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POST-EARTHQUAKE RECOVERY PLANNING: UNDERSTANDING AND SUPPORTING DECISION MAKING USING SCENARIO PLANNING

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ABSTRACT

Data collected from satellite and airborne sensors have been widely used in post-earthquake damage assessment and in planning immediate humanitarian and financial assistance. Disaster managers are also increasingly using geospatial data to plan and track recovery. This paper describes the use of a disaster scenario planning game as a tool to better understand the information needs of post-disaster managers. In particular, it aims to show how, when, and what information derived from remote sensing can be used to support decision making at various stages of the recovery process. The information needs of hazard preparedness and recovery planning were assessed in a series of earthquake scenario planning exercises with senior disaster managers in Kyrgyzstan, Tajikistan and Turkey. These realistic scenarios were played-out during one-day exercises that allowed disaster personnel to simulate the post-earthquake decision making process. A suite of innovative methodologies for dynamic, multi-resolution monitoring of recovery were provided to assess if, when, and how remote sensing-based tools can be integrated into existing decision workflows. The findings pinpoint how information derived from multi-resolution imagery can be effective in planning and assessing recovery of transportation networks, transitional shelters and the built environment, whilst providing proxy information for socio-economic indicators.

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Understanding and supporting post disaster decision making using scenario planning

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ABSTRACT

Data collected from satellite and airborne sensors have been widely used in post-earthquake damage assessment and in planning immediate humanitarian and financial assistance. Disaster managers are also increasingly using geospatial data to plan and track recovery. This paper describes the use of a disaster scenario planning game as a tool to better understand the information needs of post-disaster managers. In particular it aims to show how, when, and what information derived from remote sensing can be used to support decision making at various stages of the recovery process. The information needs of hazard preparedness and recovery planning were assessed in a series of earthquake scenario planning exercises with senior disaster managers in Kyrgyzstan, Tajikistan and Turkey. These realistic scenarios were played-out during one-day exercises that allowed disaster personnel to simulate the post-earthquake decision making process. A suite of innovative methodologies for dynamic, multi-resolution monitoring of recovery were provided to assess if, when, and how remote sensing-based tools can be integrated into existing decision workflows. The findings pinpoint how information derived from multi-resolution imagery can be effective in planning and assessing recovery of transportation networks, transitional shelters and the built environment, whilst providing proxy information for socio-economic indicators.

Introduction

There is little in-depth understanding of decision-making after a major disaster. Time is compressed and there is an urgency to bring relief and to ‘get back to normal’ – to rebuild livelihoods, clear up the debris, repair the damage and, amongst the more far-sighted, to ‘build back better’. Planning decisions (tackling, for example, immediate response, clearance, restoration of services and rebuilding), happens much faster and under more pressure than routine decision-making in non-emergency situations. Experts come together for a limited time, usually less than two years, and are given extraordinary powers to get things done [1].

This paper describes the use of a scenario planning game as a tool to better understand the information needs of disaster management decision makers. In particular, it aims to how, when and what remote sensing information can be used in decision making at the different stages of the recovery process, including preparing for a future event. It is essential to understand changes in a society’s vulnerability, and to integrate this into robust estimates of risk and of losses that follow an extreme natural event, such as an earthquake. This is especially important in countries such as those in Central Asia, where area-wide knowledge of the existing building stock is lacking, and the urban environment is rapidly changing. Remote sensing and geospatial technologies can play a valuable supporting role in disaster risk management through information provision from earth observation (EO), in-situ surveys and modelled outputs. Often these tools are poorly understood by those who need them most - disaster practitioners, especially in countries with sparse data availability/infrastructure. This is the key driver for the

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European Commission FP7 project "SENSUM: Framework to integrate Space-based and in-situ sENSing for dynamic vUlnerability and recovery Monitoring", described in this paper. SENSUM is developing software tools on a free and open source basis, allowing its wider dissemination to the disaster management and mitigation communities. The early consultations with such groups from Kyrgyzstan, Tajikistan and Turkey on data requirements during and after earthquake events are described in this work.

Disaster decision-making

Previous research suggests that recovery follows a roughly s-shaped curve and that early in the process, decision-makers require information quickly and are prepared to work with imprecise aggregate information in lieu of more detailed information. However, as the process evolves through time, they need more detailed information and are prepared to wait longer to secure more precise data. Comerio [2] argues that recovery depends on circumstance and that the two key variables are the degree of central government control and the extent of citizen involvement. Other variables include economic wealth/poverty, and information rich/poor.

Partners in the SENSUM project team have had previous experience investigating user needs. In 2008, in an EPSRC-funded project to develop indicators to monitor recovery using remote sensing, a consortium (ReBuilDD), made up of CAR, ImageCat and the University of Cambridge, conducted a survey of senior aid agency workers and aid agencies. It was found that people tended to have different information needs depending on the sector they were working in, but, in general, people wanted multiple indicators rather than a reduced set of easily measured physical indicators [3]. Consequently, working on case study sites in Pakistan and Thailand, a set of 13 indicators was developed, including buildings, accessibility, services, and livelihoods sectors [4]. Nevertheless, a number of outstanding questions remained that the SENSUM project has sought to address, including:

- Timing: when and how quickly is supporting information needed?
- Resolution: what level of detail is needed?
- Accuracy: what level of precision is required?
- Cost: how much are people prepared to pay for this information?

Scenario Planning

The scenario planning game developed for SENSUM involved getting people to dynamically ‘play’ through an imagined future. The ‘Game’ collapsed real time to highlight significant issues and to focus on strategic decisions. Moats *et al.*[5], describe how, after major disasters, leaders are required to make high consequence decisions with incomplete or inaccurate information, ill-defined goals, and the pressures of time and a constantly changing situation, by drawing on their training and experience. They posit scenario planning as a way in which managers can understand better their environments so as to lessen the impact of disastrous events and to put in place efficient and effective plans for coping if disaster should strike. Bradfield *et al* [6] say public policy makers are increasingly using scenarios as fora to involve multiple agencies and stakeholders in policy decisions, enabling joined-up analysis and creating an accommodation platform to assist policy implementation.

Scenario planning was developed by Herman Kahn at the Rand Corporation in the early 1950’s and used extensively in military planning [7]. In 1961, Khan established the Hudson Institute where he applied his scenario methodology to social forecasting and public policy. At the same time Gaston Berger was developing similar methods at the Centre d'Etudes Prospectives in Paris to guide public economic policy [8]. Shell used the technique in the 1970s to evaluate strategic options and Davis [9] described four basic types of scenario planning exercise: Inductive, Deductive, Incremental and Normative. The 'Incremental' type is particularly relevant to this research where the purpose was to better understand the post-disaster context and be able to specify how GIS and EO data might be used appropriately [10].

In the disaster management field, the approach has been applied in 'shakeout' type preparedness exercises and drills aimed at raising public awareness. Bradfield *et al.* [6], in a review of the origins and evolution of scenario techniques, describe how they have been used in crisis management, such as civil defence exercises in which scenarios are used in the form of simulations of future crisis situations. Of particular interest, Chermack [11] analyses decision failure by isolating three key issues that affect dynamic decision-making in situations similar to those found in disaster management: bounded rationality, exogenous variables and friction. All of these may be at play in decision making after a real event and may lead to what Chermack describes as "folly". All three were observed in the described exercises in Bishkek and Izmir.

Mason [12] suggests focusing scenario planning exercises on events. He says that key events function as markers. This enables managers to recognise significant change as it occurs. This idea of using events as the main driver for the exercises was something adopted in the described SENSUM scenarios.

Designing the game

The first idea for the scenario planning exercise or 'game' was developed rapidly and described in a simple hand-drawn representation of a 'game-board' divided into columns representing time periods: Day 1, Week 1, Month 1, Year 1 and Year 2+, and rows representing Events, Decisions and Information. It was envisaged that the game might be played in five 30-45 minute sessions followed by a discussion. The game would begin with news of an earthquake. The players would be divided into three 'teams' – events, decisions and information. The Decision Making team would be the authority charged with relief and recovery. They would ask for information from the Information Providers who would choose what to supply from a range of pre-prepared flash cards or ad hoc cards produced during the game. The Event Creators would inject additional external incidents, for example international aid, a Presidential declaration of emergency, or an aftershock or landslide triggered by the earthquake or aftershock.

A game board was made from five sheets of A3 paper and coloured post-it notes and trialled internally; playing through a two year scenario in two hours. This trial was felt to have been sufficiently successful to merit being used as the primary method of collecting user-needs information at the start of the SENSUM project.

The handwritten post-it notes were transcribed into a table that was used to generate Event and Information flash cards to be used in the final version of the game. It was also understood that this transcription would form the data for analysing decision-making and the use of information in the two SENSUM case studies, Bishkek and Izmir. The cells of the table were colour-coded in terms of whether the note was Discussion or Decision by the decision-makers or were an Event or Information card. These cells became an initial list of flash cards for the Game.

Events flash cards were produced for both events and information bulletins, with additional blank cards that could be filled in by the Event Creators during game-play in reaction to the performance of the Decision Makers Group. The Information flash cards had an indication of how long it would take to deliver the information, its resolution, accuracy or confidence and, possibly, cost in person days of the required engineer, image analyst or GIS person's time.

Running the Game in Bishkek and Izmir

In April and May 2013, the scenario planning game was carried out as the primary form of information collection for understanding the data requirements to support post-disaster decision making. The game was played in Bishkek, Kyrgyzstan and Izmir, Turkey. In Bishkek, the cross-border exercise was attended by 20 participants, including 3 people from the Committee of Emergency Situations and Civil Defence, Tajikistan (KES), 7 from Ministry of Emergency Situations, Kyrgyzstan, 2 from the Red Crescent, and 1 from the United Nations Development Programme (UNDP) in Bishkek. It was supported and hosted by project partners from the Central Asian Institute for Applied Geosciences (CAIAG), Bishkek. In Turkey there was a larger number of attendees (27), both from local government (the Disaster and Emergency Management Presidency (AFAD) – Izmir, Bornova Municipality - Izmir) and central government (AFAD HQ), as well as from NGOs (i.e. Turkish Red Crescent, Turkish Radio Amateur Society). The exercise was supported by academics from the Izmir Institute of Technology and Izmir University of Economics – Faculty of Architecture.

In both cases, the scenario game was run over two days. The first day comprised of three presentations from SENSUM on the aims of SENSUM, Project Indicators and remote sensing, and an introduction to the scenario planning exercise. These were followed by an introduction to disaster management in each country and a description of hazards in the case study site (Batken/Isfara, Kyrgyzstan/Tajikistan, and Izmir, Turkey), and finally a discussion of decision makers' information needs in relation to earthquake and landslide risk.

Components of the Game

There were five components to the game, each of which had to be translated into Russian and Turkish, respectively, for the two countries:

1. Information on the earthquake event: One-page mock-ups of USGS PAGER and WAPMERR Qlarm [13] reports of a realistic, but fictitious, damaging earthquake event centred on the study region.
2. Events: flash cards and game board.
3. Decisions: game board.
4. Information: SENSUM product matrix and flash cards showing remote sensing products.
5. Rules: A4 sheet.

Component 1: USGS PAGER and WAPMERR Qlarm cards reporting the event

The scenario began with the automatic notification of a quake alarm and loss estimate generated for these exercises by the WAPMERR Qlarm loss estimation system [13], and a mocked-up estimate of losses and fatalities as would be described in a USGS PAGER report. These scenarios were devised to be a realistic as possible for each study area.

Component 2: Events Flash Cards

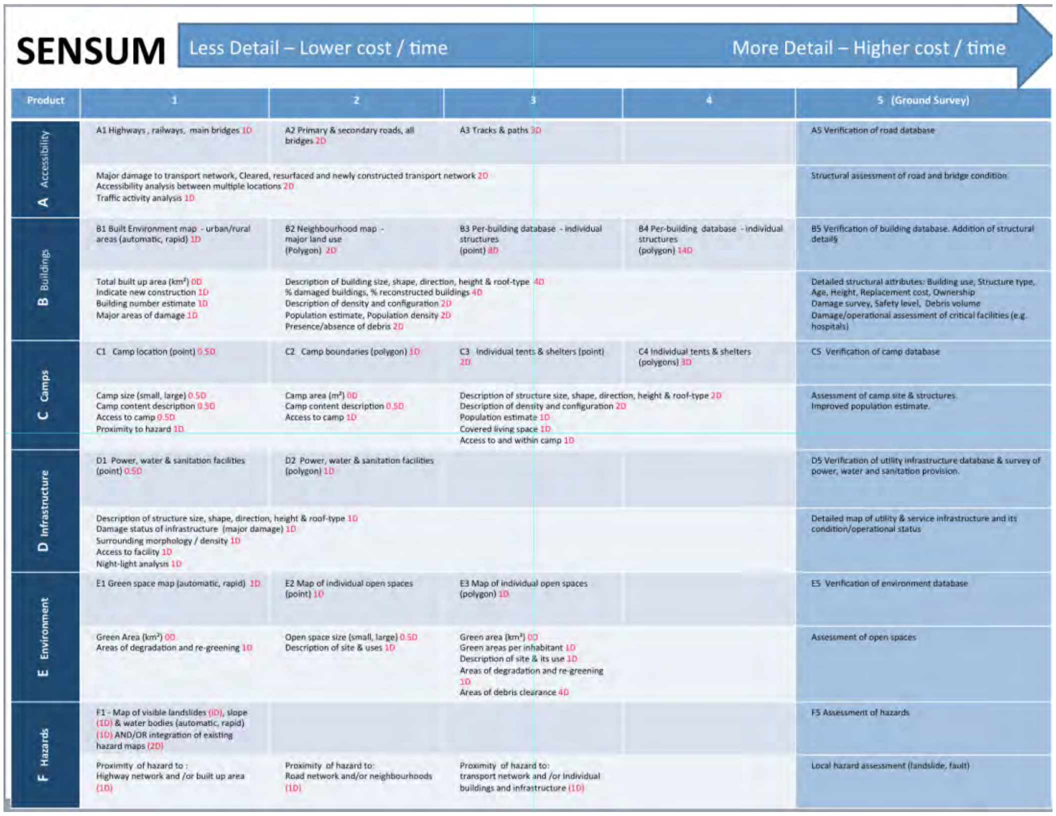
A set of 28 generic events cards were devised. The Events teams began by discarding those cards that they considered inappropriate to their culture or situation. In the events board for Izmir, eight events that were deemed inappropriate to Turkey were discarded and are grouped on the left of Figure 1. The chosen event cards, plus additional cards devised by the team, are sorted into time periods representing the same time periods used in the game (1 Day, 1 Week, 1 Month, 1 Year, 2+ Years).

Figure 1. Events Board from the Izmir Game: Event cards drive the game. Those with images were pre-prepared, while the others were devised on the day by the Event Creators. Those on the left were discarded as irrelevant to Turkey. The rest are arranged chronologically by the Events Creators.

Component 3: Information flash cards and SENSUM product matrix

The most important aspect of the Game, from the point of view of the SENSUM project, was generating discussion on the data products users would require (to support post-event recovery and pre-event vulnerability estimation activities), and products that could be developed within SENSUM. both. Considerable dialogue between SENSUM partners and an extensive literature review helped develop a comprehensive spreadsheet of exposure and vulnerability indicators. This set of indicators was married with the ReBuilDD indicators [4]. This list was too extensive to be used in the game, so a sub-set of SENSUM products was selected representing a range of remote sensing-derived data product.

Since the end goal was to investigate the level of detail users required at different stages in the recovery-preparedness cycle, indicators were arranged in a matrix with columns of increasing detail and higher cost and time to deliver. The matrix covered sectors including “Accessibility”, “Buildings”, “Camps”, “Infrastructure”, “Environment” and “Hazard”. Five different levels of detail were identified. Each cell of the matrix (Fig. 2) represented a possible information product. Typically, the least costly data was provided semi-automatically and the most detailed and costly involved ground survey verification. We estimated the times to provide each product in terms of skilled GIS/analyst person days. The flash cards were derived from this matrix.



SENSUM Less Detail – Lower cost / time More Detail – Higher cost / time

Product	1	2	3	4	5 (Ground Survey)
A Accessibility	A1 Highways , railways, main bridges 1D	A2 Primary & secondary roads, all bridges 2D	A3 Tracks & paths 3D		A5 Verification of road database
	Major damage to transport network, Cleared, resurfaced and newly constructed transport network 2D Accessibility analysis between multiple locations 2D Traffic activity analysis 1D				Structural assessment of road and bridge condition
B Buildings	B1 Built Environment map - urban/rural areas (automatic, rapid) 1D	B2 Neighbourhood map - major land use (Polygon) 2D	B3 Per-building database - individual structures (point) 8D	B4 Per-building database - individual structures (polygon) 14D	B5 Verification of building database. Addition of structural details
	Total built up area (km²) 0D Indicate new construction 1D Building number estimate 1D Major areas of damage 1D	Description of building size, shape, direction, height & roof-type 4D % damaged buildings, % reconstructed buildings 4D Description of density and configuration 2D Population estimate, Population density 2D Presence/absence of debris 2D			Detailed structural attributes: Building use, Structure type, Age, Height, Replacement cost, Ownership Damage survey, Safety level, Debris volume Damage/operational assessment of critical facilities (e.g. hospitals)
C Camps	C1 Camp location (point) 0.5D	C2 Camp boundaries (polygon) 1D	C3 Individual tents & shelters (point) 2D	C4 Individual tents & shelters (polygons) 3D	C5 Verification of camp database
	Camp size (small, large) 0.5D Camp content description 0.5D Access to camp 0.5D Proximity to hazard 1D	Camp area (m²) 0D Camp content description 0.5D Access to camp 1D	Description of structure size, shape, direction, height & roof-type 2D Description of density and configuration 2D Population estimate 1D Covered living space 1D Access to and within camp 1D		Assessment of camp site & structures. Improved population estimate.
D Infrastructure	D1 Power, water & sanitation facilities (point) 0.5D	D2 Power, water & sanitation facilities (polygon) 1D			D5 Verification of utility infrastructure database & survey of power, water and sanitation provision.
	Description of structure size, shape, direction, height & roof-type 1D Damage status of infrastructure (major damage) 1D Surrounding morphology / density 1D Access to facility 1D Night-light analysis 1D				Detailed map of utility & service infrastructure and its condition/operational status
E Environment	E1 Green space map (automatic, rapid) 1D	E2 Map of individual open spaces (point) 1D	E3 Map of individual open spaces (polygon) 1D		E5 Verification of environment database
	Green Area (km²) 0D Areas of degradation and re-greening 1D	Open space size (small, large) 0.5D Description of site & uses 1D	Green area (km²) 0D Green areas per inhabitant 1D Description of site & its use 1D Areas of degradation and re-greening 1D Areas of debris clearance 4D		Assessment of open spaces
F Hazards	F1 - Map of visible landslides (1D), slope (1D) & water bodies (automatic, rapid) (1D) AND/OR integration of existing hazard maps (2D)				F5 Assessment of hazards
	Proximity of hazard to : Highway network and /or built up area (1D)	Proximity of hazard to: Road network and/or neighbourhoods (1D)	Proximity of hazard to: transport network and /or individual buildings and infrastructure (1D)		Local hazard assessment (landslide, fault)

Figure 2. SENSUM matrix of information products derived from remote sensing. The matrix orders SENSUM information products vertically by sector – Accessibility, Buildings, Camps, Infrastructure, Environment and Hazard – and horizontally by resolution from the less detailed to more detailed higher cost products.

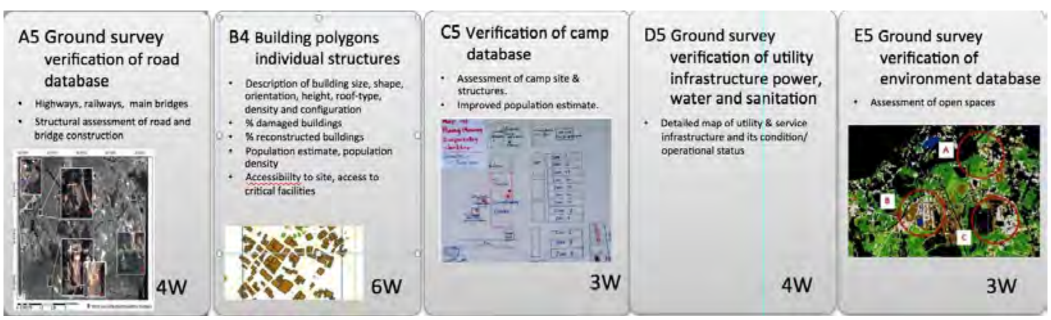


Figure 3. Sample of flash cards representing cells in the matrix (Figure 2)

Description of the progress of the games

Day 1 – Week 1

In Bishkek, the Decision Makers had difficulties in coping with the sequence of events generated by the Events team, but the main problem was that the events cards had no contextual information about the source, location and likely consequences. The Events team then provided this extra information and the Information Providers started providing useful information without waiting for it to be requested, allowing the decision-making to improve. In Izmir, the Decision Making group were immediately well organised but there was a delay in returning information fast enough for the decision-makers.

Month 1 – Year 1

In Bishkek, the Decision Makers were concerned that they were not being provided with the information they needed from the Information Providers, while the Information Providers explained that they were ready and waiting to provide information, but that the requests were too imprecise. To improve interaction, two Event cards where created asking for specific information relating to shelters and transport accessibility, allowing the Decision Making group to function more effectively. In Izmir, although there was a rapid flow of information between the Decision Makers and Information Providers, the information provision was still too slow to keep pace with decision-making.

Year 2

As time passed from the emergency response phase towards longer-term recovery, it became clear that the Game was played with less energy. During the discussions that followed each game, participants made it clear that, in reality, the majority of their attention is focused on response, while mitigation and preparedness are not usually addressed by the participating organisations.

Figure 4. The Completed Decision Board in Izmir. The post-it notes record game play: green for events, yellow for information and pink for decisions. Each post-it represents a decision event or data product used, in chronological order, to simulate the unfolding earthquake scenario. These boards were transcribed and translated and formed the basis of the analysis of decision-making and information use.

Findings

- *Remote Sensing and GIS technology:* In Kyrgyzstan/Tajikistan, the use of remote sensing data to support emergencies is virtually non-existent and only plays a small role in subsequent phases of disaster management or vulnerability monitoring. In particular, there is a lack of skilled GIS and remote sensing personnel in the response teams. In Turkey, GIS is used at almost every level, both locally and by AFAD HQ, but there is a high level of discontinuity and heterogeneity in the technical preparation between AFAD HQ and local practitioners. Remote sensing is already used at that HQ level, enhanced by smooth international EO data exchange protocols via the International Charter for Space and Major Disasters and similar emergency-based initiatives.
- *Timeliness and resolution:* In Bishkek, little attention was paid to the estimated cost of the information in terms of resource-time or complexity. Sometimes end users were unable to choose between different levels of resolution, partly because the demands from decision makers were not specific enough. In Izmir, timeliness and resolution was better understood than in Bishkek, but not used properly by the Information Providers. This was probably due to the pressures of the Game, or perhaps because there was no apparent limit on the resources available.

- *Monitoring:* During the Game there was no evidence of monitoring of vulnerability-related indicators in either Kyrgyzstan or Tajikistan. While the concept of continuous monitoring was understood, since any information collection is strongly based on field surveys, the cost of such monitoring exceeds the available resources. Moreover, any monitoring of vulnerability-related indicators entails a close collaboration among different ministries or departments, which is currently absent and difficult to achieve.
- *Model-based estimation:* It would have been useful to have estimated the number of casualties and displaced people, However, the idea of estimation based on models that are informed by remote sensing was beyond the experience of the participants and the concept of dealing with uncertainty with probabilistic information was not well understood. Nevertheless, when presented with the possibility of such products during the Game, the end users were interested and thought that they would be useful for emergency management.

Potential for using remotely sensing-based indicators in disaster management

In Bishkek, issues linked to accessibility, building damage, camp location and size and location of available green spaces received most attention from the end users. In fact, a great deal of information about exactly what information products users wanted was obtained. Besides the products that were requested, the SENSUM team also identified other products that would have informed decision making. In particular, products for the evaluation of the hazard potential, both for flooding and earthquakes, as well as products for the identification of open spaces for relocation activities, could have been usefully requested by the Decision Makers. The actual choice of products focused on damage assessment and early recovery, and end-users confirmed that, although vulnerability assessment is recognised and understood, there was no notion of using this information to inform decisions.

The main areas of interest for the development of SENSUM data products are as follows:
- *Accessibility:* a complete evaluation of the conditions of the existing transportation and technical infrastructure, and to provide suggestions for improving safety. This product would correspond to the most refined level of detail that “Accessibility” products can provide (A2 + A5 flash card, Fig 2).
- *Buildings*: data about building stock characteristics (e.g., size, shape, orientation, height, etc.) by using remotely sensed data (Flash card B4) combined with a ground survey to verify the initial building database (Flash card B5).
- *Open space*: determining suitable locations for new hospitals, police stations, and technical infrastructure would have required an analysis of the available open spaces and hazard conditions in the proposed locations, plus a connectivity analysis using the accessibility maps.

Managing natural disasters, especially at larger scales, requires geospatial information related to the geographic distribution of vulnerability and impact, the location of critical facilities at risk, accessibility issues and re-routing needs.

Remote sensing can rapidly and unobtrusively provide information about large areas, whilst minimising the need for survey teams to access the impacted area, with often limited accessibility and security. Remote sensing can be an invaluable tool for post-disaster damage assessment and is an effective way of systematically and independently monitoring recovery and redevelopment over-time, by means of multi-temporal change detection analysis. When judiciously combined with GIS systems and innovative methodologies of ground survey, remote sensing provides an unparalleled degree of useful information that can be exploited to inform vulnerability assessment and preparedness. The potential of EO technologies has spurred considerable interest in the scientific community. However, it is still unclear how decision-makers can benefit in practice from the use of EO, GIS and detailed ground survey information. To date, these techniques do not seem to be used to their full potential in disaster management and risk reduction due to:

- Data being not always available or accessible at the time of need;
- Lack of understanding of end-users' needs;
- Lack of adequate communication of the potential relevance and applications of EO-derived data;
- Complex remote sensing sensors and methodologies that would require substantial training for users to be operational.

The aim of using scenario planning in SENSUM was precisely to begin to identify barriers to the take-up of these new techniques by focusing on the reality and constraints of users' needs for information at each stage of the recovery process. With this in mind, it was important to design a wide-range of alternative SENSUM products, with information flash cards that would:

- be transferable to both data rich / data poor countries, allowing case study comparisons;
- allow inferences about end-users' preferences, for example, for less data-rich products;
- list technologies at different levels of complexity and detail that would highlight the trade-off users have to make between speed of delivery and detail.

Bearing in mind the areas in which remote sensing and GIS offer the greatest benefits and building upon the team's experience in previous recovery projects [3,4], each product was designed to correspond to a set of potential indicators – those dealing with recovery derived from this previous research, and those related to hazards produced by the SENSUM team.

The SENSUM Technical Approach

Learning from the outputs from both games, the project team is currently investigating a number of methods for aiding the understanding of pre-event vulnerability and post-event recovery using remote sensing and in-situ observations. These information products will be multi-resolution and range from automatically-generated products over large areas (these may be relevant in the days after the event), to fusion products, taking modelling, EO and in-situ surveys into account (these take longer to produce and would realistically be used for preparedness, rather than response or recovery). Per-sector applications include the identification of both land-use and land-cover, with the delineation of homogeneous urban areas, and the definition of a preliminary set of building footprints to be used for detection-change purposes. These techniques are being implemented in a simple and modular open-source software structure, where each module can be used as a stand-alone process or within a workflow. Results are due mid-2014, and these will be presented back to our user groups in Central Asia and Turkey through workshops and a technical summer school to train local teams to use the free software and algorithms resulting from SENSUM.

Conclusion

The scenario planning game worked remarkably well in the two case studies, and the participants found it realistic and absorbing. They were able to imagine how the scenario might play out and use their imagination and experience to generate the detailed content. The Game successfully met its two main aims: a) to gain a deeper understanding of the real data needs of the end-users, and b) to define a list of vulnerability and recovery indicators that would guide the development of appropriate SENSUM products that will help meet these needs. The transcripts of the games clearly revealed the interplay between events, decisions and information in a way that other types of enquiry (e.g., users needs surveys or interviews) would have failed to show and the outcomes of the exercise brought new insights into how current and new sophisticated geospatial information products need to be developed. The Game revealed many cultural issues, including understanding existing protocols and inter-/intra-agency relationships, that may have gone unnoticed when using traditional survey methods. In terms of improving the Game, to maintain the intensity, it might be played as two half-day (emergency response/recovery and preparedness) sessions, with game players covering the whole disaster cycle. It would be useful to have players with experience and responsibility for all stages of recovery and in cultures where there are known hierarchies, representatives might be brought in from different sectors.

Great potential for the use of EO data was identified, yet users had difficulty in transferring information needs into requests for data products. As the Game and subsequent analyses of the two transcripts revealed, the inexorable pace of a disaster event, and the necessity to make and justify choices under time constraints, forces decision makers to follow standard protocols. Remote sensing and GIS tools/data need to be integrated into established procedures if it is to be used effectively. Whereas previous attempts to study user information needs using conventional interviews and questionnaire techniques had given unsatisfactory results [3], the scenario planning exercise proved to be an effective tool. These games have strong potential as training aids for disaster managers, as was recognised by the participants who recognised they could be used as an annual exercise to maintain preparedness and to train new members of their teams.

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