	
時　期	噴火発生後、24時間以内
データ形式	PDF及びGeoTIFF
提供・公表形態	メール提供、国土地理院HP、関係機関向けwebサイト

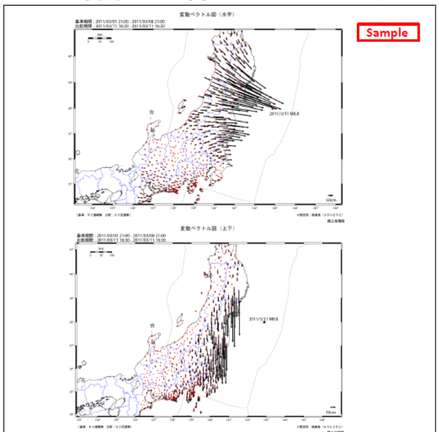
問い合わせ先：企画部防災推進室　E-mail：gsi-bousai@ml.mlit.go.jp

Catalogue No. 5

国土地理院

No.5 Volcanic land condition map

No. 12 変動ベクトル図（地震による変動があった場合提供）



※3月11日（発生当日） 地震調査研究推進本部地震調査委員会提出資料

変動ベクトル図は、電子基準点で観測されたデータを解析し、震源域周辺の地震による地殻変動を矢印で表示した図です。
水平成分及び上下成分の2種類を速報値として提供します。この情報は、地震規模や断層モデル等の地震現象の解明、広域な地盤沈下の把握、高潮・津波等に対する注意喚起等の防災情報として活用されます。
※地震による被災状況等により、電子基準点の復旧・データの回収が必要となることがありますが、その場合、早期に復旧、データ回収・再解析を行い、迅速に情報を提供します。

提供できる時期と形式	
時　期	発災後（地震）5時間後
データ形式	PDF
提供・公表形態	メール提供、国土地理院HP、関係機関向けwebサイト

問い合わせ先：企画部防災推進室　E-mail：gsi-bousai@ml.mlit.go.jp

Catalogue No.12

国土地理院

No.12 Crustal displacement map

No. 16 無人航空機（UAV）

平成27年9月関東・東北豪雨に伴う鬼怒川破堤地点周辺

平成27年9月関東・東北豪雨に伴う西仁連川破堤地点周辺

国土地理院ランドバード班は、立入困難な被災地域を無人航空機（UAV）を用いて、現地の状況を撮影いたします。

撮影された映像は現地の状況を俯瞰的に把握できるので、迅速な状況把握に役立ち、人命救助や道路啓開等の初動活動に利用できます。

提供できる時期と形式	
時　期	撮影後、活動拠点に到着してから6～12時間程度
データ形式	静止画：JPG 動画：WMV
提供・公表形態	メール提供、国土地理院HP

問い合わせ先：企画部防災推進室　E-mail：gsi-bousai@ml.mlit.go.jp

Catalogue No. 16

国土地理院

No.16 Unmanned aerial vehicle

No.11

Country	Malaysia
Organization	Department of Survey and Mapping Malaysia (DSMM)
Title	The Use of Unmanned Aerial Vehicle (UAV) to Monitor the Flood and Its Impact in Malaysia
Outline of the subject natural disaster	Floods are the major natural disaster threat facing Malaysia. The 2014-year end downpour and floods has been the worst ever in the country's history, affecting more than half a million people. Damage to infrastructure alone was estimated RM2.851 billion. Areas that have never experienced floods before were also inundated and floodwater rose at an unprecedented level.
Response	The video and aerial photo captured using UAV have been used to provide information about the areas that were susceptible to the floods and locations where people can be evacuated to. The data have been used for making post flood damage assessments and identifying the facilities need to be repaired urgently such as roads, bridges, water treatment plant, etc.
Effect	The process to search and rescue flood victims were expedited by using the UAV data. Besides that the refurbishment and reconstruction of damaged facilities were expedited to ease the transportation links in moving people and goods to the affected area. The use of UAV also has saved the operational cost due to its flexibility and cheap flying operation with less constraint on time and human resources.
Future	To provide UAV data during and after disaster for relief and recovery purposes particularly on the remote area. Efficient dissemination of information

No.12

Country	Malaysia
Organization	Department of Survey and Mapping Malaysia (DSMM)
Title	Earthquake Struck Ranau in Sabah, Malaysia
Outline of the subject natural disaster	A magnitude 5.9 earthquake struck near Mount Kinabalu killing 18 and stranding more than a hundred people on the peak. The quake damaged roads and buildings, including schools and a hospital on Sabah's west coast. Geospatial information also plays a big role to monitor the crustal and surface motion by using Continuously Operating Reference Station (CORS) data.
Response	The earthquake that occurred in Ranau on 5th June 2015 which is near to Mount Kinabalu had caused massive landslides around the mountain and nearby area as well. The data before and after earthquake from CORS stations (MyRTKnet) and 11 GNSS monuments were analysed and has indicated the surface motion on the area is between 36 to 53 cm. The output reflected the benefit to monitor the progress of motion so that the early warning for earthquake can be disseminated to alert the surrounding people.
Effect	The data from CORS stations (MyRTKnet) and 11 GNSS monuments has contributed significant information for an early warning system for earthquake in order to expedite the necessary evacuation of people from the hazard area. Also important in the following cases: • Overall picture and extent of damage caused • Indication of ground displacement • Planning and distribution of aids
Future	To densify the CORS stations (MyRTKnet) throughout the country

No.13

Country	Republic of the Philippines
Organization	National Mapping and Resource Information Authority (NAMRIA)
Title	Multi-Hazard Mapping of 28 Priority Provinces and the Greater Metro Manila Area
Outline of the subject natural disaster	The Philippines is consistently visited by tropical disturbances exposing communities to hydrometeorological hazards such as strong winds, storm surge floods/flashfloods, and rain-induced landslides. The country, being located in the Pacific ring of fire, is likewise exposed to seismological hazards such as ground shaking, ground rupture, earthquake-induced landslide, and liquefaction. Aiming to have a safer and disaster resilient communities, multi-hazard mapping of the 28 high risk provinces was implemented to map out areas exposed to natural hazards. The output of this activity will facilitate evidence-based decision-making by local and national authorities.
Response	The Agency provided base maps, capacitated LGUs on the use of GIS technology, engaged technical staff in the integration of hazard maps for use by the local government units and national government agencies, and participated in the conduct of information and education campaign (IEC) in the communities primarily exposed to hazards.
Effect	1. Raised awareness on the impending hazards confronting the exposed communities in the provinces. 2. Hazard maps are increasingly used in the formulation of land use and physical development plans. 3. Hazard maps used in the formulation of local DRRM plans. 4. Increasing number of LGUs expressing interest in the use of GIS for DRRM
Future	

No.14

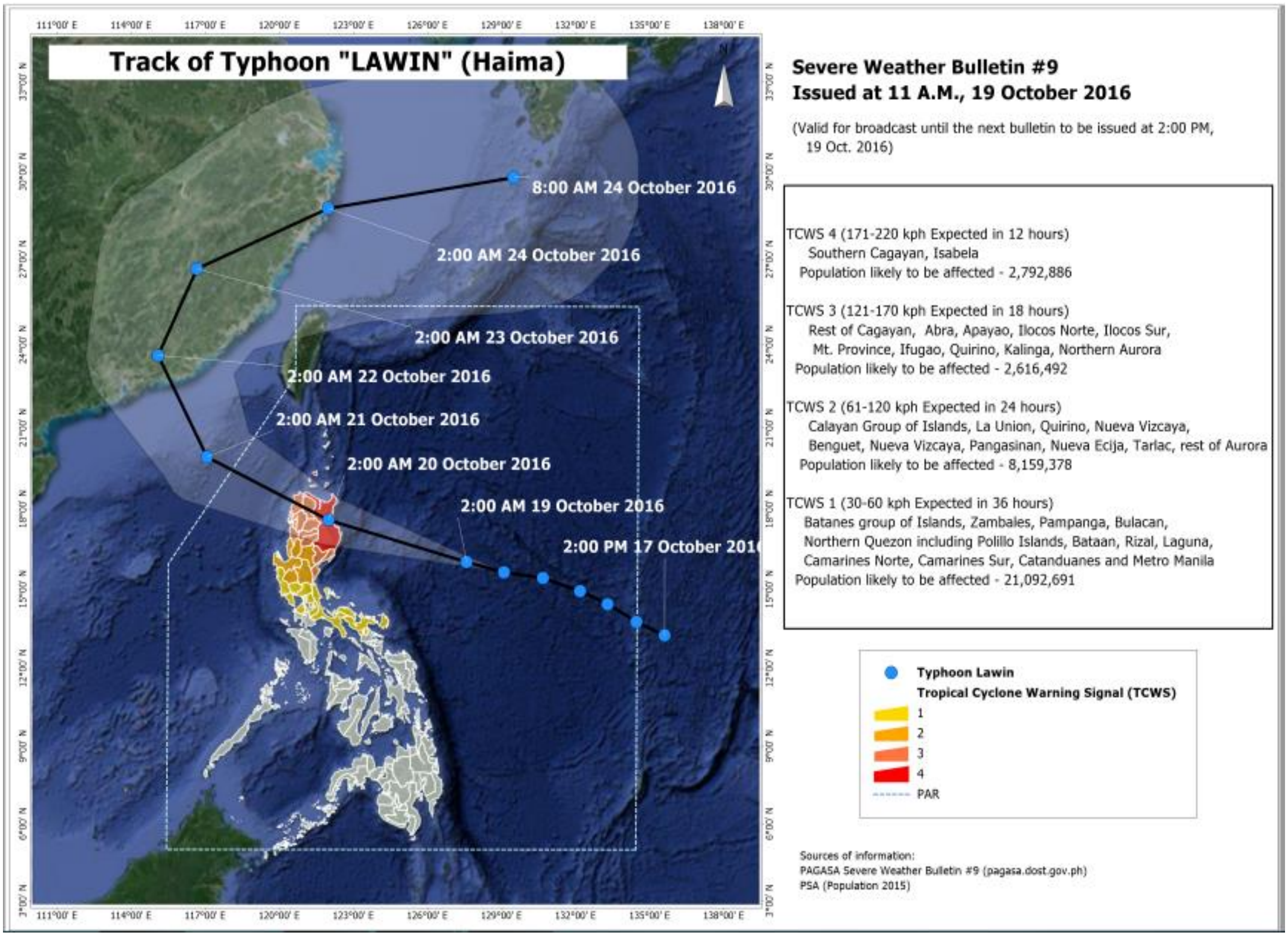
Country	Republic of the Philippines
Organization	National Mapping and Resource Information Authority (NAMRIA)
Title	The Philippine Geoportal
Outline of the subject natural disaster	The Philippine Geoportal is envisioned to provide a comprehensive and consistent geospatial information of the country. It aims to support the geospatial information needs of users in various disciplines by providing access to such information. In the aftermath of Tropical Storm Ketsana (Ondoy) which left Metro Manila and 30% of the provinces in the Philippines under state of calamity, geohazard maps were prepared for the 28 high risk areas in the country. These maps were made accessible to the public through the Philippine Geoportal.
Response	Developed in the Philippine Geoportal is a DRRM application which provides a visual appreciation of the hydrometeorological and seismological hazards in the high risk areas of the country.
Effect	1. Increased awareness of the public on the hazards faced by the community. 2. Hazard maps are increasingly used in the formulation of land use and physical development plans. 3. Hazard maps used in the formulation of local DRRM plans.
Future	

No.15

Country	Republic of the Philippines
Organization	National Mapping and Resource Information Authority (NAMRIA)
Title	Recovery and Rehabilitation after Typhoon Haiyan
Outline of the subject natural disaster	The harrowing impact of typhoon Haiyan left about 4 million people homeless. This prompted the Philippine government to ensure the safety of the affected communities, moving them away from the seashore to more suitable relocation sites. In focusing on the recovery and rehabilitation phase, the immediate objective is to identify areas suitable for relocation of those left homeless by the typhoon.
Response	NAMRIA provided technical assistance with the provision of IfSAR data which includes digital terrain models (DTM), digital surface models (DSM), and orthorectified images used in the identification of suitable relocation sites for the affected communities.
Effect	The government was able to advance and fast track the identification of safe and unsafe zones in the Haiyan-affected areas.
Future	

No.16

Country	Philippines
Organization	National Mapping and Resource Information Authority (NAMRIA)
Title	Mapping of Track of Typhoon Lawin (International Name: Haima) and Affected Areas and Population
Outline of the subject natural disaster	In 19 October 2016, Typhoon Lawin (Haima) classified as extremely dangerous by the state's weather agency affected the provinces in the northern part of the country. As it intensified into a super typhoon, destructive floods and massive landslides were expected to be brought by moderate to heavy rains within its 800-km diameter.
Response	NAMRIA prepared a map layout showing the track of Typhoon Lawin (Haima), the likely affected provinces and population. NAMRIA integrated data from various sources such as Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) and the Philippine Statistics Authority (PSA). The map was made public via NAMRIA's website for download by other DRR agencies, local government units, and other interested parties.
Effects	The public is able to visualize the track of the typhoon and is made aware of the areas and population likely to be affected by it. This increased awareness of the residents in the likely affected areas to prepare for the impending typhoon.
Future	Strengthen coordination with DRR and other agencies providing statistical data relevant to disaster preparedness.



Map showing the track of Typhoon Lawin and likely affected areas. The map was made available for public download at NAMRIA's website.

No.17

Country	Philippines
Organization	National Mapping and Resource Information Authority (NAMRIA)
Title	Philippine Active Geodetic Network (PageNet) – Surigao Earthquake
Outline of the subject natural disaster	The Province of Surigao del Norte in northeastern Mindanao was struck by a magnitude (M_S) 6.7 earthquake on 10 February 2017. The earthquake was generated by the movement of the Philippine Fault-Surigao segment. The groundshaking was felt at PHIVOLCS Earthquake Intensity Scale (PEIS) VII in Surigao City and San Francisco. Liquefaction and earthquake-induced landslide were documented as well as collapsed bridge, damages to buildings, ports, roads, and bridges. As of 15 February 2017, there were 202 reported injuries and 8 reported casualties.
Response	NAMRIA measured the displacement of PageNet stations as a result of the M6.7 Surigao Earthquake on 10 February 2017. The recent earthquake caused a 2D shift in the coordinates[1] by as much as 12.9 cm in the north-west direction. This displacement (10.1 cm to North, 8.0 cm to West, and 2.8 cm Down) was measured from 9 to 11 February 2017 from the active geodetic station (AGS) PSUR of PageNET, which is located in Surigao City, 14km from the earthquake's epicenter. The next nearest AGS PTGO in Tagoloan, Misamis Oriental, which is 158 km from the epicenter, showed no significant shift in its position. The data from PSUR was processed using Bernese GNSS Software from 01 to 20 February 2017 (10 days before and after the event) using the best available products (e.g. orbits, clocks) from the International GNSS Service (IGS). The displacements measured are not fixed to a stable tectonic plate and are just based solely on the change in position in the ITRF. The reference coordinates of the stations are based on the May 2015 monthly solution from Bernese. Continuous monitoring of the stations is ongoing for post-earthquake events. Coordinates in the International Terrestrial Reference Frame (ITRF) 2008
Effects	Results of the measurements and continuous monitoring of the stations will be made available to the Philippine Institute of Volcanology and Seismology (PHIVOLCS) in support of the Agency's (PHIVOLCS) assessment and analysis related to the recent seismic activity.
Future	Strengthen partnership with PHIVOLCS and other DRR agencies such as Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) to promote the use of AGS data for seismological, meteorological, and other potential applications.

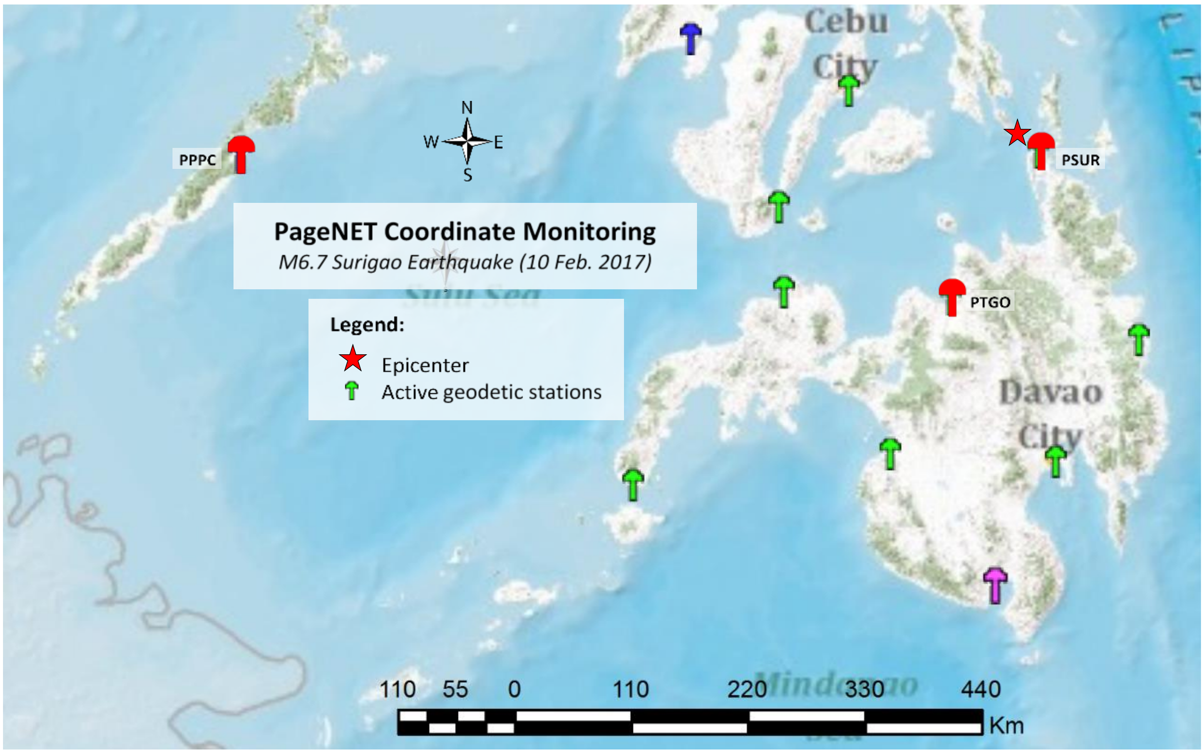


Figure 1. ***PageNET active geodetic stations monitored*** *(in red)*

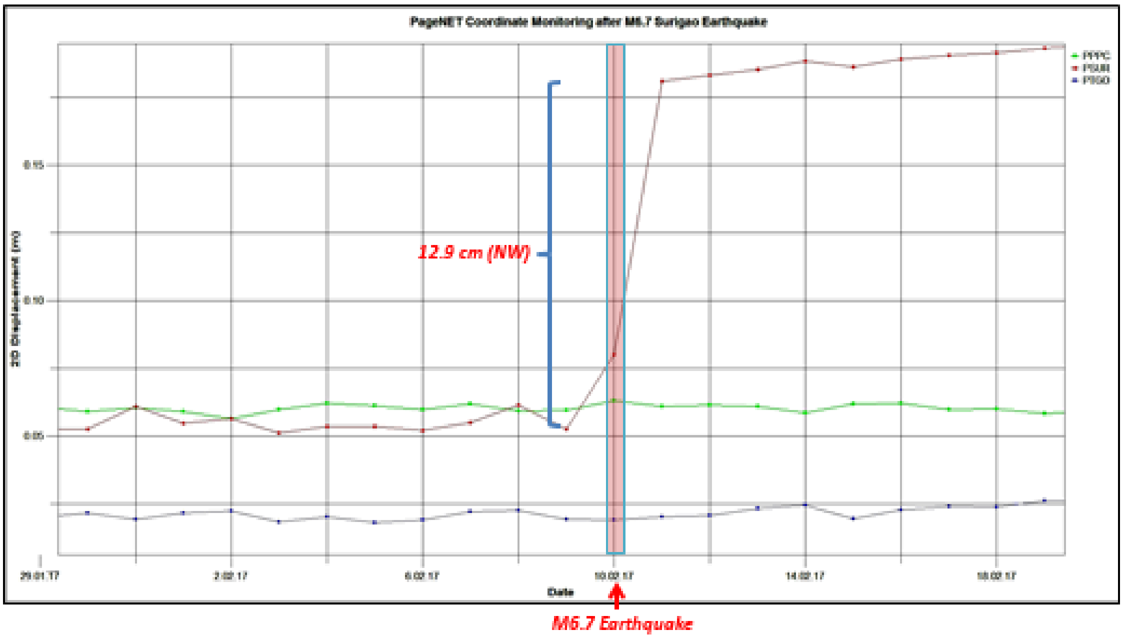


Figure 2. ***2D Displacement*** *(9 to 11 February 2017 = 12.9 cm, north-west)*

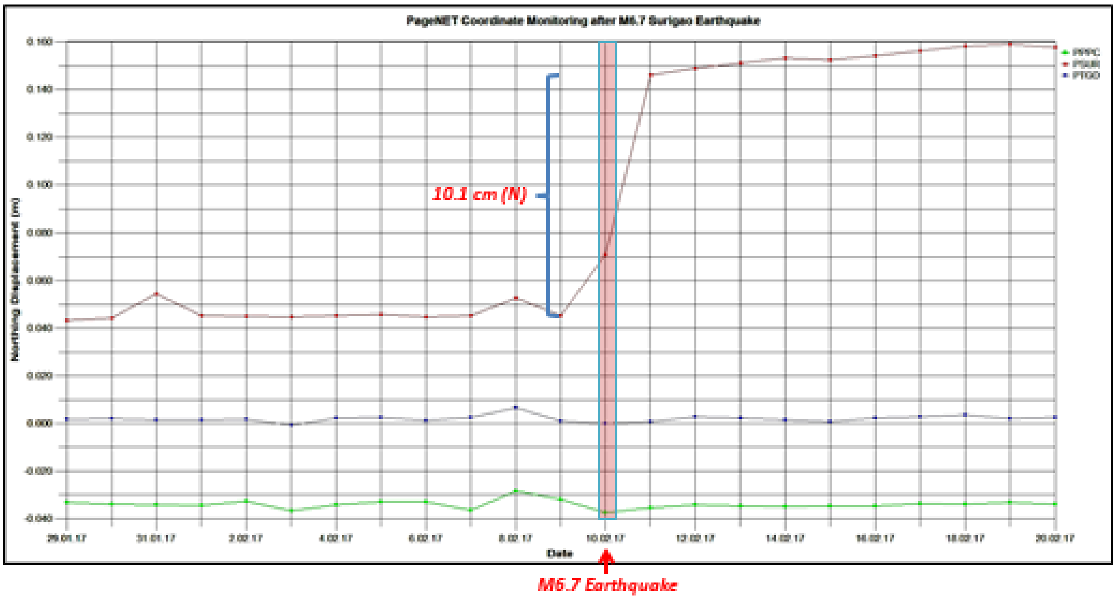


Figure 3. ***Northing Displacement*** *(9 to 11 February 2017 = 10.1 cm, north)*

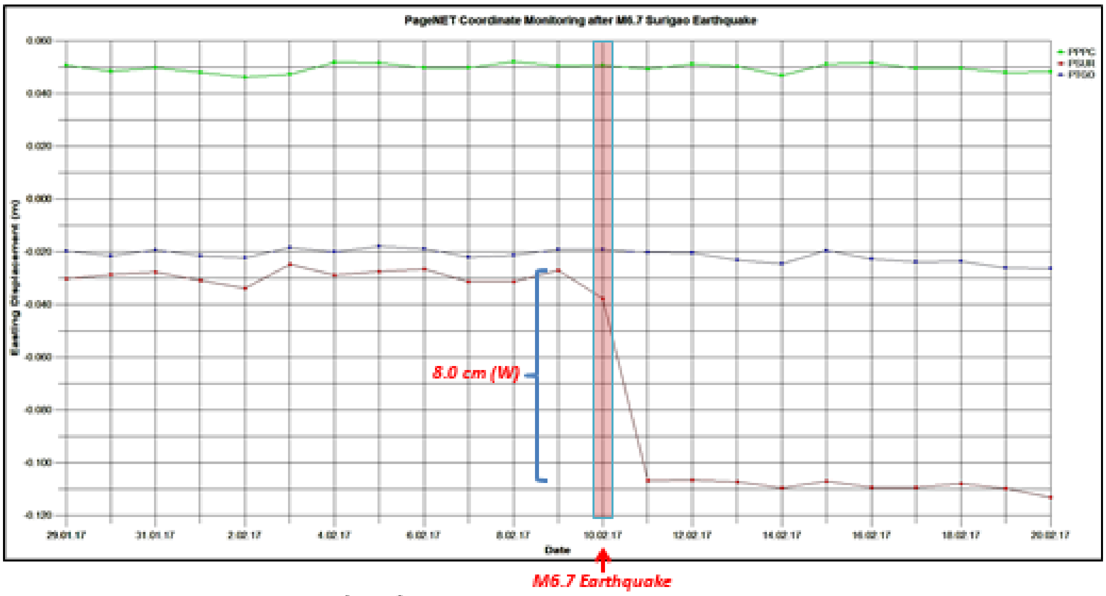


Figure 4. **Easting Displacement** (9 to 11 February 2017 = 8.0cm, west)

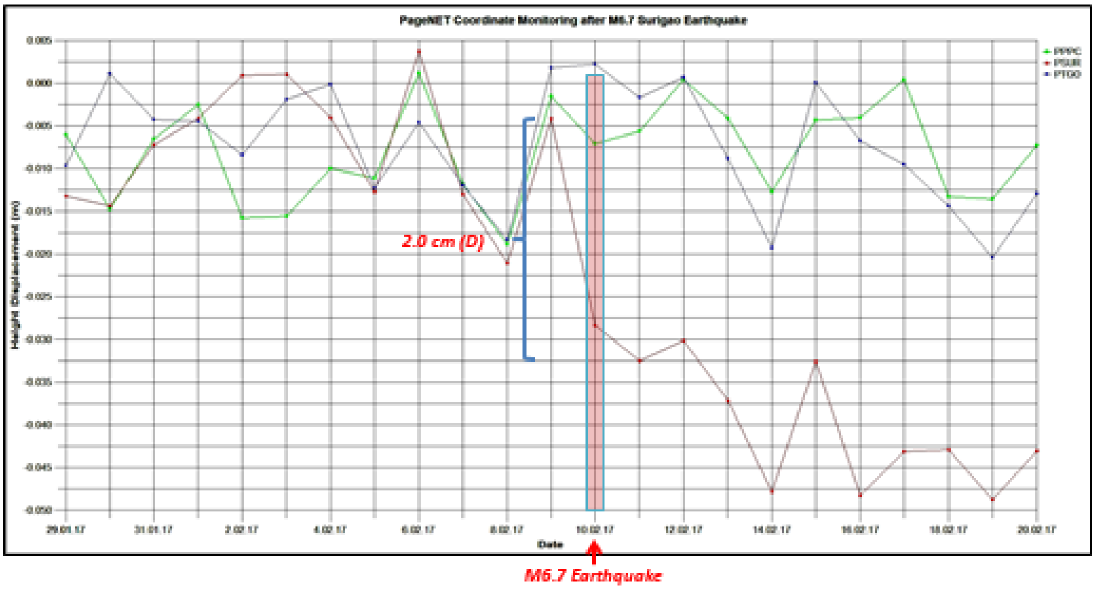


Figure 5. **Height Displacement** (9 to 11 February 2017 = 2.8cm, down)

Notes:

1. *Date format: dd.mm.yy, e.g. 1.02.17 = 1 February 2017*
2. *Each data point corresponds to one daily solution processed from Bernese*
3. *Displacements measured is difference of each daily coordinates from PageNET AGS' reference ITRF2008 coordinates (epoch 15 May 2015). For example, in Figure 3, PSUR Northing has moved ~0.04 m (N) on 29 January 2017 from its 15 May 2015 coordinates.*

No.18

Country	Sri Lanka
Organization	Survey Department
Title	Surveyor General
Outline of the subject natural disaster	Tsunami – 2004 December 26
Response	Providing available digital data / maps and technical support to map the disaster prone areas / damages Identify available resources for relief activities
Effect	Help quick dispatch of support Relief providing activites Locations for relief camps Medical support availability information
Future	Fully pledged database on topographic information / resources available which is shared with stakeholders / allowing them to add / update information Quick mapping with UAV when required Provide accurate digital elevation model

Annex 3

How did the Geospatial Information Authority of Japan Respond to the 2016 Kumamoto Earthquake?

-A Case Story-

October 2017

Geospatial Information Authority of Japan

Contents

List of Acronyms

ALOS-2:	Advanced Land Observing Satellite
CORS:	Continuously Operating Reference Station
CDMC:	Central Disaster Management Council
DGO:	Designated Government Organization
DMHQ:	Disaster Management Headquarters
GEONET:	GNSS Earth Observation Network System
GSI:	Geospatial Information Authority of Japan
GSI-LB:	Geospatial Information Authority-Land Bird
MLIT:	Ministry of Land, Infrastructure, Transport and Tourism
NGIA:	National Geospatial Information Authority
ODMHQ:	On-site Disaster Management Headquarters
REGARD:	Real-time GEONET Analysis system for Rapid Deformation Monitoring
RSD:	(GSI) Regional Survey Department
SAR:	Synthetic Aperture Radar
SFDRR:	Sendai Framework for Disaster Risk Reduction 2015-2030
SGDAS:	Construction of Seismic Ground Disaster Assessment System
SI:	Seismic Intensity
UAV:	Unmanned Aerial Vehicle
UN-GGIM:	UN Committee of Experts on Global Geospatial Information Management
UN-GGIM-AP:	The Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific
VLBI:	Very Long Baseline Interferometry

Introduction

Role of Geospatial Information in Disaster Risk Reduction

Since natural disasters take away many lives and assets, and hinder sustainable development, disaster risk reduction has been an important international challenge. The United Nations, having recognized the importance of disaster risk reduction, convened in 1994 the first World Conference on Natural Disaster Reduction, and established the United Nations Office for Disaster Risk Reduction (UNISDR) in 1999 to facilitate the implementation of the International Strategy for Disaster Reduction. The outcomes of the subsequent efforts were consolidated at the 3rd United Nations World Conference on Disaster Risk Reduction in 2015 into the Sendai Framework for Disaster Risk Reduction 2015-2030[1] (SFDRR), which outlines the issues, policy framework and measures to be addressed on disaster risk management up to 2030. The resolution on SFDRR was subsequently adopted by the UN General Assembly in the same year. It is noteworthy that SFDRR recognizes the potential role of geospatial information in disaster risk reduction, and urges the geospatial information community to: develop location-based disaster risk information, including risk maps, by using, as applicable, geospatial information technology; make use of space and in situ information, including geographic information systems (GIS); and disseminate risk information with the best use of geospatial information technology, in its Priority 1 – Understanding disaster risk.

Activities of UN-GGIM on Disasters

Pursuant to the adoption of SFDRR, the UN Committee of Experts on Global Geospatial Information Management (UN-GGIM) established a Working Group on Geospatial Information and Services for Disasters (WG on Disasters) in 2015 to discuss the optimization of geospatial information applications and services at all levels of disaster risk management. The results of the WG on Disasters discussions were compiled into the Strategic Framework on Geospatial Information and Services for Disasters[2], which was adopted at the seventh session of UN-GGIM in 2017. The final goal of this Strategic Framework is that "quality geospatial information and

1 http://www.unisdr.org/we/inform/publications/43291
2 http://ggim.un.org/docs/UN-GGIM%20Strategic%20Framework%20for%20Disasters%20(FINAL%20VERSION%20-%20UNGGIM7%20dated%2003%20August%202017).pdf

services are available and accessible in a timely and coordinated way to support decision-making and operations within and across all sectors and phases of the emergency cycle." The WG on Disasters is now drafting a resolution for the adoption of the Strategic Framework by the Economic Social Council of the United Nations, and is developing an assessment tool to assist Member States and UN-GGIM regional committees to evaluate and develop their respective implementation plans, and to monitor and report progress on the implementation of the Strategic Framework.

Activities of UN-GGIM-AP on Disasters

In parallel with this global attempt to implement the SFDRR, the Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific (UN-GGIM-AP) established a Working Group on Disaster Risk Management (WG on DRM) to discuss specific activities that National Geospatial Information Authorities (NGIAs) in the Asia-Pacific region, where the frequency and intensity of natural disasters are very high, and to contribute to disaster risk management in accordance with SFDRR. This Working Group has been closely cooperating with the WG on Disasters of UN-GGIM. The WG on DRM of UN-GGIM-AP so far has been concentrating its efforts to understand what the NGIAs and relevant disaster management agencies of the Member States in the region have been doing on disaster risk management, and to find out their best practices to share them in the region. One of the goals of the WG on DRM is to develop guidelines for the NGIAs in the region for the disaster risk management that will be consistent with the Strategic Framework, which was also welcomed at the Seventh Session of UN-GGIM in its decision. The guidelines are now in drafting phase and expected to be finally adopted at the UN-GGIM-AP at its Sevenths Plenary Meeting in 2018.

Special Session at the Sixth Plenary Meeting of UN-GGIM-AP

In light of the need of thorough understanding on what NGIAs are actually doing specifically on disaster risk reduction and of sharing them among the NGIAs in the region, in order to develop the guidelines that are to include specific actions NGIAs could take to assist their respective governments in better managing disaster risk in accordance with the Strategic Framework, UN-GGIM-AP is organizing a special session on the applications of geospatial information for disaster risk reduction during its Sixth Plenary Meeting on 17 and 18 October 2017 in Kumamoto, Japan. Specifically, the special session will focus on a case study of disaster responses for the 2016 Kumamoto Earthquake that occurred in April 2016. The Geospatial

Information Authority of Japan (GSI), the host of the Sixth Plenary, will provide detailed information on the actions it took in response to the Earthquake, and will share its experiences. The participants will also be expected to join the case study and share their own experiences to find some common denominators on the role of NGIAs in disaster risk management as well as other relatively unique activities that may not be immediately applicable to some countries, but may be considered as important options as their potential roles for the future. GSI will share its activities and experiences for the Kumamoto Earthquake mainly on the types of geospatial information it prepared, the cooperation with relevant authorities and stakeholders, and how the information and data were disseminated in a timely manner. In addition, the GSI's activities will be shared for different phases of disaster, including, preparation phase, onset phase, early response phase, and recovery phase. The results of the special session discussions will be incorporated in the guidelines on the roles of NGIAs in disaster risk management, which are scheduled to be drafted by WG on DRM.

GSI prepared this case story document for the participants of the Special Session as the background information. The participants are expected to read this document in advance to get well prepared for sharing their own experiences and challenges during the session to facilitate the development of the guidelines.

Chapter 1
Background

1.1 Japanese Geography and Natural Disasters

Japan consists of several island arcs that form a part of the circum-Pacific orogenic zone off the eastern edge of the Eurasian Continent. It consists of five relatively large islands – Hokkaido, Honshu, Shikoku, Kyushu and Okinawa from the north, and nearly 7,000 islands around them. Geologically, the country is situated at the eastern end of the Eurasian Plate and the end of the North American Plate. The major parts of archipelago are thought to have been detached from the continent and formed due to the subduction movements of two oceanic plates (i.e. the Pacific Plate and the Philippine Sea Plate) under the two continental plates. Since it is situated at the convergence zone of the continental and oceanic plates, active crustal movements cause approximately 20 % of the world's earthquakes of magnitude 6 or higher in and around Japan. With 110 active volcanoes, constituting nearly 7% of the global total, Japan is also one of the most volcanically active countries in the world.

The Japanese archipelago except Hokkaido is in temperate wet monsoon climate zone, with significant temperature variation in the year and four distinct seasons. The annual average precipitation is approximately 1,700 to 1,800 mm. The weather is hot and humid between June and August due to the southeast monsoon which, in combination with typhoons, causes a large amount of rainfall. In winter between November and March, the northwest monsoon prevails. The continental side of the mountainous backbone of the Japanese archipelago has heavy snow that becomes more than several meters deep in some places, while the Pacific side has a dry climate in winter. Due to the steep and complex landform, temperature and precipitation variations by regions and seasons are significant.

Due to its location on the earth, topographical features, weather and other natural environmental conditions, Japan suffers many natural disasters, such as earthquakes, tsunamis, volcanic eruptions, typhoons, local downpours and heavy snow. Between 2001 and 2010, the annual average number of earthquakes with noticeable tremors was approximately 1,700[3]. It means, using a simple average, tremors large enough to

[3] Source: Seismic intensity database search on the Japan Meteorological Agency website

be felt by people take place approximately five times every day somewhere in the country. Of the 1,036 earthquakes of 6.0 or greater in magnitude that occurred on the globe in the first ten years of the 2000s (2000 – 2009), 212 (20.5%) occurred in Japan[4]. On average, every year 2.6 typhoons that are born above the Pacific Ocean hit the Japanese archipelago.

Economic loss due to such natural disasters is enormous and many precious human lives have been lost. Since 1945, for example, the death tolls were 2,306 in the Mikawa Earthquake and 3,756 in the Makurazaki typhoon in 1945, 3,769 in the Fukui Earthquake in 1948, 5,098, in the floods caused by the Ise Bay typhoon, or Typhoon Vera in 1959, 6,437 in the Great Hanshin-Awaji Earthquake in 1995 and 18,880 in the Great East Japan Earthquake in 2011, and 84, in the landslides caused by the torrential rain in western Japan in 2014.

1.2 Policy and Legal Frameworks on Disaster Risk Reduction

1.2.1 Legal Framework

What kinds of measures have been taken in Japan against such disasters? The Basic Act on Disaster Control Measures was enacted in 1961 as the most fundamental law for disaster management, after the Ise Bay typhoon tragedy in Nagoya region in 1959. It provides the fundamentals of disaster prevention schemes and plans required for the national and local governments, as well as of disaster management and responses[5]. The Act also clearly states that it is the responsibility not only of government agencies, but also of the entire nation to commit to the implementation of disaster management plans, mutual cooperation and other measures. After experiencing the Great East Japan Earthquake in 2011, the Act was amended to take advantage of geospatial information in 2012. It is also noteworthy that the Act mandates municipalities to prepare hazard maps for floods, landslides and tsunamis in their jurisdiction.

The national and local governments have established organizational structures and disaster prevention plans in accordance with the Act. Specifically, the national government has the Central Disaster Management Council (CDMC) led by the Prime Minister with the participation by the Minister for Disaster Management and all other

[4] Excerpt from the Cabinet Office White Paper on Disaster Management 2010

[5] The definition of disasters by the Basic Act on Disaster Control Measures includes not only disasters caused by earthquakes, local downpours and other abnormal natural phenomena, but also accidents such as large-scale fires, explosions and release of radioactive substances.

ministers. The Cabinet Office serves as the Council's secretariat where the development and implementation of Japan's Basic Disaster Management Plan are managed. The twenty four Designated Government Organizations (DGO), including GSI, have developed their respective Disaster Management Operation Plans, which are used in conjunction with the Basic Disaster Management Plan to respond appropriately to disasters. All prefectural (forty-seven) and municipal (more than 1,700) governments have their respective Disaster Management Councils and develop and implement their local Disaster Management Plans.

1.2.2 Policy Development and Enforcement at the Time of Disaster

The response at the time of a disaster in accordance with these disaster management plans at national level is as follows. When a large-scale natural disaster[6] is first reported to the CDMC, the Disaster Management Office will be established in the Prime Minister's Office, and the members of the emergency team, consisting of staff members of the Cabinet Secretariat and relevant ministries, and individual ministries will be contacted immediately to begin the collection of information on the damage and response status. Photos and videos acquired with helicopters and other platforms, and general damage information provided from relevant ministries and public agencies will be compiled by the emergency team at the Office of the Prime Minister.

If large scale damage is reported, Disaster Management Office will be replaced by Disaster Management Headquarters (DMHQ). When DMHQ is established, all cabinet members will be summoned by using all available means. The duties of the DMHQ are: the collection of disaster information from DGOs; the prioritization of the government's policies based on the understanding of the overall situations; and the enforcement of the policies on emergency disaster countermeasures and other matters through the DGOs. When necessary, a government investigation team headed by the Minister for Disaster Management or an initial emergency survey team will be deployed to the stricken areas. DGOs will engage in their respective duties in accordance with the policies adopted at DMHQ. At the same time, individual ministries and organization establish their disaster management headquarters to take

[6] A call for an emergency team is issued when an earthquake with a seismic intensity (on the Japanese scale) of 5 or higher in the 23 special wards of Tokyo and 6 or higher occur in other areas, or when a warning of a tsunami or Tokai Earthquake Advisory Information is announced by the Meteorological Agency.

Seismic intensity (seismic coefficient) (SI) is a scale to indicate the strength of earthquake vibrations. In Japan, SI means the seismic intensity scale of the Japan Meteorological Agency.

necessary countermeasures in a timely and coordinated manner. These initial and emergency responses will be made within two or three hours from the outset of the disaster.

Meanwhile, disaster management headquarters will also be established by the local governments of the stricken areas to collect detailed information on the damage, and conduct rescue and first aid measures for the victims. If the national government deems it necessary to enhance the coordination between the local governments in the stricken areas, an On-site Disaster Management Headquarters (ODMHQ) will be established, with the deployment of a Minister of the Cabinet Office and his or her staff members.

1.2.3 Role of Local Communities

While emergency measures taken by the national and local governments mentioned above including the rescue of victims, the securing of evacuation routes and means, the prevention of secondary disasters, the establishment of shelters, and the supply of everyday commodities are all crucial to save people's lives and their properties, it is often emphasized in Japan that a balanced approach is important on the combination of Self-help, Mutual-help and Public-help. Self-help means protection of people's own lives through improved preparedness and appropriate responses for disasters by the people themselves. Mutual-help means the protection of local community and people living there through enhanced preparedness and appropriate responses for disasters by helping each other with family members, local communities, companies and others in the vicinity. Public-help means emergency rescue and support, and restoration and recovery measures conducted by public agencies, including the police and fire departments. Public-help is limited at the time of a large-scale disaster. While Self-help is the basis of disaster responses, not all people can protect their own lives by themselves. Thus, Mutual-help is reevaluated and promoted to enhance the capacity of disaster responses in local communities, particularly helping vulnerable people, including small children, senior citizens, and disabled people.

After experiencing the Great East Japan Earthquake in 2011 and following disasters occurring frequently throughout Japan, people have been reminded of the importance of disaster management. Disaster drills at community, school and company levels, and inventory of emergency goods such as portable flashlights and food stocks have become very common in local communities because of the elevated awareness of people on the importance of Mutual-help to minimize disaster damage. Furthermore, 2,200 “disaster prevention corps” have been organized in Japanese local communities. Along with the official fire fighters belonging to fire departments, a total of 860,000 disaster prevention corps members now engage in fire-fighting and rescue activities at the community level, ensuring Mutual-help aspects for disaster response.

1.3 GSI’s Role in the Government

GSI, which is one of the expert organizations in the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), conducts survey administration in accordance with the Act for Establishment of MLIT and the Survey Act. With 650 staff members and 86 million US dollars of budget (for fiscal year 2016), GSI itself conducts survey that provides the basis of all survey works (basic survey), and give guidance and advice on public survey conducted by other national government agencies and local governments. As a DGO, it also acquires image data of stricken areas using airplanes, UAV and satellites, analyzes crustal movement by GNSS surveying, and provides acquired geospatial information to relevant government organizations and the general public, at times of natural disasters.

1.3.1 Core Responsibilities of GSI

The three fundamental missions GSI is engaged are “Surveying,” “Portraying” and “Safeguarding” the national land. In “Surveying,” GSI maintains the horizontal and vertical datum in Japan using VLBI and other space surveying technologies. It runs the GNSS Earth Observation Network System (GEONET) [7] as an infrastructure for surveying and real-time positioning. In “Portraying,” it has developed the Digital Japan Basic Map as the basis of all maps and provides it in a variety of media. A web-based online map called “the GSI Map” is one of the most popular media GSI uses to disseminate its products. The GSI Map provides aerial photo images, thematic maps and the latest disaster information and archives (e.g., damage situation maps) in addition to the Digital Japan Basic Map. GSI puts high priority in updating the Digital Japan Basic Map, particularly the transportation networks as soon as they are made available to the public, to ensure that the Map is always ready even for those

[7] GEONET （GNSS Earth Observation Network System) is a continuous observation system consisting of Continuously Operating Reference Station (CORS) at 1,300 locations throughout Japan and the Data Analysis and Management Center at GSI Headquarters in Tsukuba. GEONET is used for the establishment of a high-density and high-precision surveying network and monitoring of crustal movements.

who are deployed on an emergency mission to unfamiliar areas in case of disasters.

1.3.2 GSI's Activities on Disaster Management

GSI developed the GSI Disaster Management Operation Plan in 1996 as a DGO and as one of its missions of "Safeguarding." It stipulates the following operations during normal time, or preparation phase of disaster:

- Development of guidelines and organizational arrangements for disaster management;
- Good management of observation facilities;
- Cooperation and communications with relevant disaster management organizations;
- Strengthening office buildings for disaster resiliency; and
- Improvement of disaster response capacity of employees.

Specifically, GSI provides the following geospatial information and services to improve the disaster preparedness for government organizations and individuals:

- Basic topographical maps as backdrop for creating disaster situation maps;
- Aerial photos which record pre-disaster landscape;
- GEONET data necessary for crustal deformation analysis;
- Thematic maps (e.g. active fault maps, land condition maps, volcanic land condition maps) that serve as basic data for preparing hazard maps and for evaluating disaster risks;
- Provision of virtually all geospatial information on web maps; and
- Management of the National Hazard Map Portal Site in cooperation with the MLIT.

The Disaster Management Operation Plan also specifies the following emergency measures GSI should take once a disaster takes place:

- Establishment of GSI Disaster Management Headquarters;
- Confirmation of the safety of all staff members and their facilities;
- Establishment of a liaison relationship with DMHQ and relevant government offices including MLIT;
- Preparation of geospatial information products including situation maps and their provision to relevant government offices and to the general public; and
- Technical assistance with geospatial information to the Technical Emergency Control Force (TEC-FORCE) of MLIT that is deployed to stricken areas for the recovery of damaged infrastructure.

More specifically, the following geospatial information and services are provided once a disaster takes place:

- GEONET data for 24 hours a day;
- Spatial distribution of crustal deformation detected by interferometric analysis of data acquired by the L-band Synthetic Aperture Radar (SAR) aboard the Advanced Land Observing Satellite-2 (ALOS-2) launched by JAXA;
- Aerial photos taken before and after the disaster;
- Provision of basic topographical maps;
- Five-meter grid digital elevation models (DEM) developed by airborne laser surveying; and
- Production and distribution of situation maps (e.g., Tsunami inundation maps).

1.3.3 Meeting Surge of Demand for Geospatial Information

GSI has a light airplane for aerial photography, which is deployed to take aerial photographs of the stricken areas when a disaster takes place. Then GSI prepares ortho-rectified photos and situation maps prepared by interpreting the photos, and provides them to relevant organizations and the general public.

However, it is sometimes beyond the capacity of the single airplane to take emergency photographs in case of a disaster that affects large areas. GSI overcomes this difficulty by cooperating with the private sector. Since there are manyaerial survey companies in Japan, GSI has established an agreement with the association of these companies on the emergency photography at times of disasters. Such government-private cooperation in photographing enables the prompt acquisition of damage information.

Chapter 2
Outset of the 2016 Kumamoto Earthquake

2.1 Geography of Kumamoto Prefecture

Kumamoto Prefecture is located at the center of Kyushu, which is one of the five main islands constituting the Japanese Archipelago. It is 900 km west-southwest of Japan's capital Tokyo, and 120 km south of Fukuoka City (population: 1.56 million), which is the largest city in the Kyushu Island. The prefecture has a population of more than 1.76 million, of which approximately 740,000 live in its capital city Kumamoto. The main industry is agriculture, and its total agricultural products rank seventh out of 47 prefectures.

A distinctive characteristic of the region's tectonics is the presence of a tectonic zone called the Beppu-Shimabara Graben. Extending 200 km in length and 20 to 30 km in width, it divides the Kyushu Island into southern and northern parts. The GSI's GEONET observation has revealed that the northern and southern parts of the island are moving in opposite directions with each other at this graben. Since this graben is lined with several active faults, consisting mainly of normal faults such as the Futagawa fault, the potential of seismic activities is thought to be high. The Government estimated that the probability of an earthquake whose magnitude is larger than or equal to 6.8 is 18-27% in 30 years. However, the last number of years had seen little seismic activities in this region, which caused the local people and the local governments to become less concerned with the potential risk of earthquakes and to use it as the sales talk to invite investment in the region.

2.2 The First Shock

Since the fiscal and academic years begin in April in Japan, April sees many students who just start their schools, and many people who are newly employed or transferred to new workplaces. Therefore, it is a season when many people are working or studying with a fresh mind, trying to get used to the new environment. Consequently, most schools and workplaces are not usually ready for disaster drills in April.

The people in Kumamoto Prefecture who had little anticipation of earthquakes and little preparation for disasters were shaken by a strong earthquake that took place at

9:26 pm on 14 April in 2016. Its focal depth was 11 km and magnitude (Mj) was 6.5. The SI 7, which is the highest in the intensity scale, was observed in Mashiki Town, 10 km east of downtown Kumamoto. It was an inland earthquake caused by the activity of the Hinagu fault that runs across the western part of the Prefecture from southwest to northeast. The shock was so strong that people could not stay on their feet, and refrigerators and copy machines fell down in Kumamoto City. This earthquake was reinterpreted later as the “foreshock” of the second earthquake of Mj 7.3 that took place on 16 April in less than two days after the first one.

The Earthquake Early Warning[8] terribly sounded from TVs, smartphones and mobile phones, and alarmed people all over Japan who were ready for going to bed. The first report of the earthquake in Kumamoto immediately reached the senior officials and disaster response staff at GSI.

2.3 Initial Response of GSI after the First Shock

Immediately after the foreshock, GSI began its disaster responses consisting mainly of the following:

- Emergency teleconference of senior officials;
- Assessment of damage caused by the earthquake;
- Analysis of GEONET data to detect crustal movements;
- Establishment of communication channels with relevant agencies; and
- Establishment of information management team.

2.3.1 Starting Initial Response

The senior officials and responsible staff members of GSI first set up the Disaster Management Headquarters (Headquarters) consisting of relevant employees of GSI to take special emergency actions collectively to respond to the disaster in a timely manner. Since SI of 7, the highest on scale, was observed and serious damage was expected, the establishment of the Headquarters was informed to Headquarters members’ cell phones via email immediately after the outset of the earthquake. At the same time, this message was used to confirm the availability of the senior officials by asking them to acknowledge the receipt within 10 minutes, a method known as the

[8] The Earthquake Early Warning (EEW) system is a system to issue a warning several to several tens of seconds before the arrival of a large shock after the occurrence of an earthquake. It is a forecast/warning provided mainly by the Meteorological Agency of Japan. Its partial trial operation began in 2004, and the full-fledge operation for most of the country, except for some remote islands, was commenced on 1 October 2007. It is the first system of its kind in the world.

"10-minute rule." [9]

In parallel with the establishment of the Headquarters, the safety of all employees and their family members was confirmed with a safety confirmation system via mobile phones or on the internet. This system is activated in case of an earthquake of a SI of 6- or higher (SI of 5+ or higher in the 23 special wards of central Tokyo). At the time of the Kumamoto Earthquake, the safety of the employees of the Kyushu Regional Survey Department 100 km north of the epicenter was also confirmed with this system.

Then at 9:35 pm, nine minutes after the outset of the earthquake, the impact of the earthquake on the ground including land slide, liquefaction and other land deformation was estimated with SGDAS[10] and shared within GSI, to have common understanding on the magnitude of potential damage caused by the earthquake.

At 10:15 pm (49 minutes after the occurrence of the earthquake), a teleconference was convened with the members of the Headquarters and chaired by the Director General. Director-General of GIS reminded the members of the need to respond to the disaster with a sense of alertness, and requested them to take necessary measures to find out the impact of the damage, including photo shooting with the GSI's airplane, analysis of crustal movements using GEONET data and interferometric analyses of SAR data, operation of DiMAPS[11] and cooperation with relevant ministries and organizations and ODMHQ. Approximately three hours after the earthquake, at 0:30 am on 15 April, the Headquarters convened the second meeting to get the reports on the progress of the activities and make necessary adjustments. Then the third and fourth meetings were held at 7:30 am and 5:00 pm, respectively, on the same day. RSDs of Kyushu

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[9] The 10-minute rule requires that, when the person in charge of disaster management sends an e-mail to notify the occurrence of a serious disaster to the official mobile phones and workplace PCs of the GSI's senior officials and persons in charge of disaster management, those who received the mail must send a blank mail back within 10 minutes to acknowledge the receipt.

[10] The Seismic Ground Disaster Assessment System (SGDAS) estimates the probability of ground liquefaction, slope failure and other types of deformation based on the seismic intensity distribution of an earthquake and by using preset topographical and geological data, and shows the results on maps. At present, information is shared only within the GSI.

[11] The Integrated Disaster Information Mapping System (DiMAPS) has been used by the Water and Disaster Management Bureau of the MLIT, and GSI since September 2015. At times of earthquake, wind, flood and other natural disasters, it can quickly collect disaster and damage information and indicate on the GSI's web map in an easy to understand and integrated manner. The system has been used for collection of information from the sites of disasters, sharing of information with disaster management-related agencies, provision of information to the general public and various other purposes.

and other regions also participated in these meetings via a web conference system. Since the circumstances of the stricken areas kept changing after the earthquake including the frequent aftershocks, it was important to frequently update the Headquarters members on the progress of the activities within GSI and make necessary adjustments. Therefore, the Headquarters meetings were held twice a day, in the morning and early evening, and whenever else necessary during the first few days after the outset of the earthquake.

2.3.2 Taking Aerial Photographs

When the first shock hit Kumamoto, the GSI's airplane was stationed at Miyako Airport in Okinawa, 1,040 km southwest of Kumamoto City in direct distance, for a planned mission of taking aerial photos of the area. In light of the difficulty of deploying the airplane immediately to Kumamoto area, GSI, in accordance with the agreement on emergency photography at times of disaster, contacted the association of private aerial survey companies at 10:30 pm immediately after the first teleconference of the Headquarters to identify companies that will be able to deploy their airplanes to the stricken areas to take aerial photos. Simultaneously, GSI fixed the extent of photographing and shared that information with aerial survey companies at 1:40 am on the next day.

After the daybreak, two affiliated companies began to take oblique photos around the epicenter in Mashiki Town at 7:00 am. Subsequently, oblique and vertical photos of areas assigned to each company were taken. Acquired aerial photo data were sent to GSI, and the oblique photos were posted on the GSI map, GSI's web based online map, at 2:30 pm of the same day. The poor weather in Okinawa prevented the GSI's airplane from taking off immediately after the daybreak. However, by late morning the weather became moderate and it was able to leave there at 11:30 am, and started taking oblique photos around Kumamoto City starting at 3:40 pm.

In addition, the GSI Land Bird team, which was formed to use UAVs for both normal operations and disaster responses, was deployed from the Headquarters to Kumamoto at 10:00 am on 15 April.

2.3.3 Crustal Movement Analysis

Crustal movements that accompanied the earthquake were also analyzed with GEONET data. The check-up of each of the GEONET stations was completed in 83 minutes after the earthquake at 10:49 pm, and the Q3 analysis[12] result of the observation data of the stricken areas was released at 7:30 am and 5:00 pm on the next day. A model of the earthquake fault was also analyzed and released on the GSI website at 1:15 pm. This fault model revealed that a crustal movement of approximately 60 cm in the horizontal direction took place along the fault at the time of the first shock.

2.3.4 Cooperation with Relevant Disaster Management Organizations

In parallel with these activities at the Headquarters of GSI, the Kyushu RSD contacted local authorities of the stricken areas to find out their needs of geospatial information, and provided available existing geospatial information. At 10:00 pm, 34 minutes after the first shock, the Department provided GSI's topographical maps of different scales to the Kyushu Regional Development Bureau of MLIT, which manages infrastructure development in the region, including road and river networks in the Kyushu Region. The Government established the ODMHQ at the Kumamoto Prefectural Government office at 10:40 am in the next morning following the earthquake, and coordinated the efforts made by different government organizations for their efficient operations through sharing the latest needs and ongoing activities of relevant organizations to rescue victims and assess the impact.

For better sharing of geospatial information prepared before and after the disaster within MLIT, GSI also began to provide available geospatial information on DiMAPS at 10:45 pm, 79 minutes after the earthquake. Active fault maps of the Kumamoto region and acquired aerial photos were also posted on the GSI map, which was announced through social networks (e.g., Twitter) at 11:48 pm on 14 April.

2.4 The Second Earthquake: the Mainshock

The disaster response to the earthquake that occurred at 9:26 pm on 14 April seemed to have been set on the right path and making progress thanks to the activities on 15 April. However, a second earthquake with bigger magnitude at midnight did not allow the GSI staff members to have a sound sleep that night.

[12] Q3 analysis is a type of GEONET analysis conducted routinely using observation data of CORSs for six hours and the IGS ultra-rapid products. It is also known as the quick solution. Q3 analysis is conducted every three hours in GEONET.

The new earthquake occurred at 1:25 am on 16 April, 28 hours after the first shock. Due to the larger magnitude of Mj 7.3 than the first shock, the new one exceeded the first one both in the intensity and the extent of damage. While the SI of 7 was observed only in Mashiki Town at the first shock, the same intensity was also observed in Nishihara Village, in addition to Mashiki Town at the second shock. This latter earthquake was also an inland earthquake and was caused by the movement of the Futagawa fault and the northern part of Hinagu fault that triggered the first shock. Since the second shock was greater in both magnitude and intensity than the earlier earthquake, it was later interpreted as the mainshock of the 2016 Kumamoto Earthquake. Accordingly the first shock was called foreshock.

2.5 Reconsideration of Disaster Management after the Mainshock

Immediately after the main shock, SGDAS automatically assessed the potential damage to the ground in Kumamoto region and shared the result of its analysis within GSI at 1:34 am, nine minutes after the earthquake. The fifth Headquarters meeting was held over telephone 54 minutes after the earthquake, at 2:19 am on 16 April. The meeting decided to repeat the emergency procedures as those that were done for the foreshock, including survey of the safety of employees, examination of the functioning of facilities, and renewed arrangements for the aerial photographing by private companies. It was found that nine CORSs in the region had lost the power due to the power outage at that time, though they were able to continue its observation with the battery installed in each station, which has the capacity to support the operation for about 72 hours.

At 6:00 am on 16 April, the sixth Headquarters meeting was convened to share the latest situation after the mainshock within GSI. Due to far greater damage caused by the mainshock, the Director-General of GSI ordered a complete renewal of the response strategy[13] and work plan, and the development of renewed measures as shown below.

＜Renewed measures taken after the Mainshock＞

1) Assignment of personnel

- Full mobilization of available employees and their timely assignment to additional tasks to support the sustainable response operations, including the

[13] As the renewed strategy was presented in the early morning, it was nicknamed “Dawn Policy”

deployment of the personnel to RSDs in Tokyo and Kyushu to keep close contact with relevant disaster management organizations in Tokyo and Kumamoto.

2) Information sharing

・Understanding of the latest situations in the stricken areas and the needs of relevant disaster management organizations.

3) Aerial photography

・Taking aerial photographs of Kumamoto, Aso, Kikuchi and Oita areas early in the morning of 16 April by mobilizing airplane of GSI and private companies based on the prior agreement.

4) Interpretation of aerial photographs

・Discontinuation of photo interpretation of those aerial photographs taken after the foreshock.

・Reassignment of photo interpreters to focus on the new aerial photographs taken after the mainshock

・Analysis of the amount of collapsed sediment caused by the earthquake.

5) CORS data analysis

・Analysis of crustal deformation with the REGARD system[14], including baseline length analysis, S3 analysis[15], Q3 analysis, and vector diagrams.

6) Interferometric SAR data analysis

・Analyses of a series of SAR data observed from different satellite paths of ALOS-2 to detect the spatial distribution of crustal deformation and to decompose the deformation into the horizontal and vertical directions.

7) Shooting videos with drones

・Land slide areas and ruptures that have appeared on the ground surface were videoed with drones.

8) Provision of geospatial information

・Timely preparation of maps, aerial photos, and thematic maps of the stricken areas, and their distribution to relevant disaster management organizations.

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[14] The REGARD system stands for the Real-Time GEONET Analysis system for Rapid Deformation monitoring. It is a system to detect crustal movements instantaneously using real-time data (one-second interval) of CORSs.

[15] S3 analysis is a type of GEONET analysis using hourly observation data of a random duration and IGS ultra-rapid products and conducted mainly in emergencies. It is also known as a very quick solution and is conducted mainly with data for three hours from the viewpoint of stability and accuracy of analysis.

Chapter 3
Emergency Disaster Response Activities

3.1 Disaster Responses after the Mainshock

Analysis of GEONET data with the REGARD system conducted immediately after the mainshock revealed that it caused subsidence up to more than one meter deep on the north side of the Futagawa fault and upheaval up to more than 30 cm high on the south side of the fault. Interferometric analysis of SAR data acquired by the ALOS-2 radar satellite also revealed that, in the horizontal direction, there were lateral dislocations of up to more than one meter long toward the east on the north side and up to more than 50 cm long toward the west on the south side.

The area damaged by the foreshock was struck by an even greater earthquake, which caused destruction and collapse of many houses and slopes over extensive areas and death of 40 people. In the Tateno area of Minamiaso Village, the Aso Ohashi Bridge, which is an arched bridge longer than 200 m in length, collapsed due to a large landslide caused by the mainshock and cut off the main traffic route between Kumamoto City and the Aso Caldera area. Being fully alert to this alarming situation in Kumamoto area, GSI began its disaster response activities in accordance with the renewed strategy. It held the 7th to 10th Headquarters meetings twice a day on the weekend holidays of 16 (Sat.) and 17 (Sun.) April to confirm the damage caused by the mainshock, and check and adjust their operations to the changing situations.

3.1.1 Assistance to Other Organizations

Since requests for damage-related geospatial information from relevant authorities were increasing after the mainshock, GSI provided assistance to ODMHQ and relevant organizations with geospatial information by deploying staff members of RSD-Kyushu there. In order to make this assistance sustainable, staff members of surrounding RSDs were also deployed to RSD-Kyushu as well as ODMHQ.

3.1.2 Aerial Photography and Interpretation

The flight plan of aerial photography after the foreshock was revised to cover the larger extent of the areas possibly damaged by the mainshock. In the afternoon of 16 April, aerial photographs taken from GSI’s airplane for making vertical photograph were transmitted from the airport in Kyushu to the GSI Head Office in Tsukuba via the internet. Aerial photographs were also taken by affiliated companies. Aerial photography of all scheduled areas was nearly completed by 20 April. Ortho-rectified aerial photos were consequently made public through the GSI Map website.

Concurrently, GSI aerial photo interpretation team began its work at 11:10 pm on 16 April to prepare a map of landslides caused by the earthquake, and ended at 3:25 am on the following day. Approximately 12 hours later, at 3:00 pm on 17 April, the first edition of the landslide distribution map was referred to the Sabo (Erosion and Sediment Control) Department of MLIT, which is in charge of landslide disaster management, in order to keep the integrity of government information for the public. The final version of landslide distribution map was then released on the GSI website late in the night of 18 April after incorporating the comments from MLIT.

3.1.3 UAV Imagery

Despite poor traffic conditions due to many unpassable roads immediately after the earthquake, GSI-LB conducted UAV photography on 16 April at the landslide site of the Aso Ohashi Bridge and in the other areas where faults emerged on the ground surface. The acquired UAV videos were released on the GSI website. They were quoted in many newspapers, including the New York Times in the US. Additional videos of cracks on the ground surface were acquired by UAV on 18 and 20 April to provide evidence of the extent of the earthquake faults that are longer than those that had been known before. The result was also incorporated into the compilation of a crack distribution map around the Futagawa Fault, which was also released on the GSI website in the early evening of 20 April.

3.1.4 Geodetic Infrastructure Management

In order to make detailed analysis on crustal movement using GEONET data, the operation status of CORS in the stricken areas had to be checked. The check-up was completed by 9:30am on 16 April, eight hours after the mainshock. Although all CORS were working, nine stations near the Futagawa Faults were initially running with the internal auxiliary battery, which is supposed to last 72 hours only, due to grid-power outages. While six out of nine stations regained the power very soon, the remaining three were likely to stay powerless beyond their battery capacity. In order to keep them operational, solar panels were installed in these three CORSs on 18 April.

Due to the large crustal deformation in the stricken areas and their surroundings caused by the earthquake, the existing survey results including the coordinates of triangulation points, benchmarks and CORSs had to be suspended in order to avoid errors in the surveys. The suspension was announced to government agencies and survey companies throughout Japan at 6:00 pm on 16 April.

3.1.5 Information Provided through the GSI Map

Most geospatial information acquired and created by data analyses in the disaster response activities, including the epicenter of the mainshock, S3 analysis results of GEONET data and aerial photos of the stricken areas before and after the earthquake were provided through the GSI map. When new information is uploaded on the GSI map, it was announced through GSI website with a special banner as well as social network services such as Twitter.

3.2 Applications of Geospatial Information to Address Secondary Disaster Risks

3.2.1 Concerns of Larger Landslides

While the areas around Kumamoto City were still frequently hit by aftershocks even after the mainshock, they also had to endure heavy rainfall of approximately 20 mm between the evening of 16 April and the morning of 17 April, and subsequently more than 75 mm on 21 April. Because the ground had already been loosened by the severe earthquakes and the subsequent aftershocks, it was seriously concerned that the rain water that was seeping into the ground would cause much larger landslides as secondary disasters. The areas stricken by the Kumamoto Earthquake are known to be prone to landslides since it is covered extensively with a thick layer of pyroclastic flows and volcanic ash, which has been accumulated over the years from the past eruptions of Mt. Aso and other volcanoes, and tends to easily collapse with heavy rainfall.

3.2.2 GSI Responses Addressing to Secondary Disaster Risks

Given that the earlier aerial photograph interpretation identified many landslides caused by the earthquakes, the 14th Headquarters meeting on 21 April decided to engage in the third mission of aerial photography of larger areas to cover the potential land slide areas. Specifically, flight plans were developed for 23 areas by using the GSI's airplane and eleven airplanes of the affiliated companies, and a total of approximately 10,000 aerial photographs were taken on 19 and 20 April.

Fortunately, no secondary disasters (e.g., large-scale landslides) were identified with the third aerial photography mission. Meanwhile, these aerial photographs were then used by municipalities (local governments) of the stricken areas for the fast track issuance of disaster victim certificates[16] that prove the status of victims' damaged houses.

In the course of aerial photograph interpretation for landslides, GSI discovered some cracks at the top of a slope in Aso City that were unknown to the rescue teams on the ground and could potentially cause landslide. Therefore, in order to avoid the risk of potential landslide of the slope, which could cause much damage to the community below, GSI immediately transmitted emergency warning information to the ODMHQ at 11:50 am on 21 April. As a result, the Aso City municipality advised the residents of the slope area to evacuate at 2:00 pm.

3.3 Preparation of Shelter Distribution Map

Due to the two large earthquakes, 8,198 houses were destroyed completely, 29,761 were half-destroyed and 138,102 were partially destroyed (Cabinet Office, as of September 14, 2016). Evacuees were compelled to live in shelters prepared by local governments or in their cars. Approximately 180,000 residents were in the shelters immediately after the mainshock. However, the national government's ODMHQ did not initially have adequate information on the distribution, locations and capacities of all shelters, or their needs for supplies, and had extreme difficulty in providing necessary relief supplies to the shelters that needed them in a timely manner, all because it did not even know "where" the shelters were.

The Chief of the ODMHQ, Vice-Minister of the Cabinet Office at that time, took this situation seriously, and requested GSI through its liaison official on 18 April to prepare a shelter distribution map. In response to the request, GSI prepared a shelter database and prepared a shelter distribution map and provided the first edition on 20 April. This map greatly contributed to the improvement of the ODMHQ's access to

[16] Disaster victim certificate: If a building is damaged by a natural disaster, the municipal government issues a disaster victim certificate to its resident after conducting a damage certification investigation of the building based on the request from the resident. The types of certification vary by the degree of damage to the building (e.g., totally destroyed, mostly destroyed, half-destroyed, partially destroyed). The certificate serves as official proof when victims receive housing-related support or claim for earthquake or other damage insurance money.

shelters and of the efficiency in supporting evacuees. Although some of the shelters have been rearranged or abolished since then with the progress of reconstruction of the stricken areas, GSI continued to contribute to the updating of the map based on the latest information on shelters provided via GSI staff members deployed to ODMHQ, until early August 2016.

3.4 Meeting the Needs of Stakeholders

NGIAs are mandated to create, manage and provide geospatial information of the respective countries. In the course of fulfilling this important mission, it is crucial to pay much attention to the needs of users on the products. The same thing is true in disaster responses, and it is more challenging for NGIAs to meet user needs because the situations of the stricken areas change rapidly over time. In the case of the Kumamoto Earthquake, the requests for geospatial information from the ODMHQ and other government offices actually changed much over time. In this connection, it is important to deploy staff members to key disaster management organizations to find out the latest user needs and respond to them in a timely manner. In addition, in order for NGIA's geospatial information to contribute to disaster response activities to protect people's lives, safety and assets, it is important to always confirm what kind of information is transmitted to who and how, and if it is transmitted accurately and at the best timing.

3.4.1 Provision of Geospatial Information to Public Organizations

Established in the Kumamoto prefectural government building, ODMHQ consisted of personnel gathered from various ministries and agencies, working in the same room. GSI deployed two staff members to ODMHQ to liaise with the other ministries and agencies and find out and respond to their needs. They immediately recognized the need of printers to print out maps for the rescue and recovery operations. Based on their suggestion, GSI sent large-format printers to ODMHQ and provided map printing services there. Also, GSI liaisons listened to the needs of the ODMHQ and made necessary modifications to the GSI data before printing maps.

As a DGO, GSI puts the highest priority in meeting the need of the other government offices. Whenever emergency aerial photographs and other geospatial information were newly acquired through its disaster response operations, push-type e-mails containing the URL of the download site were sent simultaneously to relevant government offices, including local governments, police, and self-defense force that have been actively engaged in their operations in the stricken areas. A total of 49 e-mail messages were sent out until 15 July. In addition, GSI responded to 40 requests for geospatial information from public organizations. For example, GSI was asked by the police and the Kumamoto prefectural government to calculate the volume of debris caused by landslides by analyzing aerial photographs to estimate the amount of work to remove the debris in the search of persons who went missing in landslides. GSI also provided topographical maps of Kumamoto with coordinate grids through its RSDs to the counterpart Regional Development Bureaus of MLIT that deployed their staff members to the stricken areas in Kumamoto in order to support their recovery operations on the damaged infrastructure.

3.4.2 Provision of Geospatial Information to Mass Media and the Public

Mass media is one of the most effective channels to disseminate information to people in different sectors and communities in a timely manner, particularly in the case of disasters. At the same time, the journalists working in mass media need to understand the significance of the information before releasing it through their media to make sure that the information will be well understood by the recipients. Since some of the geospatial information GSI provides during its disaster response activities is often technical and may not be easily understood by the recipients, GSI sometimes invites journalists at a press conference to explain to them about the technical details in an easy-to-understand manner, in addition to normal press releases.

It is also important to have other channels to reach out to the general public. Because of the recent infiltration of social network services into the society, it is particularly effective to provide timely information to the general public through social network services including Twitter and YouTube. For example, GSI-LB’s UAV videos have received significantly increased access of more than 250,000 times, once it was tweeted in the Twitter.

3.4.3 Functional Teams for Provision of Geospatial Information

When a large disaster hits the country, the GSI’s guidelines for disaster management stipulates the immediate establishment of specific functional teams, including recording, public relations, information provision support, and emergency map production as to fulfill cross-cutting tasks during the disaster. These designated teams process the requests from relevant stakeholders by providing the geospatial information prepared by GSI in such a way to meet their needs.

Chapter 4
Activities for Recovery and Reconstruction

4.1 Development of a Disaster Response Plan for the Recovery Phase

In the stricken areas, major transportation services were gradually resumed and recovered with the reopening of all Kyushu Shinkansen (Bullet train) lines on 27 April, less than two weeks after the earthquake, and the restoration of expressways for automobile in Kumamoto Prefecture was also on the right track for the reopening by mid-May. Living conditions of residents in the stricken areas were beginning to return to normal, with the power supply completely regained by 20 April, and 90% of water supply recovered by 21 April. While approximately 38,000 people were still evacuated to shelters at the end of April, the disaster operations were moving towards recovery phase from initial emergency phase.

Emergency disaster responses were nearly completed by the end of April. Since efforts by local governments and other organizations were expected to start in full fledge starting from early May, GSI began to plan the preparation and provision of geospatial information that would be useful in the recovery and reconstruction phase. Specifically, it developed plans on the resurveying of triangulation points and benchmarks, and the preparation and provision of maps for recovery and reconstruction measures and elevation data.

4.2 Geospatial Information Necessary for Recovery and Reconstruction

GSI commenced the following processes in early May to prepare and provide geospatial information necessary for the recovery and reconstruction phase in a timely manner:

- Resurveying of triangulation points and benchmarks;
- Preparation and provision of aerial laser surveys and digital elevation models as measures against the rainy season for the areas that underwent subsidence after the earthquake;
- Preparation and provision of basic maps necessary for reconstruction planning; and
- Revision of the active fault maps.

4.2.1 Resurvey of Control Points

The first task that needs to be done before major reconstruction activities is the resurvey of control points, including triangulation points and benchmarks that have been moved by the co-seismic activities of the earthquake. However, there are two questions that have to be answered before actually starting the resurveying project: i) what will be the extent of the areas for resurveying or more specifically, which control points will have to be resurveyed?; and ii) when will be the earliest time to start the resurveying, since the ground was still moving, though slowing down, even after the earthquake due to the post-seismic activities around the faults?

When the CORS system was not available in the past, GSI had to spend many months to resurvey all ground control points that may have been influenced by crustal movement. Thanks to the GEONET, however, GSI is now able to accurately monitor the extent and amount of crustal movement in a few hours. This capability enabled GSI to find the control points that needed to be resurveyed and anticipate when the post-seismic activities would wane.

Based on the amount and extent of crustal movement detected by GEONET, 38 CORSs, 4,169 triangulation points and 296 benchmarks in Kumamoto and four surrounding prefectures had been already announced to be suspended for use at 6:00 pm on 16 April. By monitoring the GEONET data, GSI decided to revise the coordinates of 38 suspended CORSs on 16 June, two months from the mainshock, and identified the control points that needed to be resurveyed. While all 4,169 triangulation points were found to be resurveyed, due to the inaccessibility to the monuments, 116 points were not resurveyed and kept suspended. As for the benchmarks, it turned out only 156 points were found to be resurveyed while the rest did not need resurveying due to the negligible impact of the earthquake. Resurveying works on the ground were outsourced to private survey companies, and new survey results of almost all reference points were provided by 12 September. For those control points that had been placed by local governments, GSI provided transformation parameters to calculate the new coordinates from the original coordinates.

4.2.2 Post-earthquake Aerial Laser Survey

There emerged a concern about the danger of further landslides and floods caused by heavy rain during monsoon season in June and July prevailing Kyushu region. Since ground subsidence caused by the crustal movements of normal fault activities at the earthquake was found in some low elevation areas of the stricken areas, some local governments requested post-earthquake elevation data for measures against potential floods caused by the heavy rain and typhoons. Aerial laser surveying was conducted with a private company and completed on 8 May. A digital elevation model (DEM) was created from the laser data. Then, the newly acquired DEM data was subtracted from the DEM data that was developed by aerial laser surveying in 2005 to prepare height difference data.

The height difference map that shows the height difference between before and after the earthquake was prepared from the height difference data and presented to the mayor of Mashiki Town, who requested the map. On 31 May, the map was also provided and explained to the mayor of Nishihara Village, east of Mashiki town, and other parties concerned. The map was made available on the GSI's web map, for a variety of applications including flood and inundation forecasts.

4.2.3 Basic Maps for Recovery and Reconstruction

Basic maps are one of the most fundamental information we need to have before starting the reconstruction of damaged infrastructures and the communities in the stricken areas. The maps will be used to develop a reconstruction plan, which requires basic "backdrop map" reflecting the post-earthquake geography in the stricken areas. Therefore, the GSI prepared 1:2,500-scale basic and photo maps to be used by the national and local governments as their standard basic maps. These maps were prepared using aerial photographs taken after the earthquake that show the landslides, collapsed buildings and other damage on the ground accurately. The same type of map was also prepared for the tsunami stricken areas after the Great East Japan Earthquake in 2011. The final versions of ortho-photo maps and the basic maps were completed by the end of September 2016 and the end of December 2016, respectively, after simplified preliminary version of both types of maps were provided in June.

4.2.4 Revision of Active Fault Maps

Since new cracks that appeared on the ground after the earthquake suggested that the existing active faults that had been mapped before actually have longer and complex structures, it became necessary to provide the latest active fault information for future urban planning and people's consideration on the places to live in, GSI is currently updating active fault maps in the stricken areas, where the original version of active fault maps was published in 2001, based on the knowledge and geomorphological evidence of related active faults at that time.

4.3 Other Relevant Activities

The Kumamoto Earthquake severely damaged the Kumamoto Castle, one of the most prominent symbols of Kumamoto area, of which the original premise was built around 1470. In its attempt to repair the Castle, the Kumamoto City government requested GSI to develop a detailed 3D model of the Castle with UAVs to record the conditions of collapsed stone walls and other damaged parts. GSI also employed a terrestrial laser system to develop a detailed 3D model of stone walls to identify and record each stone piece which will have to be removed from the stone walls first before the walls are to be reconstructed. The UAV videos were made available on the GSI website and YouTube on 19 May.

During preparation of such geospatial information necessary for recovery and reconstruction, heavy rain exceeding a total of 500 mm that continued in the Kumamoto region between 20 and 30 June caused many landslides as secondary disasters. The rain also caused power outages at electronic reference points and the situation seemed to be back to the emergency response period from the recovery period. GSI took aerial photographs of the area where landslides occurred in cooperation with an affiliated company in early July, and submitted the results of extracting landslide sites in the form of a landslide distribution map to the Sabo Department of MLIT. The map was also made available for the general public on the GSI website with the final update on 27 July.

Chapter 5
Lessons Learned from the Kumamoto Earthquake Response

5.1 Managing Disaster Responses

The Disaster Management Headquarters meetings at GSI were held every day, up to three times a day, since the first meeting held immediately after the foreshock of the Kumamoto Earthquake on 14 April, to keep all staff members on the same page on the situations on the disaster, and to discuss the policies and actions to be taken by GSI to appropriately respond to the disaster, while flexibly updating them in accordance with the changing circumstances of the stricken areas under the leadership of the top management. Replacement of the Director General of the GSI, who is also the Chief of the Disaster Management Headquarters, on 21 June did not make any gap in the leadership on the policies or activities, because the new Director General had been working closely with the former Director General as his Deputy.

As mentioned above, in the case of large disasters, such as the Kumamoto Earthquake, the GSI's disaster responses have been managed by the Disaster Management Headquarters led by the Director General. At the outset of a disaster, the latest situations are shared, and the initial, emergency and recovery/reconstruction policies are discussed and revised at the headquarters meetings. Disaster response activities are conducted in accordance with the policies, and geospatial information that shows the impact of the disaster on the ground is prepared and provided to the national and local governments and other stakeholders for their use in disaster responses in the stricken areas. While GSI usually starts with preparing geospatial information that it considers necessary from the viewpoint of the provider, it is important to find out the needs of recipients/users of the information, and when it finds it necessary, to tailor the original geospatial information to make it meet their needs by establishing a good communication channel with them to keep up with their changing needs.

In managing the disaster response activities, it is also important to improve the way the disaster responses are conducted by reviewing them through the cyclic steps of Plan, Do, Check and Action in each disaster phase and when each cycle of disaster response is completed, by following the PDCA cycle, which is a leading management method for quality control in business activities. It is also useful to find out how the

GSI’s products have been used in different government offices for the future improvements of disaster responses.

Most GSI’s disaster responses for the Kumamoto Earthquake, which started with the foreshock on 14 April, were found to be completed at the 42nd Headquarters meeting on 25 July. In order to find out the potential areas of improvement in the disaster response activities and policies while the memory of the staff members are still fresh, a meeting to review the emergency responses was held on 8 July in advance of the 42nd meeting, in which staff members involved in the disaster responses presented issues and areas for improvements in disaster response operations and procedures. These specific points are to be reflected on future improvement in disaster responses.

When a large-scale natural disaster occurs, it becomes a concern not only of the victims but also of the entire nation, and its progress is covered extensively by TV and other mass media. Under such circumstances, there are high expectations for timely provision of appropriate geospatial information to respond to the needs of the stricken areas and relevant authorities. It is the responsibility of NGIAs to provide the latest situations of the land promptly and present it to the society, while continuously improving its operations in their timeliness and accuracies.

5.2 Conclusion

The above mentioned activities are just one example of disaster responses conducted by GSI. Just after the end of major responses to the Kumamoto Earthquake, three typhoons hit the Japanese archipelago in August caused river flooding and landslides that required another disaster responses.

Although it is impossible to prevent all natural disasters, there are still many things that NGIAs can do to minimize the damage at times of disaster, through preparation and provision of geospatial information. GSI will continue to take thoroughgoing measures based on its experience and lessons learned in past disaster responses while learning best practices of the other countries.