ISSAI 5540

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INTOSAI

Use of Geospatial Information in Auditing Disaster Management and Disaster-related Aid

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Part 1: Introduction

1. Purpose, scope and structure

1.1 Disaster management involves managing the risks of disasters with the aim to reduce these risks and to prepare for disasters if and when they happen. It also includes post-disaster activities (relief and rescue operations, rehabilitation and reconstruction) which aim to address the needs of the affected population. See ISSAIs 5510, 5520 and 5530 for guidance on auditing disaster risk reduction and disaster-related aid. ISSAI 5540 concerns the use of geospatial information in auditing disaster management and disaster-related aid. The purpose of ISSAI 5540 is to explain and illustrate the added value of using geospatial information in audit work. It focuses on the role geography plays in disaster management and how geospatial information can be a useful tool in support of audit work on disaster management.

1.2 ISSAI 5540 also introduces Geographical Information Systems (GIS) as an audit tool and provides practical guidance and encourages auditors to improve and expand on the use of geospatial information in their work. Geospatial information can improve the efficiency and effectiveness of audit work and also help to assess the compliance, efficiency, economy and effectiveness of disaster management. See chapters 4 and 5 and Appendices 4 and 5 to this ISSAI for illustrations of this point.

ISSAI 5540 is structured in five chapters:

1. Introduction
2. Geospatial information and geographical information systems (GIS)
3. The use of geospatial information in disaster management
4. Using geospatial information in auditing disaster risk reduction
5. Using geospatial information in auditing disaster response and recovery

1.3 Chapter 2 introduces the specific characteristics of geospatial information and describes how a GIS can help in analysing geospatial information and how this is done in the public sector. In chapter 3 the use of geospatial information in the various activities of disaster management is described as a stepping stone to chapters 4 and 5, which present the use of geospatial information in auditing disaster risk reduction and in auditing response and recovery activities.

Background information and practical examples are provided in the Appendices 1-5 to this ISSAI:

1. Types of geospatial data and where they can be found;
2. Using geospatial information in the public domain;
3. Using geospatial information in disaster management;
4. Using geospatial information in auditing disaster risk reduction;
5. Using geospatial information in auditing response and recovery.

Part 2: Geospatial information and geographical information systems (GIS)

2. What is geospatial information?

2.1 Geospatial information is information about a specific location on earth, for instance a municipality: the name of a municipality, the number of persons living there, the presence of an industrial area, the characteristics of the surrounding area (e.g. soil, slope, land use), etc. To be able to visualise this information on a map or analyse this information in a Geographical Information System (GIS), information is needed on the specific location of the – in this example – municipality on the Earth's surface (where can it be found?). To define a specific location on the Earth's surface, coordinate systems have been introduced: for instance the metric coordinate system (X and Y, longitude and latitude)[1]. When information is available about a certain location, the information can be linked to that location by using coordinates. For more information on the characteristics of geospatial information, reference is made to Appendix 1.

3. Analysing geospatial information with a GIS

3.1 Decisions are made on the basis of information and often information is needed about a certain location: where to go on holidays, where to build a new school, what is the closest hospital, what is the shortest route to work? Most of the daily decisions can rely on simple maps or route planners. But when more extensive and complex information has to be included in the decision making process, simple maps are not enough. More assistance is needed to handle the quantity of information that has to be taken into account. For this reason software has been developed that helps to store, maintain, visualise, simplify and analyse geospatial data, called Geographical Information System (GIS) software.

3.2 A Geographical Information System (GIS) can be described as a computerised system that facilitates data entry, storage, analysis and presentation especially for spatial (geo-referenced) data. A GIS can assist in decision making when extensive and complex data has to be taken into account. For instance, when a company wants to know where to build a new store it needs information on:

- the distribution of its customers (where do my customers live);
- the infrastructure (can my customers reach the store, do I have easy access to my customers, can I supply my store easily);
- the availability of land (what parcels are for sale, at what price);
- the use of the available land (what type of soil, elevation, what kind of activities are possible and allowed).

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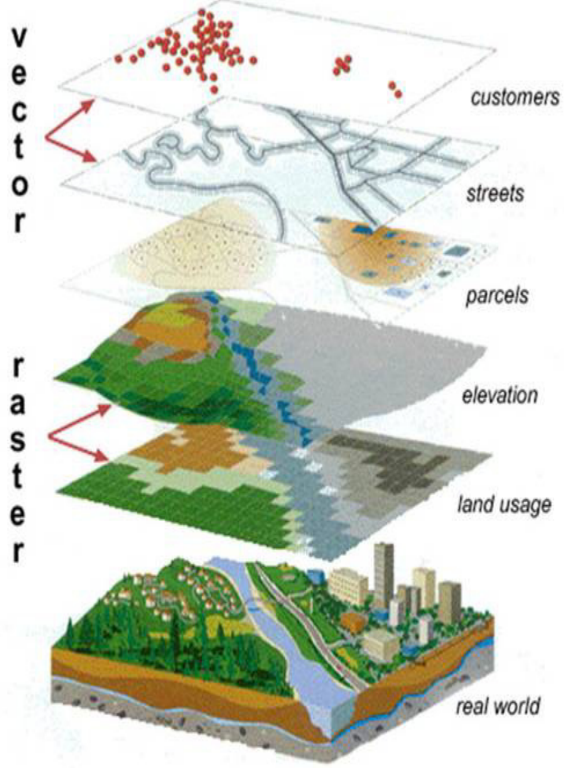
[1] To read more about coordinate systems see Field Guide to Humanitarian Mapping of Mapaction (Mapaction, 2011), Multi-hazard risk assessment (Westen, 2009) and Principles of Geographic Information Systems (ITC, 2004).

3.3 The answer to the question where to build a new store is based on an analysis of various datasets: customers, infrastructure (streets), parcels, elevation and land use. Each dataset represents a layer of information. A GIS is able to answer questions by combining the information in the various datasets, see the illustration below.

Figure 2.1: Overview of a GIS



GIS enables users to store and maintain a large quantity of geographically related information, to visualise and simplify complex data, to create new data from existing data, and to produce high quality maps.

The most powerful aspect of a GIS is that it allows users to perform complex analyses by linking data layers and overlaying different data sets to get a spatial perspective.

Image Source: Univ. of Western Ontario, http://ssnds.uwo.ca

3.4 Just as GIS can assist private companies in their decision making processes, GIS also plays an important role in decision making by public entities. For instance when a municipality wants to prepare itself for a flood, it needs to know where civilians are living, where hazardous economic activities (e.g. chemical plants) are located, how people can be evacuated to higher ground as soon as possible (infrastructure and elevation), what the impact will be of a flood in terms of damage, where to take measures like building dams or dikes, etc.

3.5 In short, a GIS can assist in analysing extensive and complex data by:

- Displaying data spatially (map data: show all schools in the country);
- Spatially querying data by location (map data in a specific area: show all schools in municipality X);
- Analysing spatial locations or relationships (where is the school with most students, what schools is closest to the main bus line, is school Y within a flood risk zone, which schools are within range of air pollution by petrochemical factory Z…?);
- Storing and viewing data as layers (schools and their location, student population, bus lines, flood risk, location of hazardous industries).

4. Use of geospatial information in the public sector [2]

4.1 The use of geospatial information and GIS in the public sector has increased for several reasons. One of the main reasons is the extent and complexity of information that has to be considered and analysed whilst making decisions. Many decisions need geospatial information and a GIS supports the analysis of geospatial information. The use of geospatial information in the public sector has also been stimulated by the increase of computer and server capacity (for storing and handling data) at decreasing prices and the fact that GIS-software has become more customer-friendly. Geospatial information plays a crucial role in the various stages of the policy-cycle: identifying the agenda of a public entity (problem identification), setting policy objectives and formulating measures to be taken, implementing policy measures and finally monitoring and evaluating with the aim of assessing whether the measures taken are implemented and leading to the desired results. The range of policy areas in which geospatial information can be used by public entities is vast: natural resource management, environmental protection, economy, education, security, water management, healthcare, etc. It is also more and more used as evidence in judicial and administrative proceedings.

4.2 Geospatial information is also used in all the activities and stages of disaster management: assessing disaster risks, taking measures to reduce disaster risks, predicting and early warning, assessing damage and needs, executing relief and rescue operations, rehabilitating and reconstructing the affected area. Chapter 3 of this ISSAI (and Appendix 3) describes the use of geospatial information in disaster management in some detail.

5. Use of geospatial information in audit

5.1 Using geospatial information can also provide added value to all stages of an audit: assessing relevant risks, designing the audit, conducting the audit, analysing audit results and communicating audit results. These different stages are briefly discussed below. Chapter 4 of this ISSAI (and Appendix 4) is dedicated to using geospatial information in auditing disaster risk reduction, while Chapter 5 (and Appendix 5) will discuss the use of geospatial data in auditing disaster response and recovery.

Risk analysis

5.2 The audit process starts with a risk analysis to identify where the added value of the audit will be highest. Using geospatial information and a GIS can assist in analysing and assessing risks. GIS makes it possible to analyse various data attributes or layers in a geographical context, which would be difficult or complicated if using only spread sheets. GIS can analyse, for example, the geographical spread of infrastructural projects behind schedule, the use of certain contractors in various regions, the geographical spread of funds allocated, demographic information, etc. Remote sensing data can be used to verify information in administrative

[2] See for a more detailed description of the use of geospatial information in the public sector Appendix 2 to this ISSAI.

databases with information from the field (can infrastructural projects registered as finished actually be seen on satellite or airborne imagery?).

5.3 In many countries natural resources like forests are under pressure of amongst others economic activities, urbanization due to population growth and migration, and pollution. To prevent forests from disappearing governments have taken measures, like restricting economic activities in certain areas by issuing and managing logging rights and restricting access to certain areas by designating these areas as natural protected areas. These measures are taken based on information regarding the state of the forests for which geospatial information is used (also see Appendix 2 paragraph 2.1). When information is available on which areas are protected or for which areas logging rights are issued, then it is possible to match this information with information regarding the state of forests. Combining satellite imagery with administrative data on forestry management can indicate risk areas (for instance deforestation takes place in a protected area), which auditors should look into.

5.4 Below (see paragraphs 5.13 – 5.15) the use of geospatial information is further illustrated by presenting the audit on forestry management, conducted by the SAI of Indonesia[3].

Audit design

5.5 When information is available on risks, geospatial information can assist in designing the audit: deciding on the audit objectives, focus and scope. First of all using geospatial information and GIS can assist auditors in managing the complexity of a topic for which risks have been assessed. This complexity can consist of the variety of data that needs to be considered, but it can also consist of the geographical area that has to be considered: 'A forest can be vast and sometimes barely accessible. Conventional methods cannot be used by auditors when dealing with land on this scale and remoteness.'[4]. The same argument goes for auditing the aid to a wide disaster area, like that of the Indian Ocean Tsunami of 2004. Geospatial information can for example provide insight into the number and geographical spread of housing projects on or behind schedule. It is easier and faster to determine which housing projects are on schedule from a map than from a table with numbers. When the realization of projects versus their planning is mapped, it becomes visually clear which projects should be audited in case a relevant number of projects is behind schedule. It can then be decided to focus on auditing procurement of contractors and managing contracts including supervision. When projects seem to be on schedule it can be decided to audit the quality of houses, occupation rates, infrastructure including water, sanitation and electricity. Furthermore, geospatial information and GIS can be used to select sample sites and the routing of the audit teams. It can also assist in establishing an optimal mix between the various sources of information needed: field visits of

3 INTOSAI Working Group Environmental Auditing (2010), Auditing Forests: Guidance for Supreme Audit Institutions, appendix 2: Using GIS and GPS in Forests Audits, http://www.environmental-auditing.org/Home/WGEAPublications/StudiesGuidelines/tabid/128/Default.aspx

4 INTOSAI Working Group Environmental Auditing (2010).

auditors and for instance remote sensing data of locations where houses have been constructed (to which locations does a team need to be sent to and for which locations can be relied on remote sensing data like satellite imagery?).

5.6 An important activity in the design phase is to decide which data (qualitative and quantitative) should be gathered from which sources to be able to answer the audit questions and realise the audit objectives. In this regard the quality of the geospatial information and its sources should be taken into account (also see Appendix 1 paragraph 2.5).

5.7 When the audit has been designed - by formulating the audit objectives, scope and questions - the implementation can start. Data (qualitative and quantitative) have to be gathered and analysed to see whether it is possible to answer the audit questions and thus realising the audit objectives.

Gathering and analysing audit findings

5.8 The design of the audit determines what kind of data should be gathered from which sources. As stated before, the auditor should be aware of the amount of geospatial information that is already publicly available and of the potential geospatial information that is available in the administration of public entities. “Potential” meaning that geospatial information can be created by linking data to certain locations as is illustrated in Appendix 4 to this ISSAI. Another way in which auditors can create geospatial information is to link their own field observations by geo-tagging these observations. For this purpose, GPS-devices or devices with a GPS-receiver can be used. When an audit team uses GPS-devices and satellite-based maps to link audit field data to their geographical location, it can analyse field data not only at a later stage but immediately when coordinates are uploaded to GPS software and combined with maps. Field data are directly and visibly mapped in a geographical context and could – on the spot – directly lead to more in depth questions with regard to the field observation. For example, when field observations indicate that housing projects are not constructed at the right location the audit team can ask more in-depth questions on the spot about the reasons behind this.

5.9 As stated before, using geospatial information and a GIS make it possible to analyse complex information by making use of its geographical location. When auditors – for instance – want to know if schools have been built in areas where children need schools then various data sets have to be analysed: data on areas affected by the disaster, data on loss of school buildings, data on surviving children and data on the specific locations where schools have been built (like elevation, disaster proneness: closeness to hazards like fault lines, volcanoes and rivers, presence of infrastructure). With a GIS spatial queries can be made that intersect the various data layers by using geography (the location of the information). One of the spatial queries that a GIS can execute is a buffer analysis: which features fall inside a given buffer and which features fall outside. This type of analysis can be used for hazard mapping or for policy measures that are directed at a certain area. See chapter 5 and Appendix 5 for the use of a buffer analysis in a study on auditing houses in Aceh, Indonesia after the Tsunami of 2004.

Visualising and communicating audit results

5.10 Visualisation of audit results – like visualising geospatial information on a map - enables a strong and clear message to the audience of an audit in comparison to solely written words. With the power of visualisation also comes the responsibility for using that power wisely. For instance the use of symbols and colours in a map has a strong influence on how the map will be perceived and interpreted by users: when using red as a colour one should be aware that this will have a negative connotation for the user of the map and thus can stimulate that findings are perceived more negatively. Auditors have to be aware of this and need to know how to present their findings and conclusions in a map without jeopardising their neutrality and objectivity. Furthermore, auditors should be aware when using maps that the audience is not able to immediately check and interpret the data on which the map is based (in comparison to a table). Auditors must be aware of this and make sure that the maps they make or are made under their responsibility follow the same quality criteria as any other form of external communication of the SAI. See the Field Guide to Humanitarian Mapping of Mapaction for some practical information[5] on this.

5.11 With geospatial information different kinds of visualisations can be made. The simplest form is a standard two-dimensional map that will be used in audit reports. Most GIS software packages can publish different file types, like jpg, png, svg and pdf. Besides two-dimensional maps, GIS software packages also have the possibility to produce three-dimensional models. These models are used for mapping elevation (Digital Elevation Model, Digital Terrain Model) of a certain area or the underground structure of an area for mining purposes or for urban planning purposes. The use of three dimensions in a GIS (for analytical and visualisation purposes) has been a recent development that will lead to a number of new possibilities for using GIS, also for auditors.

5.12 Next to static maps, GIS software packages also make it possible to establish and publish interactive maps: maps where the user of the map can create its own visualisations by selecting and analysing data layers. The GIS software packages that enable publishing interactive maps on the internet (webservices) are costly and often require additional investments in hardware (servers). A more simple and low-cost way of providing interactive maps is the use of the geographic functionalities in document reader software, like software to publish and read pdf-files.

[5] Mapaction. (2011). *Field Guide to Humanitarian Mapping*, 2nd edition July 2011. Buckinghamshire: Mapaction, http://www.mapaction.org/?option=com_mapcat&view=mapdetail&id=2426

Case study auditing forestry management with geospatial information

5.13 The SAI of Indonesia has conducted an audit on forestry management in which it used geospatial information[6]. The SAI of Indonesia wanted to know whether illegal deforestation occurred in national parks, conservation areas, wildlife reserves and protected forests. To be able to answer these questions, the SAI of Indonesia gathered data on:

- forest zone determination (which parts of forests are protected and which parts are meant for production: logging or plantations);
- the condition of forests;
- the administrative boundaries of districts and forest areas/zones;
- production activities (for which areas have licenses for logging, plantations, mining, etc. been given and to which companies).

5.14 In the design phase of its audit on forestry management the Indonesian SAI has gathered and analysed information on land coverage, the boundaries of Licensed Forest Companies (hereinafter called an 'LFC'), and the physical boundaries of a forest. This information enabled the auditors to determine whether or not a plantation or mining activity is complying with its license. During planning, a GIS was used to select sample areas to be audited: in which areas of the forest do fires frequently occur and which areas have the highest level of deforestation.
The SAI of Indonesia used multiple data sources for assessing the differences in the state of forest zones in time: administrative data of the Ministry of Forestry, satellite imagery from the National Institute of Aeronautics and Space (LAPAN) and open source information from the Google Earth platform. Based on this analysis the auditors were able to determine whether deforestation has taken place between the beginning of the year and the end of that year and to select areas where indications were strong that the Licensed Forest Companies were not complying with rules and regulations (e.g. logging licences obtained from the Indonesian government).

5.15 The SAI of Indonesia was - with the assistance of a GIS - able to calculate (approximately) the amount of hectares that had been cut in which areas based on the available satellite imagery with high resolution from government and open sources. The selected areas were visited by an audit team to assess whether primary forests were indeed (partly) cut – as was shown on the available satellite imagery. The auditors were able to assess the illegal logging of primary forests during their visit to the selected area for which they used GPS-devices for navigation and to "geo-tag" their observation. By doing this, the auditors were able to display their observations on a map and to match these with the available data on forest condition, logging licenses, boundaries of protected areas, etc.
One of the results of the audit was the evidence that primary forests were replaced by plantations as can be seen in the map below.

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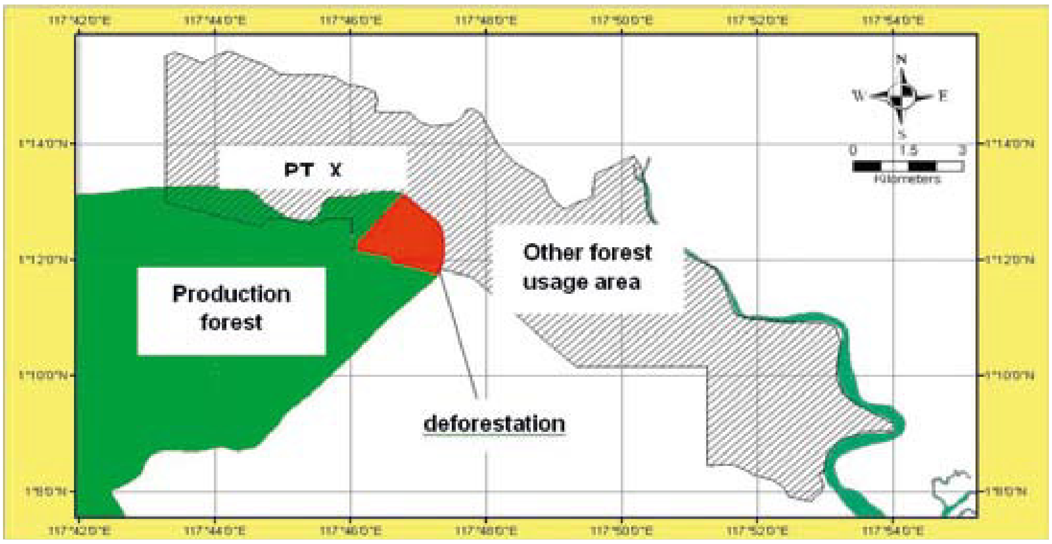
6 INTOSAI Working Group Environmental Auditing (2010). Idem

<u>Figure 2.2</u> - Map of forest usage



Source: SAI of Indonesia

Part 3: Using geospatial information in disaster management

6. Introducing disaster management

6.1 The UN International Strategy for Disaster Reduction (UNISDR) defines disaster as: "A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources[7].

6.2 Managing disasters has evolved in the last two decades from a focus on disaster response and recovery (post-disaster) to a focus on reducing disaster risks. Disasters used to be seen as the result of hazards, defined by the UNISDR as follows: "A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage." (UNISDR, 2009) Nowadays disasters are seen as the result of a complex interaction between hazards, vulnerability and the capacity to cope with the impact of a hazard materialising in an event like an earthquake or flood. "An event such as an earthquake by itself is not considered a disaster when it occurs in uninhabited areas. It is called a disaster when it occurs in a populated area, and brings damage, loss or destruction to the socio-economic system." [8]

6.3 Due to the increased impact of disasters on human society, governments have become increasingly aware that action is needed to enhance the resilience of the people under their responsibility. Governments have also become more aware that the impact of disasters can be managed: although it is not possible to restrain natural hazards, the vulnerability of the population can be reduced. This awareness was the driving force behind the UNISDR's Hyogo Framework for Action 2005-2015 (UNISDR, 2005), a 10-year plan to make the world safer from natural hazards. Disaster risk reduction (risk assessment, mitigation, prevention and preparedness) has therefore become a central part of disaster management. This is illustrated in the disaster management cycle shown below.

6.4 The disaster management cycle (see Figure 3.1) is a conceptual model in which the various stages and activities of disaster management are defined. Various such models are in use. In the following model disaster management activities are clustered in pre-disaster (risk assessment, mitigation and prevention, preparedness), emergency activities (warning, rescue and relief operations, damage and needs assessment) and post-disaster (rehabilitation and reconstruction) phases.

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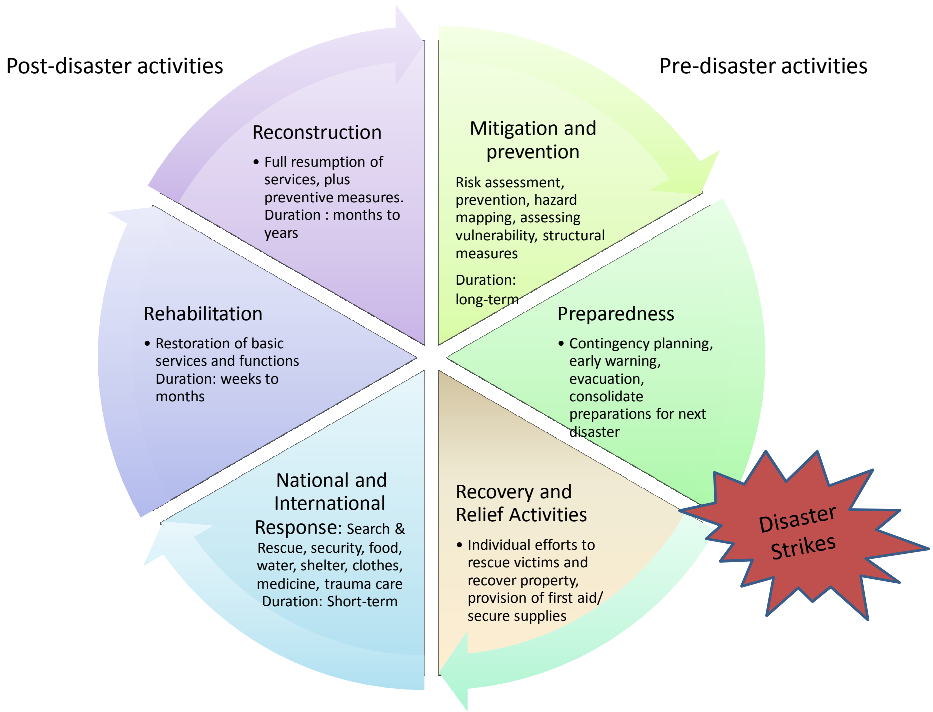
7 UN International Strategy for Disaster Reduction, "UNISDR terminology on disaster risk reduction (2009)", http://www.unisdr.org/eng/terminology/terminology-2009-eng.html, August 2012.

8 Westen, Cees. v. (2009). Multi-hazard risk assessment. Distance education course. Guide book. Enschede: United Nations University – ITC School on Disaster Geo-information Management, p. 1-3.

Figure 3.1 - Disaster management cycle



Source: prepared for the WG AADA by the SAI of Indonesia

6.5 In order to prevent the negative consequences of hazards materialising into disaster events, national governments need to know their country's disaster profile: which hazards are likely to occur, where, when and with what consequences? The conduct of risk assessments is an important step in deciding which measures to take with a view to disaster mitigation and prevention. It also helps in setting priorities: where is vulnerability the highest? Despite such risk-reduction measures, disasters can still occur. Some chains of events are hard to foresee. This was the case with the earthquake that rocked the Sichuan province of China on 12 May 2008. While the earthquake itself killed approximately 80 000 people, many casualties were caused not by the earthquake but by other hazardous events. The earthquake triggered 50 000 landslides in the mountainous areas of the province. Where these occurred in river valleys, they led to 828 landslide dams obstructing the flow of water and causing devastating floods (501 rivers were completely blocked other rivers partially). Twelve "quake-lakes" were created in the affected area. (Gorum et al., 2011) Other harmful events following on from the earthquake included debris flows, city fires and the interruption of lifelines like drinking water and electricity[9].

6.6 Governments therefore also have a role in establishing population early warning systems so that the necessary action (relief and rescue operations, evacuation, etc.) can be taken as soon as

[9] Cees van Westen. v. (2009), p. 3-15, 3-16.

possible. They also have a part to play in raising awareness about disaster risks and how to react in disaster situations; this can be done through education, communication and training (such as simulation exercises).

6.7 When a disaster strikes, it is crucial for public entities to have a common operational picture that can be shared by all the entities participating in rescue and relief operations. This common picture should be based on geospatial information that indicates where damage has occurred (damage assessment) and where immediate, mid- and long-term needs – such as medical assistance, food, shelter, reconstruction of hospitals, schools, infrastructure and houses – are highest (needs assessment). Relief and rescue operations can be coordinated and rehabilitation and reconstruction efforts can be planned on the basis of this common operational picture. In recent years, the international community and countries affected by major disasters have sought to implement major "building back better" programs, the main feature of which is that rehabilitation and reconstruction in disaster-stricken areas should aim at rebuilding societies in a better way than before the disaster occurred. The same objective applies to the rebuilding of societies in areas that are less prone to disasters, and to preventing future events from having the same disastrous effects by reinforcing community resilience and implementing risk mitigation and prevention measures.

6.8 Disaster management should also comprise transparency, accountability, evaluation and audit – just like all activities involving public funds. These four concepts are equally important for the donors of disaster-related aid and for the final beneficiaries (the disaster victims). They are also crucial to learn how to respond better in the event of a future disaster. In 2008, the predecessor to WG AADA, the INTOSAI Task Force on Accountability for and Audit of Disaster-related Aid, published a report on the lessons it had learned for enhancing transparency, accountability and the audit of disaster-related aid from its analysis of the Indian Ocean tsunami of 2004[10].

7. Disaster risk reduction, response and recovery

Importance of geospatial information for disaster risk reduction

7.1 Margareta Wahlström, the UN Special Representative for Disaster Risk Reduction, has characterised the importance of geospatial information for disaster risk reduction as follows: "Each year, disasters arising from storms, floods, volcanoes and earthquakes cause thousands of deaths and tremendous damage to property around the world, displacing tens of thousands of people from their homes and destroying their livelihoods. Developing countries and poor communities are especially vulnerable. Many of the deaths and property losses could be prevented if better information were available on the exposed populations and assets, the environmental factors in disaster risk, and the patterns and behaviour of particular hazards.

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[10] INTOSAI Task Force on the Accountability for and Audit of Disaster-related Aid (2008), Lessons on accountability, transparency and audit of Tsunami-related aid. The Hague: Netherlands Court of Audit, http://eca.europa.eu/portal/page/portal/intosai-aada/home

Increasingly, this information is becoming available with the help of technologies such as meteorological and earth observation satellites, communication satellites and satellite-based positioning technologies, coupled with hazard modelling and analysis, and geographical information systems (GIS). When integrated into a disaster risk reduction approach, and connected to national and community risk management systems, these technologies offer considerable potential to reduce losses to life and property. To do this requires a solid base of political support, laws and regulations, institutional responsibility, and trained people. Early warning systems should be established and supported as a matter of policy. Preparedness to respond should be engrained in society." [11]

Risk assessment data requirements

7.2 The Hyogo Framework for Action stresses the importance of knowledge of the hazards and physical, social, economic and environmental vulnerabilities to disasters that most societies face, and of the ways in which hazards and vulnerabilities are changing in both the short and the long term, so that action can be taken on the basis of that knowledge.
Therefore, information is needed about the hazards that are likely to occur – including their location, the elements that are at risk when hazards materialise into disaster events, the vulnerability of society and the critical infrastructure that will be exposed to the consequences of the disaster. (see Appendix 3, paragraphs 1.2 – 1.4 for further details).

Measures to reduce disaster risks

7.3 Having obtained information about disaster risks, the public entities subsequently need to assess whether it is possible to mitigate those risks and prevent the likely hazards from having a serious impact. It should be clear from the risk assessment where society is most vulnerable to the hazards that are likely to occur. Priorities can then be set for risk avoidance, reduction, transfer or retention[12]. Possible measures may include restricting the habitation of disaster-prone areas, tightening building codes so that buildings can withstand events such as earthquakes and storms, strengthening flood defences, restricting logging to prevent landslides, and informing and educating the population about disaster risks and the action to be taken in the event of a disaster. Where the disaster-prone area is highly urbanised, spatial planning – supported by geospatial data analysis software – is an important part of mitigating disaster risks.

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[11] Joint Board of Geospatial Information Societies and United Nations Office for Outer Space Affairs (2010) , Geoinformation for Disaster and Risk Management. Copenhagen: JB GIS, http://www.un-spider.org/sites/default/files/JBGIS_UNOOSA_Booklet_0.pdf

[12] Cees van Westen (2009), *op. cit.*, p. 7-23; Risk avoidance aims to eliminate risk by modifying the hazard, Risk reduction aims to mitigate the risk by modifying the vulnerability to damage and disruption, Risk transfer aims to outsource or insure and modify the financial impact of hazards on individuals and the community, Risk retention aims at accepting the risk and budget for the expected damages.

Early warning systems

7.4 Despite disaster risk reduction measures, disasters can still occur. An integral part of disaster management must therefore be the establishment of population early warning systems so that the necessary action (relief and rescue operations, evacuation, etc.) can be taken as soon as possible.

7.5 "Early warning systems are intended for the provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response. Early warning systems include the following components:

- Understanding, and mapping the hazard;
- Monitoring and forecasting impending events;
- Processing and disseminating understandable warnings to political authorities and the population; and
- Undertaking appropriate and timely actions in response to the warnings."[13]

7.6 Thanks to the increase in the availability and quality of remote sensing data, it is possible to map different types of hazards and monitor hazard events. Technological developments have increased the availability, reliability and accuracy of short-term disaster warnings, particularly in cases of tropical storms, wild fires, high rainfall, floods, volcanic eruptions, tsunamis and crop damage (e.g. frost, locust plague and drought)[14]. An example of such an early warning system is provided by the United States government's National Hurricane Centre[15]. In addition, global warning systems and platforms for disaster coordination have been set up to support disaster management, like the Global Disaster Alert and Coordination System (GDACS)[16] and the IASC Humanitarian Early Warning Service (HEWS)[17].

Disaster response and recovery

7.7 When a disaster occurs, immediate action is required to assess damage and needs, and to plan and coordinate rescue and relief operations. This is the response phase, defined by the UNISDR as follows: “ The provision of emergency services and public assistance during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected."

For this phase it is crucial to have a common operational picture based on geospatial information that indicates where damage was done, with what consequences and what needs should be immediately addressed.

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[13] Cees van Westen (2009), p. 7-29.

[14] Cees van Westen (2009), ibid.

[15] http://www.nhc.noaa.gov/nhc_storms.shtml.

[16] http://www.gdacs.org/.

[17] http://www.hewsweb.org/hp/.

7.8 This first phase is followed by that of the recovery of the affected area, its population and its assets. The recovery, or post-disaster, phase is defined by UNISDR as follows: "The restoration and improvement where appropriate, of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors."
In this phase the more structural needs of the affected population have to be addressed in the most efficient and effective way. Geospatial information is used for determining where rehabilitation and reconstruction activities should take place. (For further details see Appendix 3 on the use of geospatial information in disaster management, paragraphs 2.2 and 2.3).

During response and recovery, there is a massive need for resources to cope with and overcome the consequences of the disaster. In major disasters, the national response is supplemented by resources from the global community. Geospatial information is therefore used to coordinate the aid and the humanitarian aid organisations that will implement response and recovery activities (also see Appendix 3, paragraph 2.4).

Accountability in the recovery phase

7.9 Given the amount of aid (in cash and in kind) required to address the needs of the affected population, it follows that disaster management should also emphasize transparency, accountability, evaluation and audit – just like for all activities involving public funds. Once a data structure (including geospatial data) is in place it can be used for transparency and accountability, providing information to donors and final beneficiaries on what is being done, where, by whom and with what results. Geospatial information can thus assist in providing assurance that aid has been spent according to the purpose intended and in an efficient and effective way.

Part 4: Using geospatial information in auditing disaster risk reduction

8. Introduction

8.1 Disaster management should be aimed at reducing the disaster risks that a geographical area (country, region, and municipality) faces. Reducing disaster risks decreases the potential impact of a hazardous event, thus preventing damage, injuries and casualties. SAIs have an important role in stimulating public entities to reduce disaster risks and in assessing whether disaster risks have sufficiently been reduced. Geospatial information can assist SAIs in this role and will have an added value for auditing the governance of disaster management, disaster risk analysis and measures to reduce disaster risks. In addition, SAIs could assess the information structure that is in use for disaster management including the information provided with regard to transparency and accountability.
SAIs could also look into the learning loop of disaster management: has past experience been used to further improve disaster management?

9. Qualities required of auditors

9.1 To be able to use geospatial information efficiently and effectively in audits, auditors should have certain qualities: awareness, skills and an open mind.

Awareness

9.2 The main requirement when using geospatial information to audit disaster management is an awareness that hazards, elements at risk, vulnerability and, consequently, disaster risks all depend on a pattern of geographical distribution. Auditors should also understand the approach taken by public and private entities to managing disaster risks and setting up the organisation of disaster management. In most countries, disaster management will be carried out by many organisations at state, regional and local level that need to cooperate and share information in a high-pressure disaster situation. There has been a noticeable shift from public to private responsibility in that private companies are now seen as answerable for their contributions to risk reduction and their capacity to act when a disaster occurs. It is likely that SAIs will be the only bodies with the necessary overview and mandate to assess the performance of the various entities that have a role in disaster management and the interaction between them.

9.3 Auditors should be aware of the vast quantity of geospatial data that are openly available through public, private and voluntary initiatives and can be used in auditing disaster management. Before these data are used, their quality must be assessed. In common with other information and information systems, geospatial data, whether acquired separately or as part of a database, must comply with certain standards regarding their integrity, exclusivity, availability, accountability, confidentiality, efficiency and effectiveness. Also see appendix 1, paragraph 2.5.

9.4 Auditors should first determine what kind of geospatial data to use in their audit. Whether geospatial or otherwise, all data should be relevant to the audit objectives and to answering the audit questions. The next step is to decide on the necessary degree of accuracy of information about geographical locations. Is information required at coordinate level, offering high accuracy (large scale, high resolution: is house X correctly located?); or is information needed at regional or national level (small scale, low resolution: which country has the most high-rise buildings?).

9.5 The dimension of time is also crucial when using geospatial information. In audits it is important to know not only where but also when an event took place. Geospatial information should be available for the right timeframe: is it necessary to specify a day or hour, or is it sufficient to know what happened in year X compared to years Y and Z.

Skills

9.6 Although basic training in geography and geographical information systems can be helpful when using geospatial information, this is not necessary if collaboration on the gathering, analysis and visualisation of geospatial data can be organised with experts from public, academic or private institutions. In the wake of the 2004 tsunami, the SAIs of Indonesia and the Netherlands cooperated with various external experts[18] on a pilot study on auditing housing programmes in Aceh (see chapter 5 and Appendix 5).

9.7 A basic training in using GIS software and GPS devices is sufficient as a first step. Another option might be to participate in existing public-sector training programmes, which would have the advantage of building up a network of geospatial experts who can be consulted during audits. Otherwise, training possibilities might be available at universities, at private companies. When selecting a training programme it is important to be aware of the GIS software that will be used during training, as auditors should logically have access to the same software when conducting their audits.

9.8 A number of commercial GIS software packages are available, as well as several open-source packages[19]. Although with the latter there is no need to purchase software licenses, other costs have to be taken into account, such as the training of technical support staff. When deciding which software to use (and by extension, that for which the auditors shall be trained in), SAIs should inquire which software is used in public sector entities (is there standard software used, public-sector wide?). SAIs should also inquire about the possibilities of participating in procurement processes or standard contracts of public entities directed at acquiring GIS-software and or GIS-training in order to see if they could benefit from these in terms of better prices and technical assistance. Using the same GIS software as other public entities facilitates the sharing of data and participation in training programmes. Finally, when deciding on a software purchase, SAIs should be aware that most GIS packages offer a panoply of functions

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18 Experts from the Rehabilitation and Reconstruction Agency for Aceh and Nias (BRR) and the Faculty of Geo-Information: Science and Earth Observation of the University of Twente.

19 For an overview of open-source GIS software packages, see http://opensourcegis.org/.

that are of little use to auditors. It could therefore be advisable to purchase a "light" version or basic module rather than opting for the full, overly-complex package.

An open mind

9.9 Auditors have to keep an open mind to the various ways they can contribute to improving disaster risk reduction. They have to be open to using geospatial information in auditing governance, risk assessment, and taking measures to reduce disaster risks (prevention and mitigation, communication and education, warning and alert systems). Open mind is also needed to liaise with experts that can assist in auditing disaster risk reduction due to their professional (technical) knowledge and know-how.
As well as looking at the range of disaster management activities, auditors also can use geospatial information in assessing compliance, regularity, efficiency and effectiveness for disaster risk reduction. Due to its important role in disaster risk reduction, auditors should also look into the quality of the (geospatial) data that is needed for and used in disaster management.

Checklist use of geospatial data in audit
What geospatial data is needed to answer the audit questions?
What accuracy is required of the geospatial data?
What is the required timeframe of the geospatial data?
What geospatial data is available?
From which sources can the required geospatial data been derived from and how reliable are they?
What is the quality of the available geospatial data?
What are the costs of the available geospatial data?
If the required geospatial data are not available, could they be gathered as part of the audit process and budget?
Do the auditors involved have the required knowledge to gather and analyse the required geospatial data or should external expertise be insourced?

10. Governance

10.1 Disaster management consists of many activities for which specific expertise is needed, and which therefore rely on specialised organisations (the police, fire brigades, hospitals and doctors, the military, water boards, etc.). Disaster management responsibilities are largely organised at different levels of jurisdiction: State, regional (provinces, districts, counties) and local (cities and municipalities). In practice, therefore, many organisations with specific expertise, mandates, jurisdiction and means will be compelled to work together in disaster situations. For most organisations, when a disaster occurs and this cooperation network is activated, it will not be "business as usual". Managing a real disaster is a highly complex affair.

10.2 This complexity can be functional, but also geographical when geographical or administrative boundaries do not match (are not congruent). When – for example – the administrative boundary of one entity responsible for water safety overlaps with the jurisdiction of two or three entities responsible for disaster management this means that a complex coordination mechanism is needed including agreements on the exchange of information and cooperation in case of a disaster. The administrative boundaries of public entities – often available at the land administration agency, national statistics institute or other public agencies and national geospatial data clearinghouses - can be mapped in a GIS as separate data layers. When these layers are displayed on a map, the geographical complexity of the governance of disaster management can be shown and analysed: where do boundaries overlap or where do many different entities have to cooperate and coordinate in case a disaster happens? A governance risk map can thus be produced that can serve for a more detailed analysis on the measures – like coordination mechanisms and agreements – that have been taken to reduce these governance risks.

10.3 Sound governance is an important precondition for the correct functioning of all stages of disaster management. When the governance structure is highly complex, it leads to high risks regarding the efficiency and effectiveness of rescue and relief operations in the first phase after a disaster happened. Auditors can make a major contribution by paying attention to the design of the governance of disaster management when auditing disaster risk reduction. Use can be made of evaluations of the handling of earlier crises or disaster situations in order to identify any signs that governance is not properly designed. Such signs might include the lack of congruence between entities that are compelled to cooperate and share information by virtue of their disaster management responsibilities. To facilitate analysis and communication, this incongruence can be shown visually on a map as is illustrated in Appendix 4.

10.4 Another precondition for effective disaster management is the allocation of sufficient funds to the necessary activities. By mapping the distribution of disaster management funds and how those funds have been spent, it is possible to estimate the risk of insufficient resources or inefficiencies. For example the distribution of available fire fighters can be mapped for each jurisdiction as is illustrated in Appendix 4 and can be related to the number of inhabitants and number of events.

Maps and analyses of this sort are also useful for comparing the number of incidents or disasters with the number and performance of staff (e.g. the time taken to arrive at the scene). By factoring the funds available into the analysis, it can be seen whether more funds also lead to better performance (efficiency and/or effectiveness).

10.5 Governance is all about setting the rules on who does what, where and when. Owing to capacity shortages, in many countries there has been a shift from full public responsibility to shared public-private ownership of safety and disaster management, with private companies becoming answerable in accordance with the principles of self-regulation. As a result, public entities depend on the activities of private companies for disaster risk reduction and response. Public entities therefore need to verify that companies are taking the necessary measures by, among other things, performing inspections of plants and sites. Auditors could make use of geospatial information on the location of hazardous industries by comparing this information with the number of site inspections made. It could then become clear whether the chance of being inspected is greater in some regions than in others.

11. Disaster risk assessment

11.1 Disaster risk assessment can be divided into three steps: assessing which hazards are likely to occur (as well as where and when), what elements are at risk when a hazard materialises into an event (e.g. earthquake or flood), and how vulnerable those elements are (can they withstand or cope with the consequences of the event). Auditors must have an understanding of the degree to which a country or region (where applicable) is prone to disasters, and where exactly disasters may occur. Equipped with this information, they can assess whether the competent authorities have made an appropriate risk assessment and whether risk prevention or mitigation measures are adequate. As disaster risks arise through the combination of hazards, elements at risk and vulnerabilities at a given location, geospatial information can provide an idea of the geographical distribution of risks.

Hazards

11.2 Information on the geographical distribution of hazards is available on a number of websites, including Munich RE's Nathan World Map of Natural Hazards[20], the UNISDR Global Risk Data Platform[21] and national online mapping tools. Other sources that can provide information about the hazards that are relevant for the auditors' country are the archives of institutes monitoring meteorological events (cyclones, heavy rains), earthquakes, floods, etc., and those of bodies like the Humanitarian Early Warning Service, which provides a calendar of hazards at country level based on historical data[22]. This calendar combines the most authoritative information on major seasonal hazards, such as floods, droughts, cyclones and locust swarms, with crop growing cycles and rainy/lean seasons. The information provided includes details of seasons and staple crops, a list of the main historical events in a given area and the number of people affected, and a list of areas most commonly affected together with the potential damage to crops when a natural disaster occurs. Newspaper archives are another valuable source of information on the hazards that are likely to occur in a specific country or region.

11.3 In appendix 4 a table is provided, in which disasters are classified by main causal factor[23]. This may assist auditors in assessing which hazards are relevant for the area under their mandate and for which hazards public entities can and have to take measures reducing their risks.

11.4 Knowledge about the relevance of hazards is useful not only for audit purposes, but also for ascertaining whether the public entities that are responsible for disaster management are fully aware of the situation. When considering hazards it is important to take account of the situation on the ground, but also above ground and underground. The presence in a country of

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[20] http://www.munichre.com/publications/302-05972_en.pdf [registration is required].
[21] http://www.preventionweb.net/english/hyogo/gar/2011/en/what/rdp.html.
[22] http://www.hewsweb.org/hazcal/.
[23] Cees van Westen (2009), p. 1-8.

underground natural resources may induce a number of hazards, as mining activities may have altered the structure of the subsoil, bringing the risk of instability or collapse. Also gas and oil fields may present a high risk of explosion if mining activities are not properly managed.

Furthermore, auditors should be aware that one hazard could lead to another resulting in a complex cause-and-effect process that is difficult to predict. See paragraph 6.5 which describes what additional hazardous events were provoked by the earthquake in Sichuan, China.

Elements at risk and vulnerability

11.5 Once the nature and location of hazards have been assessed, the next step is to determine whether, in the hazard-prone areas, there are any elements that would be at risk should a specific hazard materialise into a disaster event. A distinction can be made between various types of elements at risk from hazards: buildings, transportation networks, lifelines (water, electricity, communication), essential facilities (emergency shelters, schools, hospitals, fire stations, police stations), population, institutions (government, socio-economic strata, (sub)cultures), economic activities and environmental elements[24]. Next, auditors should look into the spatial distribution of the vulnerability of elements at risk and the measures governments are taking to reduce that vulnerability.

11.6 Auditors could gather information about these elements from open sources (Google Maps, OpenStreetMap, online risk mapping tools, etc.) or from closed sources to which they have access (information held by land administration agencies, national statistics institutes, etc.). They could then select elements at risk in order to assess their vulnerability to the consequences of a hazard event. For example, it could be examined whether building codes are set to minimise vulnerability and are complied with, especially where vulnerable groups (children in schools, hospital patients) and essential facilities (emergency operation centres, fire and police stations) are concerned. In many countries, vulnerability varies by sector or population. As stated above, the urbanisation rate has increased markedly in certain areas of the world, leading to scarcity of land and thus to large resident populations in hazard-prone areas (such as steep hillsides at risk of landslides). As part of assessing the disaster risk, it is important to know how the population is distributed (in space) across the hazard-prone area. This distribution will also vary (in time) according to the time of day, especially in urban areas, where people move from home to work and school, and back at the end of the day. Both time and space should thus be taken into account, as well as the ability of certain groups of people (such as the elderly, children and hospital patients) to evacuate the disaster zone.

11.7 Auditors should also look into the vulnerability of essential facilities that provide services to the community and must be restored to functionality after a disaster event. Essential facilities include hospitals, police stations, fire stations and schools (for providing shelter). Auditors

[24] Cees van Westen (2009), 4-2.

should assess whether essential facilities are at (high) risk with regard to hazards whether they are registered and mapped and whether their location has been made known to all the entities with responsibility for disaster management and to the affected community.

Furthermore, auditors should look into high potential loss facilities, facilities that are likely to cause heavy losses if damaged by a hazardous event, such as an earthquake. They include nuclear power plants, dams, military installations and hazardous industries. If, for example, a dam bursts in the event of an earthquake, it may cause catastrophic flooding downstream. Severe damage to a nuclear power plant or hazardous industry could lead to massive secondary emissions of dangerous toxic or radioactive clouds. This was the case in Japan in 2011, when the tsunami caused by a major earthquake severely damaged the Fukushima nuclear power plant.

Geospatial data infrastructure

11.8 Disaster management activities depend on the availability of comprehensive information, including geospatial information. As part of an audit of disaster risk reduction and of disaster response (relief, rehabilitation and reconstruction), auditors could look into the quality (also see appendix 1 paragraph 2.5 and Appendix 3 paragraph 1.1) of the information structure that the various entities are using. They could assess whether the information structure conforms to the 10 "key points" formulated by WG AADA in relation to the situation in Haiti:

- Up to date geospatial base dataset: coordination will be improved if all agencies are using the same base data set, comprising regular coordinate system, data on infrastructure, administrative boundaries, etc;
- Reliable, stable, and precise geospatial information of projects: project locations clearly identified with GPS derived coordinates will reduce location errors and enable efficient overview of all activities;
- Aid management and tracking systems driven by coordinate based geospatial data: enables easier project identification, reduces errors and confusion typically associated with name based location systems, and supports activities and coordination at international or agency levels;
- Integration of geospatial data in accountability reporting; knowing where the support went shows gaps, overlaps, possible monopolies of contractors or local fraud;
- A longer-term (5-7 years) commitment to the acquisition of geospatial data: will assist in providing information on efficiency and effectiveness of the aid in the longer term;
- A one-stop-shop data delivery mechanism: will allow for efficient, effective and timely data distribution to the aid community, since disaster response is dynamic and time critical;
- Data delivery mechanism open and accountable to data providers, donors and humanitarian aid organisations;
- Data availability known to humanitarian aid organisations; humanitarian aid organisations can only use data if they know if and where it is available;

- Freely accessible geospatial data: access to the geospatial data at no cost, or data reproduction cost only, with unrestrictive licensing so the aid budget is not wasted on paying for the same data multiple times;
- Collected data supported by complete accurate information about the data: Without accurate, consistent, metadata the geospatial data is only useful to the creator of the data and cannot be shared

11.9 One of the main challenges in the wake of a disaster is the need for a suitable register of property and land. If there is no such register, it will be difficult to identify victims and distribute aid effectively. Many victims' rights are not well protected, so that they lose those rights when a disaster occurs and destroys their homes or the land on which they work. Auditors could look into the rights of people living in hazard-prone areas, and the way those rights are formalised and registered. Auditors should also look into the reliability and completeness of registers containing data on the population (census registrations for example). Especially for highly urbanised areas that often have many people residing in informal dwellings for which no reliable data are available this could hamper risk assessment and deciding on measures to reduce disaster risks. Geospatial data – like satellite and airborne imagery – can assist in assessing the number of houses and people living in such dwellings[25]. Auditors can assess whether public entities are using available methods – like remote sensing – for assessing the elements at risk in informal dwellings.

11.10 The results of the auditors' risk assessment could be compared with the results of risk assessments conducted by public entities. Risks that have not been taken into account (a vulnerable group has been overlooked, or underground hazards have been ignored) should be signalled. Risk assessment also implies identifying measures that should be taken to reduce the greatest risks. Based on their own assessment, auditors could assess whether the authorities are implementing those measures. Some hazards, such as tropical storms and heavy rains, recur with a certain frequency. When these hazards lead to disasters, it could be argued that too little was done to reduce the risks. It could even be argued that, owing to the lack of appropriate measures (evacuating people from hazardous areas, enforcing flood protection, etc.), such disasters are man-made rather than natural. Auditors can make an important contribution by signalling measures that must be taken to reduce the risks posed by recurrent hazards.

12. Measures

12.1 When disaster risks have been assessed, the following step is to take measures to reduce disaster risks. Due to scarce capacity in terms of funds, staff, materials, etc. priorities have to be set: often not all risks can be reduced, so choices have to be made. These choices will also depend on the risk strategy and/or risk culture of a specific country, area or public entity: is there a preference for eliminating risks (risk avoidance) or for accepting risks and save for expected

[25] European Union and World Bank (2011), *Using high resolution satellite data for the identification of urban natural disaster risk* . Washington: Global Facility for Disaster Reduction and Recovery.

damages (retention of risks). Furthermore, choices will depend on the type of hazards a country/area is prone for: certain hazards can be altered by taking measures (for instance constructing dikes and levees to prevent flooding), other hazards cannot be altered – like earthquakes or tropical storms – and measures then should be directed at reducing vulnerability of the elements at risk. See table below for an overview[26].

Table 4.1- Different risk strategies

Strategy	Objective	Measures
Avoid risks	Eliminate risks by modifying hazard	Constructions of dams, dikes, levees
Reduce risks	Mitigate risk by modifying vulnerability to damage	Urban and land use planning, building codes, disaster management, early warning, training, information and education
Transfer risks	Outsource or insure financial impact	
Retent risks	Accept risk and budget/save for expected damages	Disaster fund

12.2 Based on the results of disaster risk assessment (risk maps) auditors can assess whether public entities take measures to reduce the disaster risks that have the highest priorities in terms of vulnerability to the impact of hazardous events. This can be done by comparing risk maps with the geographical location of measures taken. Where auditors see a mismatch of risks and measures taken, they could flag this out by using maps.

Auditors should also assess whether public entities and/or private entities comply with intended measures: for instance, assessing whether constructors are complying with building codes in areas prone to earthquakes. Auditors would need technical knowledge regarding construction to assess this, knowledge that often goes beyond the regular knowledge of auditors. For this reason, technical experts could be consulted. Compliance with for instance building codes could also be audited by looking into activities of public entities to assess compliance themselves, for instance inspections looking into construction works. Auditors could for instance map the geospatial distribution and frequency of inspection activities and match that with risk maps: are the areas with the highest risks inspected?

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[26] Cees van Westen (2009), p. 7-23 - 7-27.

Checklist for auditing disaster risk reduction[27]

What information is available on the hazards for the area of interest?
What hazards are relevant to the area of interest?
What elements are at risk when hazards materialize into an event?
How vulnerable are the elements at risk?
What measures can public entities take to reduce disaster risks?
What measures have they taken?
What is the quality of the information used by public entities to assess disaster risks and take the necessary measures to reduce risks?
Are the jurisdictions of public entities that have to cooperate regarding disaster management congruent?
Have the available means for disaster risk reduction been distributed according to the priorities resulting from risk assessment?
Have activities of public entities been directed at high priority areas?

[27] Reference is made to ISSAI 5510 Auditing disaster risk reduction that provides a more extensive checklist for auditors.

Part 5: Using geospatial information in auditing disaster response and recovery

13. Introduction

13.1 When a disaster has happened, response activities immediately have to be undertaken. In this first phase search and rescue activities, assessing damage and immediate needs and preventing other hazards like the outbreak of fires, landslides and diseases have a central place. The next phase - after the situation is fairly stabilised- is directed at rehabilitation and reconstruction of the area affected by the disaster. For both phases resources (aid) are needed (cash and in-kind). Depending on the capacity of the local and national government, these resources can come from national or local sources or from international sources. The international response to the needs of the countries affected by the Indian Ocean Tsunami was for instance enormous: an estimated 14 billion US dollars were gathered and made available to the affected countries[28].

13.2 The aid or resources for disaster affected areas can be seen as a geographical movement from a source (donor) to a destination (recipient) and a flow of information from recipient to donor. These resources will consist of public and private funds. Donors and recipients of these resources want assurances on the following questions:

- Have the resources pledged been provided (trust)?
- Have the resources provided been spent on its intended purpose and in conformity with rules and regulations (regularity)?
- Have the resources provided been spent in the most efficient way (efficiency)?
- Have the resources provided been spent in the most effective way (effectiveness)?

13.3 These questions cannot be answered without an audit trail. Geospatial information can assist in constructing such an audit trail by providing insight in damage, needs and the measures taken to address the needs of the affected population. Furthermore, disaster-related resources are intended for a specific area in which needs must be addressed. The efficiency and effectiveness of aid is largely dependent on the geographical context, for example: infrastructure, impact of disaster, demography, soil characteristics, etc.
Geospatial information thus should be used to plan, coordinate and monitor disaster-related aid in order to prevent waste, duplication, harmful competition between aid organisations, fraud and corruption. It should be an integral part of the information structure that is in place for disaster management as was stated in the previous chapter.

13.4 Furthermore, geospatial information can assist auditors in auditing the response phase. It could enable more efficient and effective audits as was concluded by the Task Force on the Accountability for and Audit of Disaster-related Aid established in November 2005 by the

[28] INTOSAI Task Force on the Accountability for and Audit of Disaster-related Aid (2008).

Governing Board of INTOSAI. This conclusion was based on a field study on auditing housing projects in Aceh, Indonesia in which the potential use of geo-information for auditing disaster-related aid was studied. This field study was followed by another field study carried out in 2010 in Pisco, Peru by the successor of the Task Force, the WG AADA of INTOSAI. For a more detailed description of these field studies, reference is made to appendix 5.

14. Auditing the disaster response phase

Observing response activities

14.1 In this first phase of responding to the impact of a disaster auditors should take a prudent role to prevent interfering with relief and rescue operations. Auditors should make sure that they create a strong information position in this phase to be able to audit recovery activities in a later stage. This can be done by sending auditors into the field for observing relief and rescue operations as was done by the SAI of Peru in the aftermath of the earthquake in Pisco. Selecting the areas to which auditors are sent must be thoroughly prepared based on official information from the authorities, but also other sources must be used like websites of international organisations, the press and platforms open to the general public on which information from the ground situation can be uploaded: Ushahidi, OpenStreetMap and Google Earth for instance. Also see Appendix 3 paragraph 2.4.

14.2 Based on these information sources auditors can identify where damage has occurred and which part of the population is affected most. This assessment can assist auditors in setting high priority areas that can be selected for sending in auditors. One of the criteria for selecting these high priority areas is the availability of reliable data about the post-disaster situation: is it safe, is there sufficient infrastructure to reach the area, etc. Satellite imagery provided under the International Charter (see appendix 3 paragraph 2.2) can assist auditors in this information need.

14.3 Before auditors go into the field for monitoring and observing the post-disaster situation it is recommended they bring equipment which enables them to take pictures and video. Moreover, it is recommended to bring GPS-devices or instruments like mobile phones and tablet pc’s that have a GPS-receivers in order to “geo-tag” pictures and videos. Geo-tagging makes sure that the observations are linked to their location and thus can be mapped at a later stage. See for practical guidance on the use of GPS-devices the Field Guide to Humanitarian Mapping of Mapaction[29] and Appendix 5.

14.4 When arriving at the disaster affected area auditors can have a direct added value while monitoring relief and rescue operations. With their presence they can contribute safeguarding that no affected groups are excluded from assistance. Auditors can observe processes linked to logistics (transportation, distribution, storage) with the aim to safeguard efficiency and

[29] Mapaction. (2011).

effectiveness but also to prevent fraud and corruption. Fraud and corruption are likely to occur in situations where many resources are made available in a chaotic situation with less supervision and control than normal.

15. Auditing the disaster recovery phase

Assessing quality of information structure

15.1 As stated in the previous chapter, planning and coordination is a crucial element for assuring the efficiency and effectiveness of relief and response activities. The success of planning and coordination depends on a strong information position. Geospatial information plays a crucial role in linking information about damage, needs and measures taken to address those needs to the relevant location. Auditors should therefore look into the quality of the geospatial information that is used for planning and coordination. For quality criteria reference is made to paragraph 11.8 which describes the 10 keys points formulated by WG AADA and to Appendix 1 paragraph 2.5.

15.2 The geospatial information used for planning and coordination should be an integral part of an information structure like a disaster management information system (DMIS) as was described in Appendix 3 paragraph 1.1. Geospatial information enables transparency and accountability with regard to the efficiency and effectiveness of the resources used for rehabilitation and reconstruction by linking financial information (funds and expenditures) and project information (purpose, targets, performance indicators) to the relevant location.

Assessing the quality of Post Disaster Needs Assessment

15.3 Before selecting specific activities (projects directed at rehabilitation and reconstruction) to audit, it is important for auditors to assemble a complete as possible overview of the damages, needs and resources available to address those needs. Often auditors can use the Post Disaster Needs Assessments (PDNA) that are made to assess the total resources needed for rehabilitating and reconstructing the affected area. If a PDNA has not been made, auditors have to gather information themselves about the damage, needs and resources available to be able to select activities for their audit. For this they should use various information sources including information from sources other than official authorities (see paragraph 14.1). Auditors could look into the information structure that was used for developing the PDNA as was described in the previous paragraph. Regarding geospatial information it is important that auditors assess whether various sources of geospatial information were used in the PDNA, because every source has its limitations with regard to the reliability of the information they produce. Moreover, auditors should establish whether no specific groups have been excluded or not fully taken into account in the damage and needs assessment. Damage and needs assessment maps can be compared with the PDNA by auditors to assess this. When auditors find that specific groups or areas are misrepresented in the PDNA they can flag this out.

Post-disaster needs assessment in Haiti

15.4 On 12 January 2010, Haiti was struck by an earthquake that killed between 217 000 and 230 000 people and severely damaged buildings and infrastructure. A damage assessment was carried out by a number of international organisations[30] and was based on multi-source data obtained from various sources, including Google, the US National Oceanic and Atmospheric Administration (NOAA) and private suppliers of satellite data. Advances in information technology, social networking and "crowdsourcing" techniques (e.g. OpenStreetMap, see Appendix 1 paragraph 2.3) played a crucial role in both developing the data and assessing the damage. An important role was played by a network of over 600 engineers and scientists representing more than 60 universities in 23 countries, 18 governmental and non-governmental organizations and more than 50 private companies (Global Earth Observation – Catastrophe Assessment Network, GEO-CAN) in the damage assessment of the Haiti earthquake. GEO-CAN succeeded in identifying around 30 000 severely damaged structures, all in less than a week, using very high spatial resolution aerial photos.

In order to validate these results, and to extrapolate the information for lesser degrees of damage (which are difficult to identify from aerial photos), strategic, targeted field campaigns were carried out. By using estimates of average floor area for different categories of ground occupation, it was concluded that over 26 million m² of building area was affected, of which around a third would have to be repaired or even replaced completely. The total cost of repairs was estimated at around US$ 6 billion, according to the UNOSAT-JRC-World Bank/ImageCat report (Government of Haiti, 2010).

Selecting projects to audit

15.5 When rehabilitation and reconstruction activities are being carried out, auditors should assess whether they are carried out according to planning and budget, in line with applicable regulations, and whether the intended output and outcome is realised. When information with regard to rehabilitation and reconstruction activities is available including information about the location, it can assist auditors in selecting activities or areas where risks regarding fraud, corruption, efficiency and effectiveness are highest and therefore attention of auditors is required. Auditors can display the progress of activities on a map. Furthermore, they can use information about rehabilitation and reconstruction activities to display gaps between damages, needs and activities to address the needs. The geographical distribution of recovery activities could also be displayed to show that certain areas are over represented and others under represented.

15.6 Auditors should not solely rely on information provided by public entities that are responsible for disaster management. They should verify the information provided by matching it with information from other sources and by going into the field and make observations on the

[30] The UN's Institute for Training and Research (UNITAR) and Operational Satellite Applications Programme (UNOSAT), the Joint Research Centre (JRC) of the European Commission, the National Geospatial Information Centre (CNIGS) representing the Haiti Government, and the World Bank (WB).

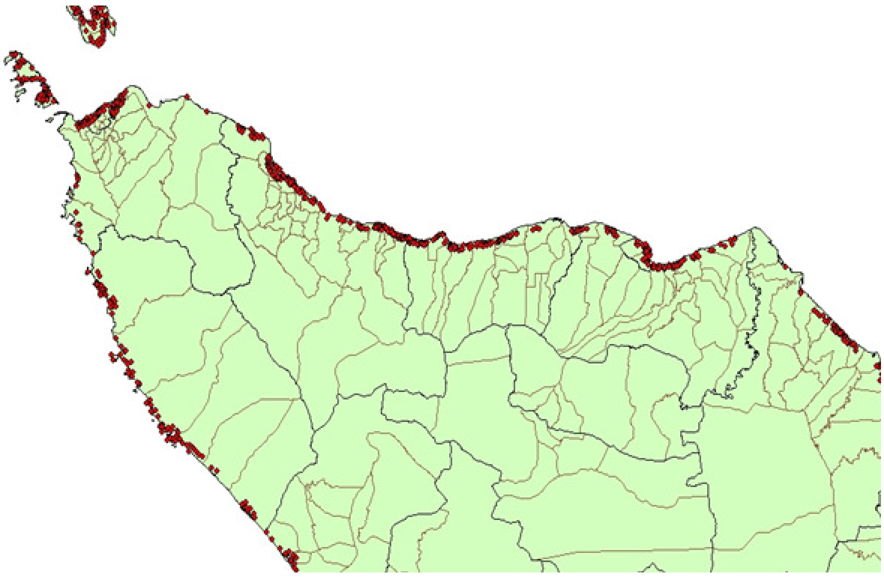
ground. In its field study regarding the audit of housing projects in Aceh, Indonesia the INTOSAI Task Force AADA used an analysis that compared the situation before and after the tsunami based on satellite imagery. See Appendix 5 for more information. Auditors can also use information from open sources, like Google Earth, Ushahidi and OpenStreetMap to conduct their own comparison between the pre and post disaster situation as was done in the WG AADAs field study regarding the reconstruction of Pisco, Peru as illustrated in Appendix 5.

15.7 Also pictures and videos that are uploaded on these open platforms provide information about the situation on the ground and could provide auditors with relevant information for selecting areas where progress has not been made according to planning for instance.

15.8 In its field study on housing projects in Aceh, Indonesia the INTOSAI Task Force AADA looked into a number of housing projects that were carried out in the coastal zone of Aceh. The Indonesian government issued a decree stating that houses destroyed by the Tsunami could be rebuilt only at locations more than two kilometres behind the coastline. This was to prevent damage and loss of life should a new Tsunami strike the coast of Aceh. The Agency for the Rehabilitation and Reconstruction of Aceh and Nias (BRR) had to comply with this decree. Organisations building houses with overseas grants did not have to.

15.9 When the available Topographic Land Map and the housing data from the DAD were combined, it was possible to map all settlements within two kilometres of the coastline as can be seen below. Despite the decree of the Indonesian government a substantial number of settlements has been built within the two kilometres limit to the coastline[31].

Figure 5.1.- Settlements Aceh within two kilometres of coastline



[31] Source data RANDatabase, map was created by Spatial Information and Mapping Center of BRR for INTOSAI.

Source: BRR

15.10 A limited number of villages on the east and west coasts of Aceh were selected as inspection sites, where it was possible to collect field data. To be able to benchmark between implementing agencies, inspection sites were selected from various implementing agencies.

Gathering field observations

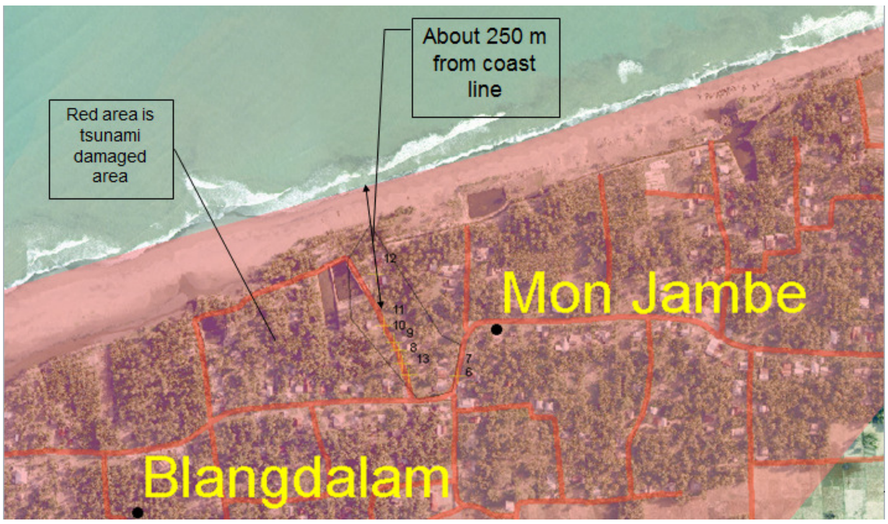
15.11 When a specific area or project is selected, auditors should go into the field to assess the situation on the ground and match it with the information that is provided by the public entities involved in recovery activities. Auditors are advised to use GPS-devices to ensure positional accuracy and to "geo-tag" their field observations, so these observations can be displayed on a map. For practical guidance on the use of GPS-devices see Field Guide to Humanitarian Mapping of Mapaction and Appendix 5.

15.12 Depending on the scope of the audit and the audit questions that need to be answered, observations have to be gathered and recorded. In its field study on housing projects in Aceh, the INTOSAI Tsunami Task Force marked the location of newly constructed houses, but also recorded other information: are the houses finished, are they occupied and is drinking water and sanitation available?

Analysing field observations

15.13 When field observations are recorded including information about their locations, auditors can upload them in a GIS and display them on a map together with other data layers that might be available (population density, infrastructure, satellite imagery, disaster affected area). In the field study regarding housing projects in Aceh, the location of newly built houses was displayed on the available satellite imagery of the area and the area that was affected by the tsunami. See the result below.

<u>Figure 5.2</u> - Field observations on location of newly built houses and tsunami-affected area



Source: BRR, KARI and INTOSAI Task Force

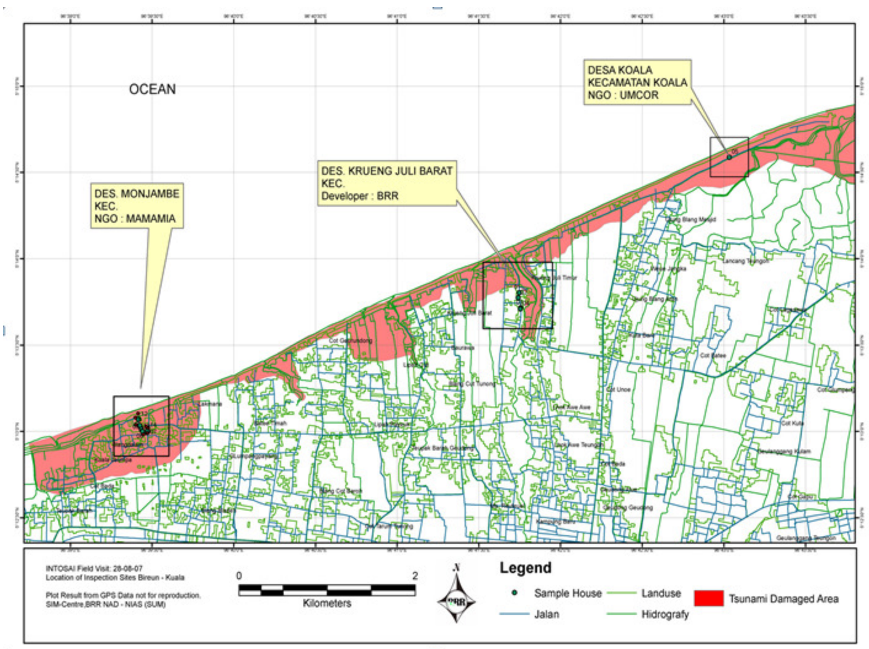
15.14 The field observations (location of newly constructed houses) are indicated with numbers on the map. The distance to the coast was calculated with the measure function in the used GIS software. As can be seen on the map above some of the houses were constructed within 300 metres of the coastline and are located in an area that was affected by the tsunami of 2004.

15.15 The measuring function in a GIS can also be used by auditors for measuring the surface of an area or building as was done in WG AADAs field study in Pisco, Peru. For a new housing project, the corners of a number of houses were marked with GPS. These field observations were uploaded in a GIS to be analysed. With the measure function in the GIS the surface of the houses could be calculated and used to assess whether the surface was according plan. See also Appendix 5.

Communicating audit results

15.16 A GIS cannot only assist auditors in analysing field observations; it can also assist auditors in communicating the main results of their audit. Visualising the audit results supports the conclusions and recommendations auditors want to make. When auditors for instance want to communicate that houses are not built at the right location due to hazards or other risks it makes their case stronger if it is visualised. In the example below field observations regarding multiple implementing agencies are displayed on a map. It can be clearly seen that houses built by NGOs were located closer to the coastline than those built by the agency of the Indonesian government, the BRR.

<u>Figure 5.3-</u> Field observations regarding newly built houses by various agencies



Source: BRR, KARI and INTOSAI Task force

Checklist auditing response and recovery
What is the quality of the information structure of the public entities involved in response and recovery activities?
What information is available regarding the damage and needs after the disaster?
From which sources is this information available?
How reliable are these sources?
Which areas should be prioritised for response?
Is it possible and feasible to send auditors to these priority areas during response phase?
Have specific groups been excluded in assessing damage and needs?
What information is available regarding rehabilitation and reconstruction activities?
From which sources is this information available?
How reliable are these sources?
Which areas should be prioritised for recovery activities?
What progress has been made regarding recovery activities?
Can gaps between damages, needs and recovery activities be indicated based on administrative, remote sensing, open source and on the ground information?