Manage Data - Manage Hazards: Methods for development of an Urban Hazard Information Infrastructure in Windhoek 

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Manage Data - Manage Hazards: Methods for development of an Urban Hazard Information Infrastructure in Windhoek

by

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Abstract

This work guides through the process of introduction of the Urban Hazard Information Infrastructure (UHII) in Windhoek, Namibia, in the core research, and sets up the framework for its development based on the different experiences coming from case studies.

The investigation of a demand and potentials for UHII and its core element UHEMIS (Urban Hazard and Emergency Management Information System) is done after an analysis of UHII requirements in the different institutional environment of Regionale Brandweer Twente (the Netherlands) in the preliminary study. The identification of bottlenecks in urban hazard data management in different organisational environments of case studies and their implications for decision-support by UHII in the framework of integrated Urban Hazard Management (UHM) was presented. The As-Is Spatial Information Management Reference Model (RSIMM) is created for the preliminary study and used as a reference to the Case-Specific Spatial Information Management Model (CSIMM) for the City of Windhoek (CoW), the core research, where young, dynamic institutions face financial, structural, legal and technical uncertainties.

As a result the institutional and technical framework for spatial data exchange and sharing in Integrated UHMis proposed. The combined soft-structured methodology with the use of Critical System Approach for analysing demands and requirements for development of UHII in Windhoek is developed. The reference to the lessons learned from the case studies is made and the guidance through required policies and strategies supporting UHII development is presented. The Urban Hazard and Emergency Management Information System (UHEMIS) development is chosen to initiate UHII introduction. It is meant to constitute a data and metadata management base for decision-making in spatial development control, risk assessment and emergency response planning. The UHII and UHEMIS models are being designed next in this research. A framework for co-operation between the CoW divisions and external spatial data providers is advised be established to supply UHEMIS and UHII with accurate, reliable and up-to-date spatial data.

Keywords

Information Infrastructure, integrated Urban Hazard Data Management, Critical System Approach in system development
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Chapter 1

Manage data - manage hazards: Spatial Data Infrastructure for Decision Support in Urban Hazard Management

1.1 Research context

The last decade of XX century (1990-2000) was declared the International Decade for Disaster Reduction (IDNR) in response to the observed increase in life loss, property damage, and socio-economic disturbances caused by numerous disasters. Many research projects were undertaken to analyse the causes of disasters and to identify the shortcomings of current Disaster Management (DM) processes both for natural and build-up environments. The latter, due to their density, dynamic development, complex spatial structure with mix of human activities and high population mobility, are considered especially prone for man-made disasters (e.g. fires, explosions, chemical spills and water contamination). This is particularly true for developing countries (i.e. Namibia) where, due to difficult climatological conditions, problems of uncontrolled population growth, HIV/AIDS vulnerability, war threat, insufficient education, and economic problems, the number of vulnerable people is the largest (Annan, 1999). Unstable financial, educational and institutional settings make the control of rapid spatial development very difficult. In result a dangerous mix of urban activities is created, where people live and work exposed to the chemical, biological and technological hazards and where food and water resources are being threatened. Even in the developed countries (i.e. the Netherlands), despite the stable institutional background, relatively stable economic situation and technological development, man-made disasters keep affecting urban areas to a large extent. A timely and efficient disaster response may not be sufficient to prevent from disaster, when unidentified multiple hazards create a chain reaction, destroying human habitats and causing numerous casualties. The DM processes should be interlinked with the Spatial Development Control (SDC) Processes that supply the most important information on urban structure dynamics.

Evidently the shift in focus is necessary from emergency response, recovery and redevelopment processes to prevention and shaping disaster preparedness\(^1\). In order to successfully prevent from disasters, mitigate hazards and to prepare for responding to emergencies, their origin and propagation should be understood and their effects should be, to the certain extent, predictable in terms of location and time. Technological disasters, contrary to the natural ones, cannot be predicted accurately according to their historical frequency and location of occurrence. To prevent and mitigate man-made disasters the sources of hazards have to be first identified through the detailed analysis

\(^1\)Preparedness can be considered combined prevention, mitigation and emergency response planning; (Coordinator, 1991)
of urban infrastructure i.e. utilities, building structure, substances used/stored, land use, and activities performed in particular locations etc. The strong dependance of the disaster preparedness on accessibility to reliable information was proven (Coordinator, 1991), since the provision of up-to-date, accurate and reliable spatially referenced information together with socio-economic data is necessary to accurately assess risks and vulnerabilities as well as model the response.

Without well developed mechanisms of information management (dissemination, sharing, exchange, quality control, etc.), the fundament of disaster prevention and emergency response may be lacking. Provision and management of spatial data, for Urban Hazard Management (UHM) involves a number of stakeholders coming from different organisations, administrative levels and application backgrounds. The missing links between UHM and the management of the city structure itself together with the use of many local, incompatible GIS and data management systems, give in consequence different data formats and models. This creates obstacles for information exchange and, in result, significant problems for co-operation in emergency situations. The development of information management techniques was, therefore, given a lot of attention among complex UHM issues (Masser and et al., 1991). This research will add to the creation of Global Spatial Data Infrastructure (GSDI) by provision of guidelines for creation of application-specific Urban Hazard Information Infrastructure (UHII) and a prototype of Urban Hazard and Emergency Information System (UHEMIS), to establish the information link between Urban Development Control and Urban Hazard Management processes.

1.2 Research Motives

Application of Geographic Information Systems (GIS) in analysis and visualisation of urban hazards may support in great extent assessment of the risks, vulnerability and potential losses. As well GIS can support strongly the creation of emergency response scenarios by providing the tools for analysis of spatial relations between the risk sources, vulnerable objects, remedy resources (e.g. hydrants, equipment stores), shelter areas, and evacuation and response routs. The importance of spatial analysis for decision-making processes is, therefore, evident. The SDC can be supported even by unsophisticated visualisation of risk sources and receivers. It can help to identify the hazard prone neighbourhoods and order their possible redevelopment or impose changes in zoning plans. This is already a very important step in multi-disciplinary disaster prevention and hazard mitigation. It proves that establishing the links between the Spatial Development Control (SDC), Natural Resources Management (NRM), Disaster Management (DM) and Urban Management (UM) is necessary to build the base for high preparedness status. Spatial development and DM policies have to be re-examined with respect to the problems in information sharing and exchange, the policies for data management have to be established, respective strategies have to address integration of UM and DM with the potentials and limitations of geographic information infrastructure development.

The provision of spatial data for decision support in SDC and DM is executed through diverse activities in urban management. The supply of spatial and thematic information is the base for authorities to take decisions. Not only the reliability and accuracy of supplied data become the success factors for balanced spatial development and disaster prevention, but it is especially availability and accessibility to required information that shape the decision-making process. Diversity of data detail levels and formats, different semantics of objects classification and incompatible data schemas as well create obstacles for synthesis of received information, thus distorting the knowledge-base and blurring the transparency of decision-making especially in when multiple objectives are considered.

The discussion on how to establish sufficient conditions of accessibility to geo-information and how to support timely exchange of information for the needs of hazard and emergency management is undertaken. Institutional as well as technical context plays a very important role in achieving the communication basis for so-called strategic crisis management, in which the multi-disciplinary and multi-objective approach is taken for hazard prevention, mitigation and response. Organisations such as governments at different administrative levels, national mapping agencies, national survey offices, non-governmental mapping and environmental analysis organisations, etc. should be aware
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of their role in providing and analysing spatial data used in numerous processes affecting disaster management. Since the GIS technology has changed capabilities of handling spatial data, the governments have to re-think their roles with respect to the provision, availability and accessibility of quality geographic information (Masser, 1998b).

1.2.1 Background Information for Case Studies

The background for the following research is constituted by the pitfalls of geographic and thematic information management in two different institutional settings. The real life examples of Enschede (the Netherlands) and Windhoek (Namibia) were analysed to come up with the guidelines for the introduction of Urban Hazard Information Infrastructure.

1.2.1.1 Spatial Information Management in the Netherlands

Growing demand for GIS-based decision support tools at the local UHM level in the Netherlands resulted in the diversity of spatial information systems owned by independent municipalities. The expected benefits of GIS usage were overestimated, since the regional co-ordination of UHM was blocked by incompatible data formats and inconsistent datasets. Lack of inter-municipal co-operation in spatial data management resulted in different spatial object classification and visualisation, thus generalisation of maps to the regional level was almost impossible. Until recently the supra-regional standardisation of DM was applied mainly for emergency assessment and response phase, nowadays, the standardisation process for risk mapping for disaster prevention is necessary. New policies for managing spatial and thematic data in DM are being established and the development of spatial information infrastructure supporting dissemination, sharing and exchange of hazard information has started (see: www.brandweer.nl). The difficulties faced in this process were recorded at the beginning of this research in order to identify critical success factors for the development of Urban Hazard Information Infrastructure.

The shortcomings of short-term data management, the lack of data integration, (vertical - on different administrative levels) and horizontal - among different organisations, fields and between independent municipalities), the redundancy of data management activities and the data itself proved to have and adverse effect on UHM and SDC decision-making, what can be seen on the example of S.E.Fireworks explosion in Enschede.

S.E.Fireworks Enschede - Accident Case. The explosion of S.E. Fireworks in Enschede, which caused enormous damage inside residential area of the city (death of 22 people, 14 serious injuries, a damage of 1500 houses, of which 200 were completely destroyed) was assessed as one of the most difficult crisis situations that have affected Dutch urban environment. The assessment of risk extent during this event has been constrained by a lot of factors, especially during the critical phases of emergency response. The effectiveness of emergency response action was evaluated and given strong criticism (see: De vuurwerkramp: Onderzoek rapport commissie Oosting - Eindrapport; M. Oosting et al, 2001; (Oosting, 2001)). It was concluded that, during the critical phases of crisis reaction, the possibilities to assess accurately the extent of risk were considerably limited due to the:

- Lack of up to date information on what was stored in the impact area,
- Lack of accurate data on the exact location of tanks and (un)accessibility to the fire source area,
- Lack of sufficient information on the type of vulnerable objects in the vicinity of fireworks,
- Insufficient data flows among the emergency units

In particular the type, volume and location of explosives stored in S.E. Fireworks, were unknown or known wrongly. Even the information on the number of people in the vicinity was missing. The fire brigades were not aware of the exact danger caused by the fire spreading around with uncontrolled speed, the assessment of vulnerability in the vicinities of S.E. Fireworks had to be done
1.2. Research Motives

immediately according to the local knowledge of fireman and police, due to the failure failure in communication and information management. This might have resulted in the loss of many more lives, if the beautiful weather did not allow a number of people to leave for weekend excursions.

The supply of information for S.E. Fireworks crisis management was assessed to be both insufficient and unreliable (Oosting, 2001). The Municipality of Enschede was found to be guilty for failing to execute development control due to the lack of up-to-date information on the illegally stored explosives. Subsequently, the recommendations on management of accuracy of topographic, demographic and building use data were given a prominent position among the recommendations of the "Eindrapport" ("Final report") on the S. E. Fireworks disaster mitigation and remedy (Oosting, 2001).

Since the S.E. Fireworks crisis the Dutch authorities at all administrative levels have been increasing attention to conducting SDC linked to UHM. The regional initiatives for risk mapping and emergency planning were followed by developing an cross-institutional approach for setting up a cross-institutional framework for management of multi-disciplinary risk assessment data (see: http://www.slagenvoorveiligheid.nl/links/; http://www.brandweer.nl-crisis prevention by Fire Brigades, Ministries and related entities). Sharing, exchanging and standardisation of information were considered crucial in disaster management and development control. New policies were established for handling information heterogeneity (see: http://www.slagenvoorveiligheid.nl; Strategies for strengthening information facilities in disaster management). The implementation of the policies is still in the process and already many problems were observed and analysed further in this research in order to benefit from Dutch experiences when creating the guidelines for UHII development.

1.2.1.2 Spatial development and urban hazards in Windhoek

Windhoek is a rapidly developing capitol city of Namibia. During the 10 years of Namibian independence the population has increased by 38% from 180 000 to almost 250 000. Currently 20% of Windhoek’s population is residing in informal settlements, lacking the urban infrastructure, built up from any type of available materials, unstructured, signed by poverty. At the same time the economic development of the city is realised through business and industrial investments in attractive locations. Regardless of the nature of development (informal/formal) there is yet no control over the level of urban hazards introduced, neither the awareness of them, what can potentially be very dangerous for the Windhoek population as well as for further development.

The city soon may face the problem of growth constraints due to the hilly surroundings, not fit for specific activities required by investors. The open space in the south of the city is nowadays being a subject of discussion between spatial planners, environmentalists, water engineers and politicians. It is the natural underground water source (southern acquifier) to be under the pressure of spatial expansion of the city.

In the savannah climate with total annual rainfall of 170-500mm, the annual evaporation potential is high between 3,200 - 3,400mm, and with the mean maximum summer temperature of 30C (source: www.krc.org.na - official Khomas Region website) the important threats expected might first the drought crisis and some fire threats. Water resources, so precious in Namibian situation, have to be used carefully; the system of pipe supply and re-use of water coming from outside the region is followed by the use (20%) of underground water sources. New policies enforce the use of acquifier for storage of saved water resources to be used in case of long-lasting draught. Drinking water has to be protected from contamination in the source and in the storage area. Also the hydrant resources for the fire brigades have to be maintained effectively, to prevent from the shortages in case of large scale accident. The responsibility for managing water resources, maintenance of pipelines, dams and reclamation plants is taken by the City of Windhoek (the CoW, municipality) together with NamWaters state company.

Within the CoW the responsibilities for DM, SDC and water management are scattered among different divisions. The divisions are independent and quite isolated what often results in redundancy of data, isolation or scattering of datasets, inconsistency of data formats and object definitions etc.
Limited information flows within the CoW show evident underused potential of the central data management system. The same applies for the co-operation between the CoW and state level spatial data providers, where the lack of co-ordination of information flows results delays of decision-making process. Data sharing is limited by the lack of legal agreements, heterogenous GIS and database management systems (DBMS) neither facilitate information exchange. Decision-making for city management faces many delays, even difficult to estimate economically. The initiative to solve data management problems is, therefore, necessary.

### 1.3 Research Focus

UHM and SDC often have overlapping goals and, thus, the common multi-disciplinary knowledge-base should be applied for multi-objective decision-making in order to improve the spatial conditions and decrease exposure to urban hazards. Different levels of decision-making will require different types of geographic and thematic information. To satisfy the actors - national and local authorities, developers and last but not least citizens, the complex information analysis and synthesis has to be performed. In order to provide the base for such analysis, the fluent information flows among all decision-makers have to be provided and the co-ordination of the urban management activities has to take place. The Spatial Data Infrastructure, though narrowed down to the particular application sector (here SDC and UHM) as Urban Hazard Information Infrastructure, can support to large extent the data connectivity and harmonisation between different administrative levels (Groot, 1997). The decision-making support system built within UHII, containing GIS-based tools and incorporated with respective institutions will have to be designed in compliance with interoperability concepts and following data and metadata management guidelines (standardisation of schemas and semantic models).

The focus of the research is meant to address the problems of spatial information management issues. The bottlenecks of access to spatial data and potentials of Geographic Information Systems as decision support tools will be discussed in the light of Urban Hazard and Emergency Management. The focus is given to possibilities of strengthening preparedness to urban hazards via building the framework for access and use of spatial information. The study aims at the introduction of Urban Hazard Information Infrastructure (UHII) in an environment, where responsibilities for UHM are distributed among different administrative levels and organisations, and where incompatibility of GIS and data management systems exists. A demand to set up wide, open-GIS compliant framework for spatial data exchange and sharing is a base for this study. The research focuses on the new methodology for design and successful implementation of urban hazard information management tools. The guidelines for introduction of UHII will be created by proposal of the policies and urban hazard information exchange and strategies for co-operation among the actors responsible.

### 1.4 Research Problem

The problem analysed in this research regards development of methods for design and successful introduction of Urban Hazard Information Infrastructure in the environment, where responsibilities for disaster management are distributed among different administrative levels and organisations, where incompatibility of GIS and data management systems exists. It is in order to support disaster prevention, mitigation and preparedness by answering the demand for the reliable spatial information expressed by various decision makers in Urban Hazard Management and Spatial Development Control in the City of Windhoek.

### 1.5 Research Objectives

The development of Urban Hazard Information Infrastructure is a leading goal for this research that was narrowed down to make it operable, feasible and to fit the time and resources frames. The study
domain was identified, therefore, as urban hazard and risk assessment for development control and in emergency response planning for fire hazards and groundwater contamination threat in Windhoek. The guidelines for methodologies, policies and strategies for provision of spatial information management tools supporting urban hazard assessment and emergency response planning are considered the main outputs of the study.

1.5.1 Main Research Objectives

1. To investigate demand and potentials for development of Urban Hazard Information Infrastructure (UHII) in Windhoek, Namibia;

2. To identify bottlenecks in urban hazard data management in different organisational environments of case studies and their implications for decision-support by UHII in the framework of integrated UHM

3. To develop a combined soft-structured methodology for analysing demands and requirements for development of UHII in Windhoek, with the reference to the lessons learned from the Dutch case;

4. To guide through policies and strategies for UHII development.

1.5.2 Specific Research Objectives

1. Investigation of a demand for UHII with identification of groups of stakeholders

2. Analysing stakeholders in terms of organisational, legal, financial and technical environment to support choice of the requirements analysis methodology,

3. Identification of available spatial and attribute data on the study areas

4. Identification of UHM procedures and analysis of information supply flows

5. Analysis of process flows and relations between organisations responsible

6. Identification of information needs and flow requirements for decision-making in UHM and SDC

7. Identification of spatial information used in decision-making for emergency management

8. Identification of information accessibility/availability bottlenecks

9. Modelling current situation of urban hazard data management

10. Creation of a model for UHII development

11. Analysis of institutional, technical, legal and user-centred requirements for and specifications of UHEMIS prototype as a core UHII element

12. Modelling of UHEMIS prototype to support decision-making in urban hazard mitigation and emergency response planning

13. Analysis of the conditions for UHEMIS prototype implementation; testing UHEMIS against the research objectives
1.6 Research Questions

1.6.1 Main Research Questions

1. Why is the urban hazard prevention not sufficient in experiences of Enschede and Windhoek and how can the emergency preparedness status be increased?

2. How does accessibility to the spatial data influence a decision-making process in UHM?

3. How to analyse the requirements for technological support in urban hazard data management to minimize the bias and non-sustainable technology-push approach?

4. To what extent can UHII and UHEMIS support accessibility to and use of spatial data for a decision-making process in urban hazard management?

1.6.2 Research Subquestions

1. What are the institutional conditions for spatial data production and usage?

2. What are the spatial data produced/possessed by the organisations and how (if) are they disseminated/shared?

3. How are the responsibilities for emergency/crisis management and for response planning distributed?

4. What is the link between geoinformation production, dissemination and geoinformation application for emergency/crisis management and for response planning?

5. What are the common requirements (case studies lit. based) for spatial data management in urban risk prevention, mitigation and emergency response in urban environment?

6. What should be the specifications and requirements of an Information System Prototype for support in urban hazard management and emergency/risis response planning?

7. What should be the appropriate technological and institutional solutions to implement the Prototype and to what extent could it be implemented in existing circumstances to meet the prototype objectives?

1.7 Research Methods

Discrepancies between the as-is and to-be of spatial data production, dissemination and exchange are visibly seen especially in developing countries when compared to the developed ones. The comparative study on geoinformation management solutions for urban hazards in developed and developing country can give an idea on necessary organisational and strategic changes to be made before reaching the point of information infrastructure initiation.

1.7.1 Two-tiered research structure

The authorities of Windhoek can benefit form Dutch experiences in introduction of Spatial Data Infrastructure (SDI) for UHM in multi-organisational environment. Analysis of SDM shortcomings was therefore conducted both in Netherlands and in Namibia. The pitfalls of spatial data management in Netherlands can be used to identify potential problems of data management in Windhoek, when corrected for different institutional settings. Dutch methodologies for introducing and development of the SDI were replaced, therefore, by the ones fit for the CoW. To answer the demand for GIS-based support in decision-making for reduction of urban hazards, the requirements for establishing UHII in Windhoek were investigated in terms of technical, institutional, financial and legal
uncertainties. To provide a base for inter-institutional sharing and exchange of standardised spatial data for development control and UHM, the focus was placed on developing methodologies for successful introduction of UHII. A number of system analysis and design methods (i.e. user requirements analysis, SWOT) was therefore combined. In order to support UHII and provide base for its management, the possibilities and specifications for local development of GIS based Urban Hazard and Emergency Management Information System (UHEMIS) were investigated.

To identify crucial bottlenecks in development of multi-institutional UHII, to develop case-specific guidelines and to provide a clear link between the case studies, the research has been structured as follows:

First the **preliminary study** was undertaken to investigate experiences of UHII introduction in the Dutch regional administrative level. The outcome was a set of universal guidelines regarding types of datasets, formats, standards, and organisational co-operation for introduction of spatial information infrastructure to support specifically fire hazard management.

Second, the **core research** was executed for the uncertain institutional, financial, structural, legal and technical settings of Namibian state and municipal institutions. The outcome included the methodology for- and analysis of organisational, technical, legal and end-user requirements in dynamic institutional settings. The guidelines for creating policies and strategies for successful provision of SDI tools were developed. The domains analysed were the risk assessment and emergency response planning for fire and water pollution hazards.

### 1.7.1.1 Preliminary research

It is meant to investigate the case of Regional Twente Fire Brigades working on SDM for urban fire risk assessment and emergency planning. The research topics are explored through interviews, questionnaires and the literature study in the respective steps:

1. Analysis of actors, processes and data flows in fire risk assessment and emergency response,
2. Analysis of policies for data sharing, exchange and standardisation,
3. Investigation of GIS-based tools for risk assessment
4. Analysis of shortcomings in spatial data accessibility, shareability and dissemination
5. Creation of a SDM model based on an example SDI
6. Creating guidelines for the development of UHII

The result is the creation of a spatial information management model to picture the relationships between the stakeholders involved in the supply and use of spatial data for UHM. The bottlenecks of existing UHM processes are primarily identified based on the case of S.E. Fireworks Explosion.

### 1.7.1.2 Core research

It is meant to take place in Windhoek, and focus on the analysis of the UHII requirements in the institutional environment of The City of Windhoek (CoW, including Fire Brigades and Disaster Management Unit) and the related spatial data providers and users (Survey General Office, Deeds Office, Topographic Survey Office, Ministry of Transport and local Police, etc.). The analysis of actors, processes and data flows in UHM preceded the assessment of UHII and UHEMIS technological (networking), organisational (strategies) and legal frame (policies) development requirements.

The study methods consist of the series of interviews (initial and cross-check), the questionnaires of 3 types (on UHM processes, data management requirements and demanded UHEMIS specifications) and the cross-organisational workshop of educative and explorative character. The questionnaires are designed to address different target groups - data providers, disaster and emergency managers, urban planners and urban infrastructure managers, spatial data managers and operators.
During the fieldwork a number of questions will be added to complete the survey with important topics not foreseen before. During the workshop, attended by main SDM actors, the discussion on linking multi-disciplinary UHM and development control with spatial information management issues was undertaken. GIS-based development control and risk assessment tools, such as a prototype of One-stop-shop development control GIS and the Flash application for risk mapping\textsuperscript{2}, were presented and assessed. The SWOT analysis was conducted based on the findings on local and regional data management problems.

The spatial information management model will be as well created in result, to visualise the "As-Is" spatial data flows and their bottlenecks. Based on SWOT Analysis, Requirements Analysis and CSIMM the guidelines for policies and strategies for the development of UHII will be created.

Subsequently, the user-centred analysis of UHEMIS requirements will be conducted to specify the design of the prototype. The model of UHII including UHEMIS will be created. The functional and structural specifications of UHEMIS will be analysed and modelled. Translation of user requirements to functional interface requirements and definition of UHEMIS syntactic and semantic environment. Information schemas will be designed in a way to provide interoperable environment; data transfer and translation modules will be designed. The important aspect will be the integration of the model with institutional settings. The prototyping process will be defined.

1.8 Thesis overview

The following chapter 2 presents the overview of the literature on the problems related to the research, where two main domain streams are discussed: development of the spatial information infrastructure and management of urban hazards as an application domain for the above. First the experiences with the development of SDI are presented with the focus given to organisational issues in GIS technology implementation. Subsequently the applications of GIS for DM and UHM are elaborated together with the usage of GIS and SDI for decision support. The decision support by development of information infrastructure is next discussed and the link to decision-making in urban hazards management is shown. Further on the issues related to disaster management and particularly urban hazard management are presented. The chapter presents as well the overview of the terms used in the research.

Chapter 3 is partially based on the two-tired field studies with the focus on developing the methodology for introducing UHII to Windhoek authorities. The demand for UHII is investigated, the stakeholder groups are identified, and their organisational characteristics are described, to decide upon a proper methodology choices. The As-Is situation of data management as coming from the preliminary and core study is presented on the background of the organisational issues. The reference and case study models of spatial data management are presented. The overview of UHII requirements analysis methods for Windhoek is discussed.

The reference cases studies are analysed in Chapter 4 in order to present the recommendations for strategies of UHII development later on in this chapter. The description of outcomes of UHII requirements analysis for Windhoek is given followed by the analysis of SWOT results for the CoW, in which the lessons learned from the case studies are considered. The guidelines for policies and strategies of UHII development are presented. The conceptual model of UHII is presented at the end.

The outcomes of user-centered requirements analysis for UHEMIS are presented in chapter 5, where the conceptual model of a prototype is presented, referring to the user requirements corrected for the bias. UHEMIS role as a decision-support tool for specific fire and water contamination hazard management and emergency response planning is discussed. The problems of use of UHEMIS for spatial data management are discussed.

Eventually the discussion, conclusions and recommendations are presented in chapter 6.

\textsuperscript{2}Friesland Risiokaart, a product of the Municipality of Friesland, the Netherlands
Chapter 2

Spatial Information and Urban Hazards

In the following chapter the main concepts of spatial information and spatial information infrastructure (SDI) are given. The question is raised on whether and how the spatial information and the access to it influences decision-making processes; the focus is given to the users of spatial information and finally to the processes of Disaster Management (DM) and in particular Urban Hazard Management (UHM) at local and regional level. In this context the role of spatial information and GIS in Disaster Management (DM) and in particular in UHM is described. Eventually, SDI development is shown as a support in achieving high emergency preparedness status.

2.1 Geographic Information - Concepts, Use and Management

Governments and private sectors have to support their decision-making processes with large amounts of data related to populations living in particular locations (i.e. socio-economic data) or describing phenomena referenced in space by geometric co-ordinates (i.e. maps of land cover, land use, cadastral boundaries or more complex datasets as EIA’s, bio-diversity analysis, etc.). The data describing the phenomena located in particular space can be named as geographic or spatial information/data, geo-spatial data or geo-information, but all of these data have spatial reference, stored in some consistent manner (e.g. post codes, administrative areas, latitude and longitude, national grids) and very often describe the change of features over time (Groot and McLaughlin, 2001).

These terms are usually used synonymously, but for the needs of this research the term spatial information and spatial data will be used the most often.

According to Malczewski (Malczewski, 1999)), geographical data can specifically include facts, results of observations, original remote sensing images, and basic census figures and statistics, all of which are gathered and communicated to the user (decision maker). This definition of spatial data presents the user in a very important aspect - the user is an entity shaping the functional environment of spatial information, acting in a way to extract the information from raw materials and basing the decisions on the outcome. From that point it is close to re-definition of GI. Malczewski (Malczewski, 1999) makes the following differentiation:

Geographic or spatial data are defined as undigested, unorganised, and unevaluated material that can be associated with a location. Data are of little value in and of themselves. When data are organised, presented, analysed, interpreted, and considered useful for a particular decision problem, they become information.

The distinction between data and information becomes especially important during the User-centred Requirements Analysis and Information Flows Analysis performed during the research (see: Chapter 3 and 4) as well as in the phase of information infrastructure modelling, due to the implication on the classification of users based on their capabilities to analyse and apply both data and...
information in the decision-making processes. The view presented by Malczewski will not be fully sustained in this thesis. For the purpose of this research the distinction of data and information will be used during the requirements analysis, where "spatial data" would refer to raw, unprocessed or not yet analysed materials, not always possible to use in the decision-making process, whereas "spatial information" would indicate its functional meaning for the users, applicability and direct useability for different purposes. In this context, however, even raw data can become a meaningful information for the users, provided they have gained the necessary experience.

One can argue that the separation between data and information is unnecessary, unless the terms primary (raw) and secondary (processed) data are considered. The nature of data and information is very similar, and their classification would be fuzzy, depending purely on user’s capabilities. To take an example: spatial data can become easily the information when they are presented in an understandable way. The set of statistic figures on the socio-economic situation in particular area can be visualised e.g. in charts or graphs on top of the map of the related area. The usage of graphic variables as size, value, texture colour, orientation and shape (Kraak and Brown, 2000) plays a crucial role in communication of the information to the public; the political or density maps can be simple examples here, as well the Dutch risk maps, visualised differently for the use of citizens and professionals.

According to the production incentives, importance, purpose and frequency of use the spatial information can be divided into the foundation, framework and application data (see: (Groot and McLaughlin, 2001) p.5):

**Foundation Data** are the basic characteristics of spatial objects such as geographic name, or the basic data from which the geo-information (e.g. maps) is derived - topographic template, orthoimagery, elevation models, network of geodetic control points etc. This type of information is usually produced by government owned organisations such as National Mapping Agencies, Geodetic Surveys, Scientific Institutes specialising in geography, Military Mapping Agencies etc.

**Framework Data** is the spatial information used commonly in decision-making processes; the information perceived in the form of i.e. maps of administrative boundaries or land use/cover, cadastral data, hydrography or transportation maps and charts, soils and geology maps etc. This type of information can be produced by the same organisations as above, but if only the foundation data is accessible (non-confidential) it is possible by non-governmental institutions to create their own framework datasets on top of the fundamental ones. Together with the foundation data the framework data belong most often to the public goods, not owned by any private entity (not excluding anybody from the use of it) and renewable in use (non-rival in consumption) (Gregoriadou and Groot, 2001). The chosen framework data are also being increasingly used for purposes of primary education, from what one could conclude, that their understanding (changing the data into information) may be more common then in case of specific foundation data.

**Application Data** create the set of specific, most often project-related spatial datasets, designed to serve specific application domains (e.g. specific pollution data for particular EIA, cellular network range maps or migration patterns of supermarket customers/supermarket accessibility routes). These data, by their nature, can be very detailed and specific, but as well they can be difficult to access, due to the fact that they can be owned by the companies having a direct benefit from them. As well these data can (but don’t have to) be the most difficult to understand by the potential non-expert user.

Having the above in mind, the role of Geographic Information Systems will be discussed in this research not only in terms of storage, analysis, maintenance and integration of spatial and attribute foundation, framework or application data, but as well in the aspect of converting row data into meaningful information. In such process the row data obtain extra values (Casserati (1993) as cited by Malczewski (1999)), what makes them suitable for usage in decision-making processes, run by particular groups of users.
Chapter 2. Spatial Information and Urban Hazards

The Spatial Information Infrastructure will be understood as an umbrella mechanism providing the access to, and facilitating dissemination (exchange, share) of spatial data and information, therefore being a crucial fundament for decision-making in such interdisciplinary domains as Disaster Management and in particular Urban Hazard Management, being as well related to Urban Planning and sustainability issues. The metadata, will be presented as a necessary component of SDI, helping the primary and secondary data become a functional information, allowing user to understand data origin, format, spatial reference, and relationship with other data. The issues of quality, standardisation, economy, legal rights, policies will be bound both to the UHM processes and to the development of GIS and SDI supporting them.

2.1.1 From Geographic Information Systems to Spatial Data Infrastructures in decision-support

The applicability of spatial information for multiple purposes is its key characteristics (Groot and McLaughlin, 2001). Hence, the rapid development of systems for digitisation, storage, maintenance and analysis of geographic information, Geographic Information Systems - GIS, was visible in the last decades. The Geographic Information System is considered a computer technology combining different types of data (spatial and non-spatial) and visualising them e.g. in the form of maps and/or reports; Masser and Blakemore state already in 1991 that GIS

"...must be regarded as a special form of database management system which facilitates operation on spatial data...these [GISs] extend from basic computer mapping systems to fully relational databases which are able to exploit the properties of geographic information."

The impact of GIS on decision-making can be seen even in its different definitions, where two aspects of information systems are taken into consideration - technology and problem solving. From the "technical" definition of GIS as a

"set of tools for the input, storage and retrieval, manipulation and analysis, and output of spatial data" (Marble at al. (1984) as quoted by (Malczewski, 1999))

The more general definitions evolved, where GIS was considered an integrated digital technology for spatial and non-spatial data combination, presentation and management (see Obermeyer and Pinto, 1994) after (O’Looney, 2000)). This is followed by "functional" definitions of spatial information systems, where the focus is placed on the ability of GIS to serve as a multi-purpose digital geo-database, used for utilisation of spatial and attribute data, and where, in detail, the integration of technologies such as Remote Sensing (RS), Global Positioning Systems (GPS), Computer-Aided Design (CAD), Automated Mapping and Facilities Management (AM/FM) occurs (Foote and Lynch 1996 /after (Malczewski, 1999)). Finally GIS is seen as

"a decision support system involving the integration of spatially referenced data in a problem solving environment" (Cowen 1998 /after (Malczewski, 1999))

Here the development of simple and sophisticated GIS based decision-support systems and computer expert systems appears already as a separate scientific branch, showing the complexity of GIS evolution for support in decision-making and in different applications. The modern GIS is capable of performing spatial analysis based on both location information (spatial reference) and thematic information (attribute), by operating on one or more classes of objects (spatial and thematic) and creating new object classes from existing ones (for classification of spatial analysis operations see Goodchild 1987, (Masser and et al., 1991)). The manipulation on integrated spatial and attribute data can be executed by spatial selection queries (e.g. "Select all hydrants within 100m distance from the fire area"), overlay and containment functions (Subselection of the parts of objects or whole objects located within other objects), slope, spread (wave propagation and obstacles), and trace analysis functions (tracing surface water flow, finding shortest routs) attribute
queries ("select the public buildings of > 3 floors and of > 100 people daily occupation"), etc. and of all the combination of these functions. Current GIS software solutions can offer the integration of relational or object-relational database management systems (DBMS) and spatial objects management systems (often with built topological relations). These characteristics allow GIS tools to be applied in decision support in such domains as environmental resources management, urban planning and management, food security, disaster prevention and preparedness, global climate changes, etc. There should be special attention given to the emerging need for knowledge exchange and capacity building (at institutional and individual level) to provide efficient use of GIS tools for such decision support.

Nowadays, the spread of already existing DBMS and GIS solutions, allows for easier conversions and use of attribute data in spatial environment. Bigger and bigger spatially related databases are created: big private entrepreneurs are interested in the usage of broad Census-related datasets for various market analyses, government organisations would profit from easier access and visualisation of data for inputs in sustainable spatial planning and environmental resources management. This integration shows market-pull rather than technology-push tendencies, being an answer for demand in spatially based decision-making.

The current diversity of GIS used in private and public sectors can be seen as a threat for achieving desired fluency of information flows between, and within organisations. Each of the independent GIS units is based on specific software solutions and has to be provided with the data that are compatible with it. Each of the domains uses different definitions and classification of objects, giving different data models and data dictionaries for used information systems. Hence, the exchange and sharing of the data between different GIS became a problem for multi-disciplinary and multi-level decision support.

Problems in data exchange were envisaged already in late 1970’s, when many national surveying and mapping agencies (NMAs) identified the need to create strategies and processes for standardising the access to, and application of, spatial data (Groot and McLaughlin, 2001). This constituted the base for modern initiatives of SDI development, but the scale of problems is currently much larger and and the type of data addressed differs due to the rapid development of digital mapping and data analysis tools. Achieving the agreements on the standard characteristics of data to exchange and share is therefore a complex issue, addressed by a number of research institutes and international organisations (i.e. OpenGIS Consortium) through the initiative of building a technical and institutional framework called Spatial Data Infrastructure (SDI), and in the wider context, the Global Spatial Information Infrastructure (Global SDI). The GISs can be seen as data storage and analysis tools used at organisational level whereas SDIs mirror the enterprise-wide and domain-oriented activities via their Geo-Spatial Data Service Centres (called here SDSC), facilitating data flows between data users and producers/suppliers (Groot and McLaughlin, 2001). In such context different GI Systems can be seen as functional components of SDI, supporting spatial data management through storage and provision of secondary/derived information. Moreover, some of the current GISs posses the characteristics of SDSC having the modules for linking spatial databases with internet data dissemination tools, therefore constituting the technological base for SDI development. Here, the marriage of technology-push and market-pull approaches manifests itself in creation of tools and methods for data models integration and for facilitation of access to information. The general examples can be the Spatial Data Clearinghouses allowing for metadata and data exploration through the www environment and so-called Spatial Data Service Centres, allowing for integration and dissemination of different spatial data.

The reason for developing more and more advanced facilities for easier analysis, access and retrieval of spatial data is to provide better quality decisions, improve information processing facilities, and to increase efficiency (time) of decision-making processes as well as save money spent on production of redundant datasets (see (Campbell and Masser, 1995), (Malezewski, 1999), (Longley et al., 2001), (El-Swaify and Yakowitz, 1996), (Masser, 1998a)). Once the operational deficiency is identified in an organisation, where decision-making processes are mainly based on spatial data, the GIS adoption is seen as inevitable by those promoting technological development and by rational management boards; the common incentives for implementation of information systems are, how-
ever, assessed as political and symbolic in the nature ((Campbell and Masser, 1995)). The role of organisational settings in development and implementation of SDI will be addressed further in this research.

2.1.2 Spatial Data Infrastructures - Concepts and role

The SDI Cookbook (Of EUROGI Technical Working Group of Global Spatial Information Infrastructure) (Nebert, ) states that the term "Spatial Data Infrastructure" (SDI) is describing the composition of such elements as technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data. The SDI addresses data users and providers within all levels of government, the commercial sector, the non-profit sector, academic society and citizens. The technical infrastructure supporting access, storage and retrieval of data and metadata includes the elements of the complete computer networks, GIS and relational/object-relational DBMS software (handling data dissemination transactions, updates, and providing data protection), www data dissemination applications, search engines, etc. These elements have to be surrounded with standard practices, protocols, and specifications of use and maintenance of geographic data and the infrastructure itself.

"An SDI must be more than a single data set or database; an SDI hosts geographic data and attributes, sufficient documentation (metadata), a means to discover, visualize, and evaluate the data (catalogues and Web mapping), and some method to provide access to the geographic data. Beyond this are additional services or software to support applications of the data. To make an SDI functional, it must also include the organisational agreements needed to coordinate and administer it on a local, regional, national, and or trans-national scale.

The role of SDI is, therefore, to connect applications to data, and this can be done both in "horizontal", general (regional, national, global) data and domain environments and vertical application and domain-specific environments.

The role of SDIs was seen in 1980’s as a mechanism for providing more effective access to geo-spatial data, with the focus on removing redundancy of datasets and improving the efficiency of NMA’s activities. In a short time this vision expanded addressing wide array of technical, legal, financial and organisational issues ((Groot and McLaughlin, 2001)). SDIs are seen nowadays as the mechanisms underpinning all application domains using spatial data as, or for the provision of, public goods (see (Gregoriadou and Groot, 2001)), be it public safety, supply of basic utilities (e.g. drinking water, health services, etc.), conducting a research on food security, or management of information and institutional capacity building for strengthening knowledge base in developing countries.

2.1.2.1 SDI for Data Management and Decision Support

The issue of decision support with the use of SDIs and their elements such as Geographic Information Systems have been given a lot of attention recently, similarly to the previous trend of analysing GIS role in decision support. There is a trend to utilise technical components of SDI to support the access to and application of data for products, services, and particularly decision-making (Williamson et al., 2003). Thus the data/metadata exchange and sharing is one side of the coin only, and the possibility of creation of dynamic maps or sharing information by accessing online decision-making support applications is the other. The importance of the dual role of SDI and its tools has been noticed by Nebert (2002) and adapted by Williamson et al (2003), to show the relations between technological SDI environment and spatial data and user/producer environments for decision-making. To say shortly the decision support component is related to the application-specific data and systems available through the SDIs; and this component is supported by the mechanisms of provision of spatial data access and exchange environment for base, framework and application specific datasets. The framework of relationships describing this situation is depicted in the model,
which in Chapter 5 is successfully used to describe the dual functionality of UHEMIS system under the UHII framework.

![Diagram of Relations between Technological SDI elements and Decision Support for Accessing Data & Technologies]

2.1.3 Organisational structures, spatial information technologies and change

Since 1970's the organisational aspects of GIS technologies implementation were investigated more and more often; the growth of awareness was visible on the role that such issues as organisational culture and structure play during development and implementation of strategies for knowledge and data exchange and sharing. Cultural issues as the type of social interactions, decision-making style, role of information (analogue vs. digital), acceptance of GIS and willingness to participate in its implementation, etc. were addressed in numerous researches on GIS and SDI development (see (Dereck E. Reeve, 1999), (Campbell and Masser, 1995), (Campbell, 1992), (W.H.E. de Man, 2002)).

The structural issues and other aspects as bureaucracy, hierarchical divisions and the level of independence in internal organisational structures also affect the process of implementation of GIS technologies.

According to Masser and Blakemore (1991), the origin of user-dive for GIS technology development depends on organisational factors such as corporate aspirations and the capabilities of the staff involved in geographic information handling. In the broader aspect, the effectiveness of management of spatial data has been predicted to depend strongly on the availability and use of data consistent in formats and models (Masser and et al., 1991). This shows the evident need to develop not only practical GIS and SDI solutions but primarily political, social and organisational framework for spatial data management - policies and strategies of their implementation. According to the above sources, there are various factors influencing the implementation of the (GI) technologies, of which the examples are:

1. Condition in internal vs. external organisational environment:
   - External: political factors, competition and dynamics of economic development (data market conditions), level of control on the data and technical resources
Chapter 2. Spatial Information and Urban Hazards

- Internal: cultural factors, hierarchy, power, gender, knowledge, acceptance, corruption, bureaucracy etc.

2. Characteristics of organisational settings:
- Autocracy or responding to public demands
- Masculinity vs. femininity of organisation (with regards to the hierarchical structures)
- State of mandate development and clarity of organisational functions
- Flexibility to respond to the changes in surrounding environment
- Flexibility of structural changes
- Knowledge base and experience of staff
- Human resources and its dynamics (staff turnover), etc.

As mentioned in the research of Campbell (quoted in Huxhold and Lewinsohn (1995)):

"Effective utilisation was not found to be simply dependent upon the technical operation of a GIS. Organisational issues, including the ownership and control of information, securing general commitment and ensuring the needs of users are met through a realistic understanding of the role [of] information in decision making, were found to have a marked influence on the implementation process."

Campbell as well indicated the factors that should be addressed early in the GIS implementation process, these are (generalising):

1. Lack of flexibility for the change of scopes of activities performed in organisational units
2. Under-utilisation of GIS for the decision-making in environmental and planning related issues
3. Centralisation of information, which is considered a centralised power
4. Social and political issues regarding GIS utilisation

Addressing the influence of GIS on the procedures, operations, and institutional arrangements among all users belongs to 9 principles of GIS successful implementation, as investigated by International Association of Assessing Officials (IAAO) and the Urban and Regional Information System Association (URISA) (Huxhold and Levinsohn, 1995). The issues reported are the organisational setup for common access database (imposing common organisational data model) including the change in the responsibilities, procedures, security measures, standards, laws and organisational structure to assure full functionality of GIS among all users. Among the same principles the education, motivation and dedication of staff dealing with GIS implementation and its further use is recorded as imperative for successful GI technology implementation. The ratio between technology-oriented, structured and soft, human and organisation oriented factors among these principles indicates that the social context of GI technology implementation was still not put as an equivalent to the technical context.

In the scope of conversion from the stand alone GIS to the multi-application environment (and similarly to the SDI environment) with multiple users, the following issues of data and process integration inter- and intra-organisationally appear (adapted from (Huxhold and Levinsohn, 1995)):

1. Connection and integration of previously separate information systems for facilitated data sharing (very relevant a well in SDI development)
2. Change in data maintenance and system support patterns (as above)
3. Analysis and better understanding of information and process flows for integration (reconciliation) of requirements of different users (compromising of the conflicting user requirements is a very relevant step in any IS or SDI development)
4. assuring high level of staff competency (important for maintenance and long-term sustainable operation of SDI; drawback in the UHII development case)

5. the problem of how to build on the existing technologies and data (according to Huxhold and Lewinsohn (1995) the old solutions have to be thrown away, whereas current practices in development of SDI try to reuse existing data and technological resources)

To deal with these issues during the implementation of technology in the organisation the strategic approach should be taken. This requires understanding the relationship between organisational setup and the proposed GIS (and in our case as well SDI). Among the matters to consider in strategic planning the organisational context is manifested through:

- type of organisation and its structure with relation to the type of technology to implement
- the time needed for organisation to adapt to the new technology
- the choice of feasible solutions (with alternatives) and creation of a relevant step-by-step time-management plan
- the leadership of the technology implementation and shaping the motivation for potential stakeholders.

These issues, according to Huxhold and Lewinsohn (1995), have to be matched with organisational mission. In the case of UHII development the target organisations as the public bodies (e.g. municipality, ministries etc.) aim in their missions to viability of living conditions by development of mandates and organisational structures in order to implement policies and strategies, procedures and programs through which the functions of organisations are fulfilled. The organisational change imposed by introduction of a new technology refers to all the above elements. Huxhold and Lewinsohn state that the dynamics of this change depends on the organisational sector (private vs. public), the philosophy of management, organisational culture, and the influence of external environment.

The same source quotes the research of Scott (‘Organisations: Rational, Natural and Open Systems’, 1987) the case of Cad/Cam technology introduction for manufacturing, for which the match between technology and organisational structure was assessed as dependent on the Complexity of the structure (number of issues/functions that organisation deals with), Uncertainty of varying procedures and materials used, Interdependence of the organisational structure elements (does a change of one results in the domino effect change of the others?).

In many cases the introduction of GI technology is the same the introduction of a "new way of doing business", altering business processes in the organisation and changing the functions of the organisation. Such a change has to be integrated in technology planning, and the strategic plan has to refer to the management of the change between the technology, data, human resources and the organisation itself. Before the strategic plan can be implemented the legal agreements have to appear in the organisation, e.g. in the forms of policies, to resolve main conflicts in the user requirements or to shape homogeneity of data management environment.

### 2.1.4 Development of SDI and its diffusion in organisations

The definition of Diffusion commonly referred to in the context of adaptation of technology in organisations is the one of Rogers:

"the process by which an innovation is communicated through certain channels over time among the members of a social system” (Rogers, (1983), as cited by (Williamson et al., 2003))

It in other words is a communication (creation and sharing of information to reach mutual understanding) about a new idea (innovation). This innovation by definition imposes uncertainties like lack of predictability (how will it work out?), structure (who should be responsible for what and how shell it integrate?) or information (how to do…? where to get …from?), in our case regarding
to the adoption of UHII in organisation(s). The Organisational Innovation Process Model shows different phases of the diffusion of technology in the organisation. It is of outmost importance for this research to realise the link between the methodological approach and this model - the developed methodology refers to different phases of information infrastructure diffusion in the organisational environment of Windhoek. The methodology for Introduction of UHII in Windhoek refers in latter chapters to the phase of Initiation and manifests itself through the methods of analysing the demands for UHII, conducting SWOT and executing fieldwork with introducing SDI concepts to stakeholders and collection of user requirements. The methodology for Implementation refers to the policy and strategic guidelines for UHII and UHEMIS implementation.

<table>
<thead>
<tr>
<th>Agenda- Setting</th>
<th>Matching</th>
<th>Redefining/ Restructuring</th>
<th>Clarifying</th>
<th>Routinizing</th>
</tr>
</thead>
<tbody>
<tr>
<td>General organisational problems that may create a perceived need for innovation</td>
<td>Fitting the problem with an innovation</td>
<td>The innovation is modified to fit the organization, and organizational structures are altered</td>
<td>The relationship between the organization and the innovation is defined more clearly</td>
<td>The innovation becomes an ongoing element in the organization's activities</td>
</tr>
</tbody>
</table>

Figure 2.2: Organisational Innovation Process Model

2.2 Disaster Management, Hazard Management and GI technology

In order to discuss management of urban hazards first the definition of disasters, hazards (threats) and risks has to be presented with relation to natural vs. man-made (hence as well urban) threat sources. Response of geographical objects and environmental phenomena to threats can be expressed as resistance, sensitivity and/or vulnerability, the last one which remains in focus during this research. All concepts are discussed in this section, with their relation to the cycle of disaster management activities, as described in chosen literature sources.

2.2.1 Hazards, risks, emergencies, disasters - main concepts

The terms disaster, risk and hazard refer to a situation in which (a) particular object(s) or person(s) is/are endangered by an entity/phenomena potentially causing their partial or total damage. The damage can be either of crisp physical, economic, social or psychical nature. In all cases the threat of life, health, property damage or destabilisation of socio-economic situation appears.

Many different organisations use various working definitions of disaster, hazard, risk and vulnerability. Below the concepts are being explained and the link is being made between the hazard man-
2.2. Disaster Management, Hazard Management and GI technology

management with emergency planning and spatial information management with GI technology support.

2.2.1 Hazards

According to Cova (Longley et al., 2001) Godshalk (1991:132) defines a hazard as

"a threat, natural, technological or civil, to people, property, and the environment”

UK Health and Safety Executive defines it as

"a physical situation with a potential for human injury, damage to property, damage to environment, or some combination of these”

Hazard therefore can be defined simply as a threatening event(Montoya, 2003); or a threat which, given a set of circumstances, may become translated into a realized event (Masser and et al., 1991). The event itself can commonly be referred to as an emergency or accident, some sources as well identify (wrongly as indicated in sections below) this event with a disaster. Sometimes the terms hazard, disaster and risk are used synonymously, but it can be accepted only in a very general approach, rather not in a professional discussion where the semantic differences are significant.

There are different types of classifications of hazards; there were the attempts to divide the hazards (as disasters) in independent classes/partitions (e.g. UNDRO disaster/hazard classifications), but the approach fails when different causes and effects of hazards overlap. UNDRO (United Nations Disaster Relief Organisation) distinguishes natural events, other disasters, and accidents, what makes this classification helpful in the emergency planning (Masser and et al., 1991). The hierarchical set-definition of hazards, as presented after Johnson (1983) in the work of Masser and Blakemore (1991) can be applied for different classification criteria.

Smith (1996) differentiates technological hazards - as large-scale structures and transportation systems facing accidental failure, or industrial activities that present life threatening risk to the local community; and natural hazards - resulting from elements of the physical environment harmful to man and caused by forces extraneous to him (as quoted by Montoya (2003)). The type of hazard and it’s origin will have an impact on the methods used in hazard monitoring, mapping and emergency planning, especially in terms of Gi technologies application.

The relationship between hazard and disasters is that the hazards

"translate to disasters only to the extent that the population is unprepared to respond, unable to cope, and, consequently, severely affected”

When talking about disaster it is important to note that it should refer not to the physical event itself but to the damage caused by such an event. The United Nations organisation states that a disaster is

"A serious disruption of the functioning of society, causing widespread human, material or environmental losses which exceed the ability of the affected people to cope using its own resources. Disasters are often classified according to their cause viz. natural or man-made.” (DHA/IDNDR 1992)

When considering the definition of disaster as the negative effect of an unpredictable event, the "state of continuous and uncontrolled expansion of a destruction” (see : official websites of Swiss Insurance Association) the terms Emergency and disaster do not overlap in the meaning any more. It is an emergency that relates to the accident event itself. Still, there are a lot of other factors determining whether the state of disaster or emergency can be announced officially by the authorities. Some of these refer to the regional or state level of the catastrophe, some to its scale of effects.

The emergency is seen in the extended (alternative) disaster management cycle as the phase occurring directly after the impact of a disaster (see Carter (1991), p.52), when the measures are taken to save lives and protect property and handle immediate effects of a disaster. The emergency response includes: implementation of plans, activation of counter-disaster system, search and rescue, survey and assessment, provision of food, shelter and medical assistance, and evacuation measures.
the term **Vulnerability** describes social (life), economic and physical (spatial, temporal) degree of [potential] damage suffered by particular elements at risk, caused by occurrence of a hazard impact. Most often this term is related to the natural phenomenon disaster, and "it is usually expressed in relative terms, using words such as 'no damage', 'some damage', 'major damage', 'and total loss', or by a numerical scale between 0 (no damage) and 1 (total loss) (adapted from official website of Ministry of Sustainable Resource Management: Resource Information Standards Committee, government of British Colombia, Canada, last accessed Jan.2004 ; and Montoya (2003)).

According to Morgan *et al* (1992) (as quoted in an above source), the spatial vulnerability is concerned with answering the question "will a particular area be affected by the event?", temporal vulnerability - "will the area be occupied by a person at the time of the event?", and life vulnerability - "will there be loss of life due to the event?". In quantified form the total vulnerability is a multiplication of the above three types. According to the Red Cross the vulnerability is

"The characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impact of natural or man-made hazards"

The important remark is being made by Red Cross, that the vulnerability always has to be described by the "to what?" context; in other words vulnerability exists only with the reference to particular hazard. (of Red Cross and Societies, )

The term **Risk** describes a derivative of hazard and of vulnerability, by estimating expected degree of loss dependent on both - vulnerability of the elements at risk and the extent of hazard itself. UK Health and Safety Executive perceives risk as "the likelihood" of occurrence of hazard impact, depending on the time and conditions of surrounding environment. The UNDRO Co-ordinator established in 1979 the official definition of risk as:

"The term risk refers to the expected losses from a given hazard to a given element at risk, over a specified future time period. According to the way in which the element at risk is defined, the risk may be measured in terms of expected economic loss, or in terms of numbers of lives lost or the extent of physical damage to property. Risk may be expressed in terms of average expected losses, such as: 25,000 lives lost over a 30 year period,[...] or alternatively on a probabilistic basis: a 75 exceeding 50 million dollars in the town of Puerto Nuevo within the next 10 years" (UND, )

Although the occurrence of hazard and vulnerability gives potential for risk assessment, but the capacity of emergency response and resilience can add to the risk value (Duran, 2003), and therefore "risk" should be put in the social context.

### 2.2.1.2 Hazards and risks in the scope of this research

In the scope of the research there are the Human-made hazards/disasters and risks related to them, in particular the case studies focus on (fire and ground water contamination) risk mapping in urban environment. Here in general we define as the "Human-made" these hazards (after UNDRO definition)

"of which the principal, direct causes are identifiable human actions, deliberate or otherwise."

This term may as refer to the human crisis, caused by military conflicts, civil strife, etc., but these are not addressed in this research. As the examples are: in the preliminary study - fire and explosion hazard, and in the core research - fire hazard, and ground water pollution hazard, resulting from the hazard of transportation accident or industrial accidents.

_Hazard assessment_ according to the same glossary refers to probabilities of the occurrence of potentially damaging phenomena, indicating probable time period, magnitude and geographical location of an impact.

To compare the _Risk Assessment_ refers according to UNDRO to the quantification of risk, whereas
2.2. Disaster Management, Hazard Management and GI technology

the *Risk Evaluation* involves the factor of social and political judgement of the subjective risk perception by individuals.

Assessment of the man-made risks lacks the component of occurrence probability evaluation, since this type of hazards do not appear in dependence to cyclic, predictable phenomena. In the case of man-made hazards, the possibility of typical quantitative assessment is limited:

"Technological hazards are more unpredictable and may be extremely rare, so that it becomes difficult to use probability concepts to quantify risk, especially those which rely on notions of relative frequency" (Masser and et al., 1991)

As well the boundaries of exposure to the risk are always the subject of discussion, since the geographical extent of the hazard impact influence on the population depends on many (sometimes very uncertain) factors such as hazard cause (or the synergy of causes), vulnerability of the population, number of the elements at risk, environmental conditions (e.g. wind velocity and direction in case of fire or toxic gas release).

In the context of the hazard and risk management in the urban environment the Dutch approach has to be quoted, as it refers to different types of risk - external vs. internal called sometimes *intrinsic*.

The latter enhances the role of the risk originating in the construction of built up elements - it refers e.g. to the risk of buildings in which are occupied by the population; whereas the external risk originates outside these constructions. Thus the explosion causes external risk by the impact wave of fire and air pressure, and internal risk by fragmenting the constructions and making them hazardous for people occupying them.

### 2.2.1.3 Dealing with disasters and hazards

**Disaster Management (DM)**

"An applied science which seeks, by the systematic observation and analysis of disasters, to improve measures relating to prevention, mitigation, preparedness, emergency response and recovery." (Carter, 1991)

*The Disaster Management Cycle (DMC)* is based on phases of disaster management processes, according to the temporal cycle of disaster events. These phases include (Hoetmer, 1991) as quoted by T.J.Cova:

1. Disaster mitigation
2. Preparedness
3. Emergency response
4. Recovery

(see fig.1 after Goodchild in T.J.Cova - Comprehensive Emergency Management). From the point of view of GIS application the division of Comprehensive Emergency Management into the operational phases has to be discussed more closely. T.J.Cova (Longley et al., 2001) proposes reduction of CEM to three main phases combining preparedness and response processes. It is proposed since the same GIS tools are proven to appear in these two different phases.

The phases of Disaster Management Cycle, according to Carter (1991) are divided in a more comprehensive way:

- Prevention - measures preventing the disaster occurrence
- Mitigation - actions decreasing the possible effects of disaster on the community
- Preparedness - measures enabling rapid and effective response to disaster situations; facilities for individuals, communities and governments such as emergency response scenarios, securing response resources, counter-disaster plans, training, etc.
• Response - measures aiming to saving life and property and diminishing the social disturbance introduced by the impact; taken immediately after or just prior to the disaster

• Recovery - or redevelopment, or reconstruction, aiming to returning the community to it’s pre-impact level of development

• Development - advancement and improvement of the community aiming among the others to improvement of disaster counter-measures

The development and prevention phases are very much related to the spatial planning processes, in fact the development process

"at any scale should consider vulnerability and risk as an integral part of the process and not as ad-hoc element" with its "Intrinsic vulnerability (prone to impact the development), the possibility to create or exacerbate vulnerability for others, and the possibility to reduce vulnerability” (Duran, 2003)

2.2.2 Urban Hazard Management - integrated approach

According to Guzman (2003), The integrated Hazard Management approach

"ensures that all organizations, including government, private and community organizations, are involved in disaster management”. (de Guzman, 2003)

It refers to the multi-sectoral and inter-sectoral coordination in hazard management, aiming to reduce redundancies and inefficiencies in HM actions.

2.2.2.1 Risk assessment in the context of spatial development

The goal of the risk assessment is not only limited to the identification and monitoring of risks, but risk quantification must primarily serve as input for disaster prevention and hazard mitigation. As such it refers directly to the development process, which can control to the certain extent the spatial distribution of man-made hazards and of vulnerable objects, and by manipulation of such spatial relationships in spatial planning it can diminish or aggregate risks. As observed by Duran (2003), the disasters are caused by

"Unresolved development problems where vulnerability represents deficits in development”

When talking about the pre-disaster measures in the context of this research, we target primarily the local (riska assessment execution) and regional (coordination) administrative/governmental levels. These measures according to Masser and Montoya (Masser and Montoya, 2000), can be of structural and non-structural types, and local authorities can respond to hazards by mitigating them building structural protections (e.g. dykes in the Netherlands) lowering the vulnerability of the population and property, or by non-structural measures such as the education campaigns or changing the functional characteristics of settlements by land use planning and development control measures. According to Duran (2003)

"Risk can not be separated either causally or in terms of management practices, from development, economic policy and planning.”
2.2.2.2 Emergency planning in preparedness measures

The Emergency Management (referred further to as EM) is described by Cova (Longley et al., 2001) after Hoetmer’s definition (Hoetmer, 1991) as

"the discipline and profession of applying science, technology and planning, and management to deal with extreme events that can injure or kill large numbers of people, do extensive damage to property, and disrupt community life (Hoetmer, 1991)".

The same source presents Comprehensive Emergency Management as organization of disaster and emergency processes with usage of GIS based tools, according to the Disaster Management Cycle. Emergency planning and evacuation has been referred to in numerous sources related to the natural disasters, less has been discussed in the subject of man-made hazards appearing in urban environments.

The emergency management can be considered either as the post-impact activity or as the set of pre- and post-impact activities combining the measures of preparedness and emergency response. In the light of this research the emphasis is given to the very particular aspect of emergency preparedness, which is building the emergency response scenarios and plans. Perry (1985), as quoted by Gatrell and Vincent in (Masser and et al., 1991) has described the comprehensive emergency planning and management as involving prevention (reduction of risk by e.g. re-zoning, routing), protection (detection of hazards, warning), response (search and rescue, as well addressing secondary threats as water contamination) and restoration. The gross of applications has been developed for the last two phases, whereas there was an evident gap in provision of measure procedures and tools for the first two, what has been pictured as a large potential for GIS utilisation in strengthening civil society.

In some developed countries, like the Netherlands, nowadays the issue of emergency planning for technological disasters in urban environment is given a lot of attention due to the failure of response measures in recent accidents, such as S.E. Fireworks explosion (Enschede) or fire in the large night club/caffee (Volendam). There, although the emergency scenarios were prepared according to the very strict criteria, following demanding standard methods of risk assessment and development control (being the inputs in emergency planning), there was no practical preparedness for an emergency (de Haag et al., 2002), especially due the possible synergic effects of the fire and other hazards. The conclusions indicated the need of emphasising the development control measures or detailed and accurate business activity information in support for emergency planning and response.

2.2.3 Spatial Information for support in Hazard Management

In this work the use of spatial information in Hazard Management is discussed in two different aspects - planning for sustainable development and development control and support for emergency response planning. Development control and spatial planning belong to prevention and mitigation processes, which can be partially supported by GI and GIS tools in order to provide high quality decision making process. Emergency response phase can be very well supported by GIS tools, but it makes sense only if GIS based emergency response scenarios already have been prepared and made available. Here the response phase depends very much on the outcome of mitigation and preparedness phases, in which the appropriate GIS tools are being used.

2.2.3.1 Data requirements for Urban Hazard Management and Emergency Planning

The main data problems addressed in hazard management are of the

"availability and quality of data concerning the populations who may be at risk from the storage and transport of hazardous substances, from toxic air pollution […] and so on. Such data are crucial either for assisting emergency services to make assessments about resources they need to deploy in such events, or for high quality estimates to be made of risk”(Masser and et al., 1991).
The other problem is caused by not acknowledged fact, that disasters do not respect any administrative boundaries (Masser and Montoya, 2000), and even in case of the urban hazards, the effects of these can vary in extent from few meters to tens of kilometers. Different organisations shall undertake a common effort not to duplicate their information on hazards and risks, and they should co-operate on supra-administrative levels to foster the comprehensive emergency preparedness.

Subsequently the procedures of data collection for disaster management focus mainly on the governmental and top-level organisations, and the supply is directed as well to the top-level decision-making (Masser and Montoya, 2000). This approach shall be extended to allow identification of all potential risk assessment information users, including private and public sectors. The commercial data users can as well be treated as providers of significant information for the use of technological risk assessment, not possible to obtain from governmental resources.

The collection of hazard information for Risk Management should be according to Duran (2003) executed in a participatory approach on info production, to mirror the real local information and risk management needs instead of external motivations. The same author as well strongly emphasises the strategic role and power of information on disasters and hazards, due to its characteristics as an input to development, the planning process, and opportunity building.

Integration of data from different providers is becoming a world wide problem in management of spatial information; potential technological solutions as GML and XML based data transfer and "data format translation" are currently being investigated. Other solutions in data standardisation either for exchange or for sharing and dissemination are discussed as well. Some of the data standards are however locally not consistent and often not reliable, even in such a developed country as US (Montoya, 2003). The lack of coordination of data management in many cases results also in mixed or no standardisation of data and metadata, so crucial to be able to identify data and assess their fitness for use and reliability before a download of information.

In order to obtain good disaster preparedness measures via risk assessment and emergency plans the following example information has to be addressed:

1. distribution of domestic and non-domestic properties with centre-lines of roads, with hazardous objects indicated
2. distribution of schools, hospitals, medical and transport services, mass gathering places with vulnerability of these indicated
3. distribution of population around the hazardous objects
4. extent of potential effects, depending on different variables (e.g. amount and type of hazardous substance, weather conditions, building construction materials
5. internal risk factor identification (remarks on building construction)
6. overlapping (synergetic) effects of hazard impacts
7. risk types, e.g. spatially - linear (transport of hazardous goods), point risks, or by the hazard cause classification
8. emergency response conditions for particular objects (e.g. accessibility to hazardous objects and remedies
9. knowledge on special on-site and off-site emergency plans valid for particular hazard objects

In order to obtain such information its potential users have to be aware of where to look for it and under what conditions they can obtain required data. In order to facilitate such process of data dissemination the hazard/disaster information networks are being created, example of which is the National Disaster Information Network (NDIN) in USA (coordinated by Federal Emergency Management Agency).
2.2.3 Spatial Data Infrastructure for Disaster Management

The goal of the SDI for hazard or disaster management as well as the goal of the NDIN is to decrease potential level of loss caused by disaster, by undertaking relevant measures involving information collection, analysis and dissemination of value added info products further to different processes. The complete information infrastructure is composed of three elements: knowledge, interconnectivity and integration, with the focus on the latter one as a factor of stakeholder satisfaction.

The scopes of the information network included (adapted from DITF, 1997):

- the inventory of available spatial and non-spatial information on particular hazards, and possibilities of metadatabase creation for assessment of data source, reliability, completeness, lineage, standardisation etc.; providers’ view (knowledge infrastructure)
- data and process flows between different elements of disaster management process, procedures to obtain data (interconnectivity infrastructure)
- provision of access to the metadatabase and distributed databases together with the assurance of organisational architecture and security of technical components (standards, protocols, system of quality assurance, system performance tracking).

2.3 Dilemmas of systems development - choice of methodologies

The development of information system and, in wider sense as approached in this research, development of an information infrastructure on the base of information systems, is presented here in the context of system analysis theory. In this research, as in natural systems modelling, an information system is perceived as a complex structure of elements of technical (i.e. hardware, software) and human (i.e. users, decision-makers, developers) nature, together with the relationships between these elements; constrained by organisational, legal, financial, social, etc. conditions and serving a particular (required) purpose. It is important to note that the relationships among human and technical elements are not only seen as parts of the system, but they are treated as fundaments for forming the shape and purpose of these same elements. This part of the research is therefore focused on choosing the appropriate methods for analysis and interpretation of the relationships appearing in the studied environment, to be able subsequently to investigate information system requirements and to model UHII. Described system approach requires careful choice of information system development methods, relevant for the observed organisational setup, relationships between stakeholders and problem situation. The appropriateness and relevancy of application of so called hard (technology oriented) and soft (human-centred) methodologies is tested, as well the known ways of mixing different of methods are described to decide on the final shape of UHII development methodology. The guidelines are taken from the literature on system development, system dynamics, and operational research in the context of social theory (see below sections of the present chapter) and from the analysis of case studies (see chapter 3).

It is important to remind that the system development as a solution to the research problem is not the assumption of the research and that the investigation of a demand for UHII and its components is a part of the research as well, as presented in Chapter 3.

2.3.1 Philosophy, Social Sciences and System Development - paradigms and methods

There are different ways of dividing existing approaches taken in the field of Information Systems Research, and the terminology used in different sources can be very confusing. Mostly, the categorisation of methods can be observed via putting technological and structured background of system development in opposition to social, human-centred base for system implementation, non- (or semi-)structured. The following types of most common "methodological antonyms” can be noted:

1. “Functional” vs. "Interpretative” methods
2. "Quantitative” vs. "Qualitative” methods
3. "Positivist” vs. "Non-positivist” methods
4. "Hard” vs. "Soft” methods

To explain the meaning of the above antonyms for grouping different IS development methods, a description of objective (functional, quantitative, positivist, hard) and subjective (interpretative, qualitative, non-positivist, soft) dimensions of the system development (and requirements analysis) has to be presented. The underlying concepts come from the social theories and philosophy, and refer to:

**Ontology** addressing the science of representation of real objects, abstract concepts and other entities existing in the domain of interest, and the structural (often hierarchic) relationships between them (i.e. data dictionary, semantic description, definitions of used terms, etc.)

**Epistemology** addressing the issue of communication of the knowledge, philosophical theory of knowledge and its collection, transformation, dissemination,

**Human nature** addressing the ways that individuals interact with the surrounding environment, and finally

**Methodology** understood for this research as creation of the operational plan for system requirements analysis and development created in relation to the above concepts.

Supported by sociology of change, in its radical and regulative approaches, the discussion on subjective and objective dimensions of ontological, epistemological, human nature and methodological concepts has lead Burrell and Morgan (1979) to the development of a below schema

![The subjective-objective dimension](source: Burrel and Morgan, 1979:3)

**Figure 2.3: The subjective-objective dimension, source: Burrel and Morgan 1979 after Clarke, 2001**

In terms of ontological discussion, the schema (See Fig 2.1) shows the opposition of two aspects regarding the perception of reality and objects existing within it:

**Realism** - objective approach, according to which the reality is objective and external to the observers
Nominalism - subjective approach based on individual consciousness and individual perception

An example of the practical representation of these aspects can be the analysis of public opinion on risks of nuclear power plants (nominal approaches) vs. scientific data on probability of risky accident (realist approach to the hazard). Public opinion is here a derivative of individual perception of risk, related to the personal, thus subjective, feeling of threat caused by technology, perceived in a subjective way as not always trustworthy. This raises the question on what "types" of risk to consider in the analysis of UHII information requirements - is the objective hazard information in the interest of potential UHII stakeholders or does subjective risk perception play more important role? The focus on realistic approach is being taken, supported by existing data on urban risk classification and quantification based on experiments and statistical analysis (see Chapter 4 in reference to the use of Schadenscenarioboek and Windhoek groundwater vulnerability study).

The second element of the schema is the epistemological domain that regards communication of the (subjective or objective) point of view on the world to the wider public. The ways of knowledge communication are based on the following views:

Positivism - objective approach, according to which it is possible to communicate the knowledge in a structured, tangible form, independent on subjective views on the domain.

Anti-Positivism - subjective approach, treating the knowledge in a soft way, related to the perception of personal experiences, communicated with a bias of individual views.

The positivistic research would focus on the hard, tangible objects i.e., hardware, network connections, data transfer protocols, etc., while the approach of anti-positivistic researcher would bring to the discussion such issues as capabilities of individuals to communicate and assimilate the computer knowledge, i.e. usability and "user friendliness" of software interfaces, expectations of users towards performance of certain applications, etc.

The third domain of the analysed model is the human nature, presented here in the context of positioning an individual in certain external conditions:

Deterministic - objective approach, stating that a human being is dependent on the objective circumstances in which it has been placed regardless its will

Voluntaristic - subjective approach, emphasising the free will of a human being as a driving force for creation of external environment and shaping the circumstances in a subjective way, according to the wishes and requirements of individuals.

The example of such approaches observed in a real research situation, can be seen in investigation of attitudes to risk mapping among municipal managers and decision-makers. Risk maps can be seen as necessary to visualise existing hazards and plan for the response in case of an emergency (deterministic view) or as well they can be used for disaster mitigation via inserting them into the spatial planning and spatial development control processes, in order to change existing hazard distribution and control its future pattern (indication of the voluntaristic will to improve existing conditions).

The fourth concept of the Burrell and Morgan’s schema - called there as well "methodology", is actually a derivative of the characters of the previous three elements. Such methodology for system development, in the opinion of the author of this research, should not be treated as a separate concept on its own, unless it regards investigation of past IS development initiatives, either for discovery of IS failure or success reasons. It is due to the fact that a choice of methodology to be applied for developing an information system should be made after the analysis of the problem situation and its background, i.e. in relation to subjective/objective aspects of the situation viewed from ontological, epistemological and human nature point of view. It would assure the used method to be case-relevant (see the discussion undertaken on appropriate choices of methods in the below referred articles and other sources, i.e. discussion groups on system dynamics) and leading to accurate assessment of system and user requirements. The dimensions of the methodology shown in the schema regard two aspects:
Nomothetic - objectivist, rooted in a systematic analysis of a number of events and leading to conclusions on universal laws, and

Ideographic - subjectivist, discovering the reality through the individual opinions and concerned with the influence of these views on the possible change of real situation.

The nomothetic methodological approach logically would follow realistic ontology, positivistic epistemology and, deterministic perception of human environment, focussing on the technical and hard aspects of implementation of IS. Ideographic approach would come after nominal, unstructured problem definition, extensive focus on individually customized ways of communicating IS functionalities to the users, and critical approach to observed environment characterised by the will of change.

Clarke and Lehaney (Clarke and Lehaney (1999) after (Clarke, 2001)) positioned different information system development methods within a framework of categorisation of philosophical and social theories created by Burrell and Morgan subsequently to the above-described schema (Burrell and Morgan, 1979 after (Clarke, 2001)). The Burrell and Morgan’s model is based on four paradigms, related to ontology, epistemology, human nature and consequently chosen methodological approach. It pictures the social science approaches in a matrix of subjective vs. objective and regulative vs. radical change attitudes (see fig 2.2).

![Model of Four Paradigms in System Development](image)

Figure 2.4: The four paradigms and information systems development methods; source: Clarke 2001

The four paradigms presented in a matrix are: functionalist and radical structuralist on objective side, and interpretative and radical humanist on subjective side:

**Interpretive** social theory paradigm, based on subjective views’ analysis and associated closer with the sociology of regulation - regarding implementation of changes in a society/organisation in a gradual way, preserving status quo of an entity, based on consensus and acting within accepted hierarchical structure; user-centred approaches in SD adhere to this paradigm

**Functionalist** paradigm, ”regulative in nature, highly pragmatic, often problem oriented, and applying natural science methods to the study of human affairs” (Burrell and Morgan, 1979: 26, after Clarke ). Unlike the interpretive paradigm, the functionalist approach to organisation theory can be characterised by both subjective or objective point of view on the IS research.
2.3. Dilemmas of systems development - choice of methodologies

Following the example given by Clarke (2001) a user-centred requirements analysis incorporated into structured methods gives more interpretive context to the functionalist views. It is as well important to note that subjective user views do not conflict with functionalist approach as long as there is a functional ground given to the synthesis of these views. In the aspect of organisational and social change both functional and interpretive paradigms are seen as regulative - acting within existing structures, conforming to them and accepting the observed constraints.

Radical humanist paradigm, on the contrary, binds the subjective aspect of interpretive approach with a tendency to impose radical changes in the environment by “overthrowing or transcending the limitations of existing social arrangements” (Burrell and Morgan, 1979: 32 after Clarke).

Radical structuralist paradigm ”shows similarities with functionalist theory, but advocates radical change through structural conflict, which finds its place in organisation studies through form of direct political action” (after Clarke adapted from Burrell and Morgan).

Radical approaches question acceptance of existing organisational and social conditions and constraints at the starting point to the system development. Radical humanist paradigm focuses on introducing a change in social inter-relations, whereas radical structuralist addresses the institutional (political, organisational, authoritative) hierarchical structures as the subject of change. It is common for both approaches to emphasise the meaning of action of an individual to emancipate "from the structures which limit and stunt his potential for development” (after Clarke adapted from Burrell and Morgan).

The sociology of radical change is concerned with revolution of the status quo, structural conflict, modes of domination (imposing changes), contradiction, emancipation (liberation from the old forms), deprivation (denial of some of the needs to achieve the goals), and potentiality (looking for and creating fresh opportunities rather than acting within the actual constraints and institutional boundaries) (based on Burrell and Morgan, after Clark). The radical change approaches have a lot in common with the Critical Social Theory, discussed later in the below sections, and regarding, in the context of this study, the system-based need for changes in social, political and hierarchical structures and knowledge distribution patterns among potential system stakeholders. The existing soft and hard system development methods can be re-shaped in accordance to the four paradigm model, in order to take into consideration the critical element. Therefore the set of re-shaped methods creates a new reference in the group of methodologies: ”mixed approaches”, ”total systemic approaches”, or ”system of systems approaches” studied extensively since the 1980s by various system development and operational research professionals including Jackson, Flood, Keys, Daellenbach, Dobson, Falconer & Mackay, Midgley, Lane, etc. (see further explanations and references in the below section).

2.3.2 System development approaches and methodologies in an organisational context

Differences in perception of organisational performance can be traced from the past by positioning together such works as F.W.Taylors Principles of Scientific Management (1911) on the theory of management of tasks, and Webers theory of bureaucracy (Weber 1946, as quoted in Obermeyer and Pinto, 1994)). The first approach corresponds to a functional and systematic (therefore structured) approach in managing the organisation, by crisp division of atomic activities and creation of hierarchic, functional organisation levels. The latter explains the growth in power on engineering level (in opposition to the managerial one), related to the uneven cumulation of knowledge (and thus power) on the processes performed by the organisation. The obstacles created due to bureaucratic power are often concentrated around one or few persons holding the procedural tools that can block or delay the decision-making processes. Such bottlenecks, although created locally, can affect global processes in the organisation, and together with the lack of transparency of information flows can make
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The sociology of regulation is concerned with:
- The status quo
- Social order
- Consensus
- Social integration and cohesion
- Solidarity
- Need satisfaction
- Actuality

The Sociology of radical change is concerned with:
- Radical change
- Structural conflict
- Modes of domination
- Contradiction
- Emancipation
- Deprivation
- Potentiality

Figure 2.5: The differences between radical change approach and regulative approach; source: Clarke 2001

the analysis of information problems very difficult. Below the discussion on different approaches to system development relate to overcoming organisational bottlenecks caused by different factors. The issues of bureaucracy and functionalism are broadened with concepts arising from the context of system development in an organisation.

2.3.2.1 Organisational problem or/and information management problem?

Organisational problems in this research are referred to in a narrow view; only these problems that affect the performance of existing and to-be-developed information systems are taken into consideration. In other words, the focus of this research is on such organisational problems, that affect information flows inside- and among stakeholder organisations. We are fully aware that information system development cannot be treated as a solution to organisational problems, still it is an imperative to show that a lot of such problems can have a direct effect on the information management and, consequently, on the decision-making processes in an organisation.

An information system, to efficiently support decision-making processes, should be implemented in an environment where either the institutional problems do not affect information management (what in subjective opinion of the author is very unlikely to appear) or where the organisational problems were carefully analysed in terms of the effect on the IS performance and life-cycle, to be able to foresee and prevent from problems in development of desired system. The analysis of problem background and its influence on information management processes should be done in relevance to the problem origin. This can showed by a pattern in categorising methodological systems approaches by Jackson and Keys (Jackson and Keys 1984, after (Daellenbach, 2001)) on the basis of subjectivity/objectivity and complexity of cases as regards the organisational background. Their analysis shows how to combine different methodologies on the structured theoretical basis to keep the goals and criteria of the system development.

The model of organisational problems created by Jackson was further adapted by Daellenbach (Jackson, 2000) as quoted by (Daellenbach, 2001)) to represent classification of problem situations and link them with system approaches relevant for responding to different problems. The Daellenbach’s model (Daellenbach, 2001) on the information systems approaches is practically consistent
with other system development methods categorisations, presented further in this section. The difference is only that Daellenbach positions the same paradigms on the platform of different contexts.

The first aspect in the categorisation is a complexity of organisational problems, which is understood by Jackson and Keys as a number of problem elements and their interactions. This complexity, according to Daellenbach (Daellenbach, 2001) can belong either be of technical origin (physical, mathematical, or computational nature of the problem) or human-related, social origin (related to relationships between stakeholders). The other important aspect (see the above referred source) is said to be the divergence of values and interests in the organisation, where on one extreme the opinions of the stakeholders are very similar or the same (unitary diversity), or, at the other extreme, all the views can be conflicting (coercive diversity). In the middle there is a variety of pluralistic views, possible to reconcile during a decision-making process (pluralist diversity).

In his work Daellenbach explains that in **Functionalist systems approach** a system is objective and independent from the observer’s opinion, but still it’s boundaries and scale of performance can be viewed differently by different users. It is crucial for this approach however to be grounded in commonly agreed goals and objectives expressed by the stakeholders. Consequently the **Functionalist systems methodologies** apply when the objectives of stakeholders are known, clear and consensus has been achieved, the problem is structured, it’s elements (variables) and the relationships are possible to picture in a systematic, quantitative way, and the problem itself is mostly of the technical nature, largely independent from the human factors. These methodologies include (after (Daellenbach, 2001))

- **Hard system approaches:**
  - Traditional MS/OR
  - RAND type systems analysis 1955
  - Systems engineering
  - System dynamics 1956
- Organisational cybernetics as Viable Systems Model (Beer, 1959)
- Complexity theory (1963)

**Quantitative methods** such as statistical analysis, computer simulations, mathematical modelling, spreadsheet calculations, can be used to support most of these methodologies.

**Positivist and non-positivist system approaches** According to Burrell and Morgan (as quoted by (Donald J. Falconer, 1999)) the positivist approach

"characterises epistemologies that seek to explain and predict what happens in the social world by searching for regularities and casual relationships between constituent elements"

It uses a framework in which the research questions and hypotheses are created early, methodologies are chosen in advance in relevance with the research domain. Such approach is possible for known and predictable research framework, with well planned and structured research design that is independent from the background situation of the research. It may be irrelevant to apply this type of approach when dealing with uncertain and complex social problems, due to unpredictability of some of the research patterns. Positivist research stands in opposition to exploratory research, where the changes in research domain are being discovered and methodologies are applied depending on the results of step-wise research outcomes. The non-positivist approach denies necessity of looking for universal laws and regularities appearing in the social domain. It assumes the very relativistic character of the society, possible to analyse through the individual views only. Detailed observation, involvement and approaching the study first from practical rather than theoretical side are the characteristics of this approach (Kaplan and Duchon 1988, source (Donald J. Falconer, 1999))
On the pole opposite to the positivist and functional approaches there is the **Interpretive systems approach** in which analysed different users’ world views are seen as personal conceptualisations of system elements’ interrelationships useful for the users and understandable for the developers when picturing concepts of desired system behaviour. The background for interpretive system analysis should reflect willingness of stakeholders to share the interests to certain extent and to agree on the goals an objectives of the system. Followed, the **Interpretive systems methodologies** are often treated synonymously with **Soft system approaches**, with their analysis of unstructured problems of human origin. The problem situation addressed by soft methods is usually complex and the core of the problem lies in the social and cultural structures of analysed entity. Different stakeholders involved may very likely have different and even conflicting points of view, different objectives are pictured in the discussion on system development and the system itself cannot be actually conceptualised until the background environment is restructured and prepared for system introduction. The interpretive methods focus therefore on structuring the problem situation and help in negotiation for consensus among stakeholders more that on the system design itself. Within these methods objectives of SD are pictured and the common agreement is made as for the system boundaries.

The widely accepted soft systems approach is Checklands (1981, after (Veeke, 2003)) Soft Systems Methodology (SSM), which in 7 steps goes from the description of and discussion on an unstructured problem through conceptual modelling to a plan of action for improvement of the situation.

The confusion might arise when specifying which method does or does not belong to the interpretive systems methodologies. One should observe that so called **Problem Analysis Tools and Strategic Management Tools** may be used as integral parts of interpretive systems analysis. These contain:

- Tree Analysis (for problems and objectives)
- **SWOT Analysis**
- Logical Framework Analysis

The research design tools supporting the above methods include Stakeholders Analysis, Interviews, Workshops, and such organisational planning and management tools as Training Needs Assessment and Cost-Benefit Analysis (Liza Groenendijk, 2003). According to J. Rosenhead (after Daellenbach 2001) there is a group of **Problem structuring methods** distinguished among interpretive SD methods including: Hypergame Analysis, Metagame Analysis, Interactive Management, Operational Gaming, Robustness Analysis, Soft Systems Methodology (SSM), Strategic Assumption Surfacing and Testing, Strategic Choice Approach, Strategic Options Development and Analysis, Drama Theory Choice Approach, and recently Theory of Constraints (see: (Rosenhead, 1989)). Daellenbach observes that most of these approaches were developed as an answer to practical problems in consultancy work on system development and that most of them, though successful, are actually used ad hoc.

Veeke (Veeke, 2003) differentiates soft and hard system approaches after Flood and Jackson in a way similar to Jackson’s and Daellenbach’s approach to interpretive vs. functional system approaches (see: Daellenbach 2001 ). Hard approaches see the system as “logically based and capable of unbiased description” and the problem is assumed to be “stated right and unambiguous”. To the hard approaches Veeke includes Operations research, Systems analysis, Software development, Database design and systems engineering. This classification is made on the higher level than Daellenbach’s - where Daellenbach discusses particular system development methods, Veeke refers to the general level of approaches to organisational change. Similarly Soft system approaches described by Veeke as [considering] system [being] a subjective perception: dependent on the observer the same system is presented in different ways. The objectives of the system may differ from the personal objectives of the observer defining the system, thus Veeke after Flood and Jackson supports the statement of Daellenbach that soft or interpretive approaches, aim to understanding and defining clearly the problem, addressing the questions on “What” [is the problem] not “How” [to solve it]. Moreover, Veeke takes the view on the hard approaches as the integral part of the soft ones, meaning that hard system approach methods can only solve the problem after the consensus on (subjective set
of) problem definition. This implies application of soft approaches as prerequisite to the application of the hard ones.

Following this line Veeke analysed the applicability of several conceptual system models in development of a logistic system, allowing for structured development but taking into account soft system approach: Soft Systems Methodology (SSM) of Checkland, (1981), the Formal System Model of Macauley (1996), the Viable System Model of Stafford Beer, the Steady State Model of in ’t Veld, and the Control Paradigm model of De Leeuw. To capture the complexity of a potential system and to build it in an agreement with the (soft) needs of its all elements Veeke treated the CATWOE principle (coming from SSM) as initial criterion for models assessment, where a picture of Customers, Actors of an activity, Transformations performed by the activity, World view of the activity, Owners and external Environmental preconditions have to be captured by the conceptual system model. For the further hard systems approach in development of logistics system model Veeke needed to be able to picture objectives of CATWOE activities, what appeared to be a gap only in Soft Systems Methodology. All these conceptual models are related to open purposive systems, which means that they serve development of an interdisciplinary system (meant to be used by different disciplines sharing common objectives), seen as defined by in ’t Veld (in ’t Veld 2002, after (Veeke, 2003)):

"set of elements that can be distinguished from the entire reality, dependent on the objective of the researcher. These elements are mutually related and (eventually) related with other elements in entire reality"

As regards to the UHII development, its interdisciplinary use can be performed as long as it consists of a set of elements supporting different disciplines, but overall still bringing benefits to Urban Hazard management. This conclusion is drawn on the base of the interdisciplinary approach to disaster management, linking different processes for better prevention, mitigation and preparedness for disasters as well as for better response to emergencies. In the light of the above concepts UHII shell be an application oriented infrastructure, built with a very strong relation to the existing spatial planning information system and to the existing elements of spatial data information infrastructure. If such elements do not exist yet, the UHII should consist a simple base for spatial data exchange and sharing itself. As well there should be an analysis made on the type(s) of user-required information system(s) constituting the core of the UHII.

The analysis of Veeke shows that there are in fact several ways of structuring system development, based on different applications and different conceptual system models, that merge soft problem structuring methods and hard (functional) approach in system modelling. Each of the chosen conceptual models has some advantages and drawbacks, and to choose proper approach to conceptual modelling it is necessary to remember about the case-specific requirements and criteria for the preparation of a final product, UHII model in case of this research. For the needs of this research the conclusion to be drawn after Veeke is that to provide a lower level system UHII model, picturing functional relations between system elements (e.g. by the means of detailed process and information flows analysis), its conceptual model has to have the following characteristics:

- objectives of particular activities have to be clear; which means, that the soft approach is meant to be applied in a step preceding modelling for defining these objectives in detail;
- applicability of the hard approach has to be assured by passing system objectives via its "function" or "process" elements rather than detailed "activities", which means that in next steps of UHII modelling it should be possible to map UHII as a system via the means of "functional analysis" representing processes executed with relation to UHII, data sources for the processes (e.g. "data stores"), and the system boundary should be clearly defined to separate terminators coming from external environment from the internal system environment;
- Needs of external environment (stakeholders but as well processes) have to be translated into data demand/supply chains - particular target functions of the system, to keep the structure of functional analysis and to keep separation of external and system environments;
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• there should be a control mechanism introduced to the model to translate the needs of the environment into above mentioned data requirements. In this research the user-centered requirements analysis will have to be validated, or cross checked with other method, in order to prevent from building UHII on the basis of the biased and conflicting user views. Here the Critical Systems Approach will be used.

• since the attempt in UHII modelling is similar to Veeke’s in terms of serving multiple disciplines by an interdisciplinary system, UHII model can be created in close reference to chosen relevant aspects of conceptual "PROPER” model of Veeke.

It is crucial to state here that the above mentioned conclusion cannot be taken directly into consideration when modelling UHII until it’s validated by other approaches. It is due to the fact that Veeke focused on preparation of a framework for a model of logistic system, which has some characteristics common with UHII (data can be treated as a product, infrastructure as a operation system to provide delivery, producers as a resource base, etc.) but it’s scope narrower than of the desired model of information infrastructure, which has to address as well metainformation management structures, and in detail data exchange methods (as assumed at this stage of the research - at UHEMIS level). Moreover, Veeke didn’t explicitly incorporate another very crucial type of system development approaches (although mentioned in his work), which is the Critical Systems Approach.

2.3.3 Critical systems thinking and critical social theory

Critical Systems Thinking, as developed since 1980s after the works of Jackson, Mingers and Ulrich, attempts to give a new view of integration of different soft and hard methods by critical analysis of their advantages and disadvantages and relevant application of multiple approaches. Critical Systems Thinking is not a methodology on its own, but it is supposed to serve as a guide into the "methodological pluralism” or application of multimethodology, allowing to decide on suitability of methodological choices for particular system purposes:

"by the critical awareness of the strengths and weaknesses of different methods and methodologies the most appropriate ones can be chosen to address (individually or in parallel) a wider range of problem issues than a single method can…[…] …[different methods] used in combination […] or aspects of one can be borrowed and incorporated into another for more effective results” (Daellenbach, 2001).

The example of critical system thinking operationalised into the complete "methodological tutorial” can be Flood’s and Jackson’s Total Systems Intervention (TSI) (1991) coming after the accepted Jackson and Keys System of Systems Methodologies (SoSM) (1984). The TSI is so-called meta-methodology

"for guiding the practice of systems intervention within a critical system thinking framework” (Daellenbach, 2001)

, suggesting 3 phases of SD: creativity (viewing organisation by means of metaphors as a machine, organism, etc.), choice (of a main methodology for SD and supporting methods), and implementation (of a change in organisation through the system). This approach was initially chosen to be a framework for UHII development research, but it had to be validated against the other approaches and the use of critical thinking theory had to be specified in an operational way for application in creating the guidelines for policies and strategies for UHII implementation. This is to prevent from assuming the relevancy and suitability of TSI for the studied cases.

Both SoSM and TSI were criticized in the discussion on the criteria of choice for the methods to apply in SD, and the choice to be made on whether the SD modelling is an answer to the problem. According to Lane the criticism is addressing different levels of the theory: the deeper philosophic paradigm level (appropriateness of use of Habermas theory), theoretical (choice of proper Morgan metaphors, see: (Morgan, 1986)), practical (real possibilities to choose and understand the complex methodologies and interpret their outcomes properly), and even the way the message was passed.
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through the work was criticized ("tone" of the book). (Lane, 1995). Moreover, the treatment of System Dynamics by Jackson and Flood was assessed as "ill-informed" (source as above), as it lacked among the others a reference to incorporated representation of values and goals within the models, and possibilities of deep qualitative system analysis. Coming back to the work of Veeke the conclusion could be drawn that his analysis, fundamental for creation of logistic conceptual system modelling, answers the requirements of Lane and it could be treated as an operationalised and extended approach to complex system modelling. Still Veeke’s work it evidently lacks the background of the real critical social theory, but it might have been simply not relevant in the single logistics application modelling of Veeke. Concluding, to make the use of Veeke’s, Jackson and Flood and other approaches, and to find universal guidelines in mixed methodologies discussion, the critical approach has to be given priority after the analysis of system objectives, deciding on the way to model or even if to model, and after detailed analysis on the suitability and goals of chosen methods.

The Critical Systems Approach was discussed by numerous system development researchers, including Clarke, Jackson and Flood, Jackson, Dobson, Daellenbach, Veeke, Midgley, etc. It is a discussion developing on the base of Critical Social Theory (referred further as CSoT) and their paradigms as stated e.g. in Burrell and Morgan’s work on Sociological Paradigms and Organisational Analysis (after). The roots of CSoT can be actually traced back in the work of Kant (1724-1804) and the modern research in this direction is known through the works of Foucault and Habermas (after), but it is in the 1980s that this domain was incorporated by management science, and subsequently by the SD research.

The main statements of CSoT regard the critical approach of human beings to existing conditions and constraints of the environment (e.g. in the social or organisational context) and are expressed by the same statement that describes the aspect of radical change (see: 2.3.1).

Daellenbach, naming the above mentioned Critical System Approaches the "Emancipatory Systems Approaches", claims that Critical Systems Approach can be located

"in the overlap between sociology, organization theory, systems thinking and by extension management science"

(Daellenbach, 2001). It builds on the functionalist and interpretive approaches, denying their acceptance to

"existing inequalities of wealth, status, power, authority, gender, race, and sexual orientation, and [...] to those views and interests of those who have no voice in the decision-making process, but who suffer the consequences, including the future generations, non-human species and environment"

These approaches are said to be mainly used for emancipating the society from political hierarchies in order to strengthen the civil society, fight the poverty and protect the environment. In Veeke’s opinion (Veeke 2003) the critical approach serves for assessing social conditions of applicability of hard and soft approaches existing social structures. In such way it may be concluded that critical approach can help in assessing feasibility and relevance of soft and hard solutions in terms of providing necessary pre-conditions for system development project and for planning the time needed for achieving organisational change. One has to remember, however, that emancipatory approaches have been assessed as suitable for dealing with the situations of moderate complexity, where the views of stakeholders are significantly different - there is no agreement on the relevancy of the system, and on the shape of it’s boundaries.

Remarks: The critical approach to application of single methods was a base to create mixed methods following cross-paradigm approaches. It is mainly the combination of soft and hard methods, seen as methodological "triangulation" but not necessarily complete in terms of social change analysis influenced by the system implementation. The critical system approach, treated as an umbrella for mixing methods, can be of a better choice in case of developing countries than the triangulation, since it gives a more complete view on the complex organizational and educational problems to be dealt with during the requirements analysis. Moreover, the proper balance of soft and structured methods, followed by critical analysis of core research outcomes in reference to the preliminary
study, can prevent from obtaining biased system requirements results. The criteria for choice of the most relevant methods of system requirements analysis and development are presented in Chapter 3, there as well the details of chosen methodology are described in relation to the above theoretical discussion.
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Chapter 3

Urban hazard data management and it’s needs analysis methods

This chapter presents the process of creation of the methodology for introducing Urban Hazard Information Infrastructure in Windhoek, where the demand for UHII was evidently recorded, but where the urban hazard management and disaster management processes were in their very initial phase of development.

The preliminary study on the implementation of the risk mapping infrastructure in the Netherlands is used as a reference, which highlights the bottlenecks in the information infrastructure development process. They relate to intra-organisational, inter-institutional, legal, technical and other issues, that should be considered before and during introducing UHII to the Windhoek institutional environment. It is done to avoid repeating by the Windhoek stakeholders the negative data management experiences of their Dutch colleagues. The differences in level of development of organisational structures in Twente and Windhoek are presented as they affect the ways in which information infrastructures can be implemented. Additional attention is given to social issues in information system development, to avoid a bias of SWOT analysis and user-centered requirements analysis, resulting from the weak organisational conditions and wrong assessment of the needs by the stakeholders. Finally the model of methodology for UHII requirements analysis is presented as developed from the mixed soft and hard methods approaches with the reference to the Critical Social Theory.

Hereafter we refer to the Urban Hazard Management (UHM) or Integrated Urban Hazard Management (IUHM) as to the inter-disciplinary process integrating disaster management activities with different urban management activities such as land use planning, spatial development policies making, infrastructure planning (water and sewage, gas, electricity, phone, IT), etc.

In this sense UHM supports urban development in a sustainable sound way, assuring creation of a safe urban environment assuring prevention, mitigation and preparedness to man-made disasters in all phases of spatial planning. This shifts the focus from disaster response and recovery to prevention or mitigation, and from Disaster Management towards Integrated Risk Management. The term RISK instead of a DISASTER indicates here involvement of analysis of social and economic elements at risk, mapping potential disaster effects in a spatial context in order to take spatial, social and economic development measures to diminish risks and prevent disasters.

When difficulties in urban hazard management decision-making are caused by bottlenecks of information flows (see 1.2.1.1) the question should be raised on how to solve information supply and management problems in investigated institutions in order to improve their product or service delivery, and how to obtain a feasible vision of an information infrastructure development from chaotically expressed needs for more data, for more accurate information, better information communication and better technical infrastructure? This two questions raised during the research, relate to the following main research objectives (see 1.5.1) put hereby in focus:

1. Investigation of a demand and potentials for Urban Hazard Information Infrastructure (UHII) and
2. Developing a method for analysing demands and requirements for development of UHII; and
3. Identification of bottlenecks in managing urban hazard information and drawbacks for decision-making processes in UHM and SDC

The developed methodology for obtaining UHII requirements analysis should allow for:

- identification of demand for- and potentials of the UHII
- investigation of the influence of internal and external institutional conditions and on-going geo-information infrastructure initiatives on the relevance and feasibility of UHII development and implementation
- identification of Urban Hazard Management process bottlenecks and data management problems and creation of guidelines for developing solutions feasible in the investigated institutional context
- prioritisation of UHII development criteria within the obtained user-centred requirements in order to assure long-term functioning of UHII
- validation of research results in terms of a bias of requirements analysis and Urban Hazard Management process analysis in order to assure the quality of the guidelines for UHII development

The above terms must be fulfilled in the conditions, where the iterative direct contact with the potential UHII users is not possible (Rapid Application Development approach cannot be applied), where the organisational analysis is semi-structured or unstructured with qualitative and not quantitative outcomes (e.g. due to the dynamic and changing organisational setting), and most of the research outcomes (both in terms of UHII requirements and organisational requirements) are biased due to the lack of awareness on the data management problems in the investigated institutions.

Therefore by the development of the methodology in this research we understand creation of a specific framework for application of already known tools and methods for institutional background analysis and information system requirements analysis. Such framework should combine the advantages of known information system development methods tailored to the internal organisational context and external institutional environment, allowing for- and stipulating the multi-institutional data exchange and sharing in order to assure better Urban Hazard Management.

The process of methodology development should answer the questions on what tools and methods to apply in order to record demand for UHII and further on UHII requirements, and it should focus on the new approach to the analysis of the collected data. The analysis of results must bring an assessment of a bias, correction of results and creation of guidelines for a sustainable way of introduction of an UHII, so that it was not a single-project short-time scenario. The assurance of livelihood of UHII within the institutional environment should be done, with the reference to the existing missions and visions of the target stakeholders. The choice of the UHII leadership should be done and the possible division of responsibilities between the stakeholders in UHII implementation should be discussed. The new methodology should highlight the ways of identification of problems possible to encounter when setting up the information infrastructure, in order to be able to create accurate scenarios of UHII implementation. Still, it is not the attempt of this research to give all the answers for envisaged problems, the attempt is to be able to picture the possible drawbacks and weaknesses of the potential information infrastructure, starting from the demand analysis and finishing at the creation of a prototype application for support in disaster mitigation and emergency planning.

Main practical considerations were on HOW to integrate structured and soft approaches to information systems development in order to obtain the best feasible solution for UHII introduction in a multi-institutional background. It was taken as an evident assumption that modelling of UHII functions and architecture will have to be preceded by detailed analysis of institutional background, to come up with a solid base for sustainable UHII, rooted well in a social organisational environment. The institutional background analysis was intentionally differentiated from the analysis of stakeholders: the objectives of the first were to provide description of characteristics of organisational
environment, whereas the latter was to indicate the UHII demands expressed by separate institutions from their independent points of view. There was a need to prepare such fundaments for the methodology of UHII development that would link organisation management theories rooted in social science, with information systems development. In fact, there exists a relatively recent (1990’s) field in Information Systems Research, that refers to mixed SD methodologies, based on combining soft and hard SD methods with the strong reference to the social theory paradigms with their critical and interpretative approaches. It is therefore proving the cultural and social organisational analysis is necessary to complement the structured system requirements analysis.

The review of fundamental System Development (SD) literature provides theoretical base for UHII introduction methodology. It as well supports the overall research aim, which is to create a functional and technological tool for data sharing and exchange, which is an information infrastructure, possibly based on a core information system, single application oriented and expandable to use in different domains. Such a tool is expected to serve in long term, answering the needs of a social institutional environment. Obtaining a balance between soft human-oriented, and structured, technology-based methodological SD approaches was then our intention, to merge the technical, functional analysis with an analysis of social organisational demands.

The research included two main pillars - tires: (1) the preliminary study, providing the reference from the analysis of case studies with a focus on Dutch study of problems in information infrastructures and systems development and (2) core study, providing the actual user-centred and infrastructure-based requirements for UHII development in Windhoek, Namibia, evaluated eventually against the recommendations arising from the preliminary study.

The preliminary study aimed to identification of the success factors in establishing SDI for hazard management support. The focus study (Dutch case) targeted two aspects - hazard data management in Twente Region, and the Netherlands national approach to spatial data management. The relationship between establishing the National Spatial Data Infrastructure and infrastructure for hazard data management was observed and the conclusions were drawn to be considered as recommendations in the core study. The analysis of problems envisaged in Dutch SDI creation would lead to a development, in a core study, of new strategies and re-adapted methods for introduction of UHII in Windhoek, parallel to the on-going development of a National Spatial Data Infrastructure for Namibia. The review of other experiences in establishing spatial data infrastructures gives the light on variety of background situations in which the information systems development initiatives take place, and the implication of these onto project implementation process. The most common obstacles and limitations for strategic improvement of information management, be it of legal, financial, social, or other origin, are being analysed. Consequently, an idea is given on methods of careful infrastructure requirements analysis and on difficulties in assessing critical success factors for SDI implementation. Each reviewed case is very much different in strategic solutions, but together they present a picture of problems that have to be solved preceding actual SDI design phase, one of which is a choice of proper requirements analysis method.

The discussion on differences between the stage of and approaches to spatial data development in developed and developing countries is raised in the introduction to the analysis of As Is situation conducted for the preliminary and core study 3.3. The insight into the stages of SDI initiatives development and their relation to the organisational characteristics provides a good reference for creation of guidelines for UHII introduction. The analysis of institutional background and target stakeholders is the base for choice of UHII introduction methods and UHII requirements analysis.

The problem of applying urban hazard data management requirements analysis in specific institutional settings is reflected by the specific research objectives (see 1.5.2), addressed in this chapter in terms of:

1. Analysing organisational demand for dissemination and sharing of data resources
2. Implication of spatial data production and usage conditions in different organisational setup on requirements analysis method, and
3. Analysis of differences in requirements for establishing (hazard) information infrastructure in different organisational setup
The overview of UHII requirements analysis methods is presented further on in this chapter, preceded by the discussion on theoretical framework for the choice of methodology and on factors determining the combination of requirements analysis methods. The background situations for data management in preliminary and core studies are as well described, in order to identify the preconditions for initiating the UHII development process in Windhoek.

3.1 Urban Hazards Data Management-driven potentials for UHII development

“There are two major forces driving the development of spatial data. The first one is a growing need for governments and business to improve their decision-making and increase their efficiency with the help of proper spatial analysis (Gore, 1998; quoted after (Williamson et al., 2003)).”

“The second force is the advent of cheap, powerful information and communications technology, which facilitate the more effective handling of large quantities of spatial data (Openshaw, 1993; after (Williamson et al., 2003)).”

The hazards remaining in the focus of this research are technological and man-made hazards, and the reference to the natural hazards is used only sporadically. It is due to the fact that most of the studies focus on mitigating and preparing for natural disasters, whereas the urban environments usually lack a widely accessible information base on technological threats, that would support local governments in decision-making for urban development. It is especially true in the rapidly developing urban and peri-urban environments. Both in developed and developing countries, there exist problems in satisfying conflicting needs arising from different types of urban actors, be it municipalities, private companies, citizens or NGOs. These actors look forward to accurate and reliable information on the possibilities of economic development (from small enterprise to the big scale public investments), or on available land and housing resources (for both permanent residence and seasonal activities), etc. This demand stipulates local governments to make the information on urban development available and accessible. Urban Hazard Information infrastructure could be treated therefore as an extension, or an integral element of already demanded wide urban information infrastructure. As well different initiatives on development of spatial data infrastructures can be supported by establishment of UHII, since they would share the objectives of providing spatial data availability and accessibility for particular spatial data users from among the above mentioned urban actors and spatial data producers as National Mapping Agencies, governmental research institutes, local government departments, consultancy companies, etc.

Apart from the above aspect, the needs for expansion of different land uses and introduction of variety of business activities on a limited space available can lead to development of such multi-use urban zone, where hazards and vulnerable objects are located in proximity to one another. An example can be here the mixed land use structure of Enschede, the Netherlands, where the S.E. Fireworks were surrounded by residential areas. Identification and monitoring of spatial relation between hazardous and vulnerable object should be incorporated into prevention and mitigation of urban disasters. The approach proposed here links disaster prevention and mitigation with spatial development control in order to provide safe urban environment, or to achieve better disaster preparedness in hazardous areas. In such a context, urban risk studies provide a very relevant input of data into the spatial planning and development control processes, as it has been proved by the practise of Dutch municipalities. To identify the hazardous and vulnerable objects, there should be enough attention given to spatial analysis of existing and planned urban infrastructure, and creation of risk maps should be one of the integral steps in spatial planning processes. Moreover, the monitoring of informal spatial development is necessary, what can be done both by the means of remote sensing data analysis or field trips, depending e.g. on RS data availability.

There has been a number of global and regional initiatives aiming to build information infrastructures for support in management of natural hazards (see 4), whereas the management of data on
urban, man-made, technical hazards requires more attention. In this research the attempt is made to understand the problems of urban hazard information provision, by learning from experiences in management of data on both urban and natural hazards (elaborated more in the subsection on experiences in application-oriented GDI development) in 4.

Before a system approach to UHII development could have been applied, an analysis of the demand for Urban Hazard Information Infrastructure had to be conducted. The following questions were therefore raised in the demand inventory to construct the base for further requirements analysis -

1. What are the demands, expressed by actors dealing with disaster management, development control and spatial data production? Do these demands consistently support the potential of UHII introduction?
2. Who of the actors should play the role of a target stakeholder(s) in the research, and who would be a potential driving force for development of UHII?
3. Is the system development a relevant approach in solving presented problem as depicted from expressed demands and what are the implications of the demand patterns on UHII introduction methodology?

The attempt to answer these questions was made in the below sections: Question 1 at 3.1.2 and 3.1.1, question 2 at 3.2 and question 3 at 3.2.3 and 3.4.

3.1.1 Demand for improved decision-support as the UHII potential

As indicated in the above paragraphs the data on hazardous and vulnerable objects have a big potential to be used not only for re-distribution of resources in emergency management but also in such domains as spatial planning, spatial development control, planning of spatial infrastructure framework for economic development, etc. The decision-makers dealing with these processes can be of various backgrounds, and can make use of the data in such detail domains as:

- validation of plans of (re)development of residential areas and public spaces,
- planning and management of water distribution infrastructure and/or sewage systems, natural resources management,
- transport management: planning and dissemination of information on road maintenance, transport of dangerous substances, planning redirection of human traffic and evacuation procedures, planning of emergency routes for public transport infrastructure, etc.
- redistribution of industrial activities of high disturbance, or high potential risk, related with the use of dangerous substances, noise, smell, requiring increased vehicle traffic, etc.
- re-allocation of community services to the local offices support more hazard-prone zones and to assure better disaster preparedness in such areas,
- creation and choice of location for programmes of public education concerning the risk and emergency management (especially valid i.e. in case of education on nuclear power plants),
- cadastral surveying, land registration and its allocation for activities related to waste management,
- valuation of land resources and real estate for different purposes including such criteria as external risk assessment - more relevant in terms of real market values than in terms of standard municipal land valuation procedures,
- mortgage valuation taking the external risk as one of the criterions,
- insurance allowances calculation, as above, etc.
3.1. Urban Hazards Data Management-driven potentials for UHII development

Mapping hazardous and vulnerable objects and creation of hazard assessment maps would provide spatial planners, decision-makers and independent investors with the information on the potential risks arising from urban activities, which can support decision-making processes in creation of spatial development plans and strategies. The knowledge of existing urban risks would help urban authorities to decide on further development patterns. The intention is that a change in urban risk distribution, imposed by implementation of particular investment, should be one of the criteria to decide on either permission, change (i.e. provision of emergency response facilities, safety systems, warning systems, etc.) or rejection of particular investment project.

To be able to re-shape the spatial development planning and control processes, by addition of development criteria arising from risk assessment, there has to be an information base provided for decision-makers regarding the urban risk situation. Urban Hazard Information Infrastructure could be seen as a facility through which spatial and thematic data are made available (and disseminated) for:

- creation of urban risk maps (including urban infrastructure plans) and preparation of urban risk analysis reports,
- assembly of urban risk maps with existing spatial plans and spatial development strategies and creation of new master plans consistent with recommendations arising from the disaster mitigation and prevention,
- creation of emergency response scenarios, and
- creation of local disaster management plans.

3.1.1.1 Demand for UHM decision-making support in Twente Region, the Netherlands

The explosion of S.E. Fireworks in Enschede caused enormous damage inside residential area of the city (death of 22 people, 14 serious injuries, and a damage of 1500 houses). The disaster was assessed in terms of effectiveness of emergency response action (Oosting et al, 2001) and it was concluded that, during the critical phases of emergency response, the possibilities to assess accurately the extent of risk were considerably limited due to the:

- Lack of up-to-date information on what was stored in the impact area
- Lack of accurate data on the exact location of tanks and inaccessible fire source
- Lack of sufficient information on the type of vulnerable objects in the vicinity of fireworks
- Insufficient data flows among the emergency units

In particular the type, volume and location of explosives stored in S.E. Fireworks, were unknown or known wrongly. Even the information on the number of people in the vicinity was missing. The supply of information was assessed to be both insufficient and unreliable (Oosting et al, 2001). The Municipality of Enschede was found to be guilty for failing to execute development control due to the lack of up-to-date information on the illegally stored explosives. Subsequently, the recommendations on management of accuracy of topographic, demographic and building use data were given a prominent position among the recommendations of the "Eindrapport" ("Final report") (Oosting et al, 2001) - the report on the S. E. Fireworks disaster mitigation and remedy assessment. Moreover, conclusions from independent analyses of two disasters (fireworks blast in Enschede and the New Year’s Eve fire accident in a Caf in Volendam) conducted by IOOV (Dutch Inspectorate for Spatial Order and Safety Management) showed a necessity of strengthening disaster preparedness by improving inter-organisational cooperation between police, fire brigades, medical rescue units - GHOR, and governmental authorities. At the start 4 regions were chosen to implement new disaster management policies - Gooi & Vechtstreek, Friesland, Limburg Zuid en Twente; these were the same first regions were official top-down co-ordination of hazard information management took place (URL6).
The lesson learned from S.E. Fireworks explosion showed that there exist the conflict between spatial/business development pressure and safety limitations that have to be introduced for urban hazard mitigation. The question of economic base for re-shaping the existing spatial distribution of land uses arises immediately when thinking of all the potential risks introduced in the urban environment: is it efficient and effective in economic terms to re-locate the hazardous objects, or is the risk to low to consider that? In any case the priority should evidently be given to monitoring of on-going business activities in terms of checking their compliance with the existing land use plans. Also collection of data on details of developed and developing building infrastructure is proved crucial in this disaster. The emphasis was given to the aspect of integration of data collected in different urban management processes, which speaks for creation of urban hazard data infrastructure as a tool to control, integrate and maintain these data for the use in disaster management. The requirements of UHM in Twente Region were analysed carefully and based on the experiences from the disaster response and on the results of detailed analysis of disaster causes the following have been concluded:

1. The municipal decision-makers should have assured proper execution of municipal laws on the amount and type of explosives stored. The lack of awareness on the illegal storage due to the lack of control activities puts the partial responsibility for the disaster on the municipality of Enschede. The conclusion is that there has to be a measure introduced to provide up to date information on on-going land use activities, especially concerning the hazardous objects.

2. Location of the storage in the direct proximity to the public spaces (a supermarket, a workspace for artists) and residential area increases the risk due to overlapping hazard influence zone and vulnerable area. Although the location of these land uses is caused historically and could not have been easily restructured, such situation should not take place in the future. There is a demand for reshaping the existing mixed land use structure to decrease existing risks and a pressure to prevent from implementation of potentially hazardous investments in the vulnerable areas, for that the access to information on existing risks and vulnerability is necessary. This can be supplied in a reliable way only in case of close co-operation of the actors involved in urban hazard management and spatial data production and dissemination. For such reason the hazard information infrastructure is seen as the best solution to co-operate in production, sharing and dissemination of data on urban risks.

3. The shortage of space and the pressure for technological, chemical, and/or large entertainment investments, etc. create the spatial development conflicts, where it is more likely to deal with the increased vulnerability and risks caused by the localisation of mutually “disturbing” land use activities. Incorporation of urban risk assessment could decrease addition of risks to the existing spatial situation. The need for conducting extra risk analysis has been recognised apart from the usual environmental assessment analysis needs, occupational health norm requirements or test of compliance with the safety norms. Urban Hazard Information Infrastructure could make the process of safety management easier, provided that it links efficiently all parties providing spatial data to the process. The main objective would be here to support decision-making on change in existing and use structure, re-allocation of investment zones and buffering the vulnerable areas.

The local, provincial and state authorities were responding very actively to the outcomes of the disaster causes and effects analysis. Governments on different levels, fire brigades, associations of citizens, ministries and ministerial geo-information management units were alerted, and the demand for spatial data infrastructure supporting the domain of disaster management grew rapidly. The detailed investigation of stakeholders is presented below in this chapter, see 3.2. The development of initiative for establishing information infrastructure supporting urban hazard management is presented among the reference case studies in Chapter 4.
3.1.1.2 Demand for UHM decision-making support in Windhoek, Namibia

The observations done in the primary and core research show that situation in Windhoek, Namibia, in terms of analysis of spatial distribution of hazards is entirely different from the one experienced in Enschede. The cities themselves play different roles: Windhoek as a capital attracts the masses from all over Namibia, Enschede is the important city in the region, but it’s location is strategic mainly from the point of view of the international transport (direct proximity of Germany) and educational institutions resources. Populations of the cities differ (Windhoek 227 thousands, Enschede no more than 150 thousands), the level of development of urban infrastructure is evidently different, so is even the climate. Still there exist one thing that allows for comparison of the spatial situation - both cities encounter problems with the allocation of land resources and struggle, or will struggle, with re-shaping the land use patterns to be able to accommodate residential and commercial uses within a limited number of parcels. In Windhoek the area still available for development is limited by relief (hills, mountains surrounding the city) and by the existence of precious and very vulnerable (due to the geological situation) acquifier in the southern part of the city. In Enschede the limitation of land resources is more related to the overall national situation where large population has to use intensely a relatively small area of the country. In both cases due to the large development pressure the introduction of investments in urban zone creates hazardous situations. In Enschede the hazard turned into a disaster event, in Windhoek still there is a space for prevention, although the spatial development trends tend to deny the importance of the problem. Recent location of the very large textile industry investment in the central area of Windhoek (Ramatex company), regardless negative opinions of environmentalists, is an example of such denial. The economic pressure, looking for solution on unemployment and poverty, and a need for generating income to support services offered by local government were the priorities when deciding on “to be or not to be” of this investment. Still, there was nothing or little done in terms of provision of the measures for public risk assessment and disaster mitigation and preparedness. This is a starting point to identification of demands for UHII expressed by local governments and units dealing with UHM.

According to the results of the core study, there are different parties of the Windhoek spatial data management interested in potential development of UHII, some of these parties, however are more interested in general spatial data exchange potential given by the concept of UHII, than in the hazard-application aspect of this initiative. In general these are:

- The City of Windhoek (municipality) with its different divisions showing the interest in both hazard management and spatial data exchange aspects
- The Ministry of Works, Transport and Communication (MinWTrCom), in particular the Road Authority Unit, responding enthusiastically for the disaster management issues related to transport of dangerous substances.
- Survey General’s Office and Deeds Office, interested specifically in establishing the framework for spatial data exchange with the CoW, to support locally the proposed state-wide initiative of Namibian SDI.

These are the main actors of the spatial data management scene, supplying the City of Windhoek with spatial data necessary for Windhoek urban management. These actors consider the potential development of UHII as a stimulation for multi-institutional co-operation in spatial data exchange and sharing that can bring mutual benefits by avoiding redundancy of spatial data, and can help in development of a local digital spatial database with the complete set of framework data, used by all the parties. Still these are not all the actors involved in production or use of spatial data on Windhoek municipal area (see 3.2), but only those who expressed their interest in UHII explicitly. Among these actors different opinions were expressed on the reasons for the demand for spatial data sharing and exchange and in particular for the access to urban hazard data to support decision-making. From the very beginning the UHII idea seemed quite interesting to all the actors, but it was never considered by the interviewers a good idea to limit the initiative of spatial information development to the urban hazard application. Still it has been recognised that UHII can become a good starting point for
further expansion to local Spatial Data Infrastructure and in the long term integration with arising national Spatial data Infrastructure.

During the fieldwork different demand drives for use of hazard data to support decision-making in different domains were observed:

**Land management problems** that have a visible relation with urban hazards when considering

- A significant pressure for the decision-makers to manage carefully the land and housing resources, appearing due to the fast population growth - Estimated annual population growth until 2031 is 4.44% (correction for AIDS/HIV impact decreases it to 1.8%), with an increase of municipal population from 227000 to 800000. Such population growth imposes dynamic land use management, with the emphasis on the provision of both residential areas and areas of business development. The latter when put in proximity to residential zones may be the source of high urban risk as learned on the S.E. Fireworks case. Attention should be given to the patterns of spatial development to prevent from putting the population at high risk of man-made or natural disasters.

- Development of large informal settlement areas hosting currently over 20% of the Windhoek population (source: fieldwork data, interviews), which is prone to fire accidents (due to the structure of materials used for building the shads) or diseases caused by lack of access to clean water or by contact with toxic materials. The informal shads are located in the suburban areas, mostly in the North of Windhoek, in proximity to the industrial zone, what might indicate large risk to which the citizens are exposed. The resettlement and/or upgrading of the informal urban areas needs the feasibility study in which both the economic aspect (pricing for municipal services and land parcels - erven) and the aspect of sustainable development (environmental assessment, balanced spatial development) play important role; the assessment of vulnerability of population and risks at which they can be put should be one of the inputs to the land management decision-making process. The importance of land management issues if measured by the percentage of the annual municipal project budget taken by provision of erven for development is very high: 89.8 Million N$ from the total 237.6 Million N$, what makes almost 38%. 2400 erven from 2800 are so called "low income erven", developed among the others for settlements upgrading and resettlement.

**Water management process** requires a lot of input data, one of the reasons is vulnerability of the Windhoek area to the long lasting droughts (average precipitation) and the necessity to provide and reclaim water from very limited resources. The existence of one natural acquifier, that potentially can be used as a reservoir of emergency water resources, is considered very important. Unfortunately, the acquifier is not isolated properly from the ground surface, there is only shallow geological cover of sands, and numerous cracks allowing for very fast infiltration of all substances from the ground surface into the acquifier. The groundwater vulnerability study conducted for the CoW indicated potential risks of water contamination in the large area to the South of Windhoek, crossed by high mobility road and designated for commercial, industrial and residential development. The study recommended further detailed research on quantification of potential water vulnerability to different land use activities. The conflict between development pressure and environmental protection is visible here, and to decide on the future patterns of Windhoek development the up-to-date and reliable information has to be provided by different parties.

**Development of roads and transportation** The Ministry of Works, Transport and Communication (MinWTrCom) expressed it’s interest in creation of policies for transport of dangerous goods and for development of road infrastructure on national scale, in co-operation with local governments. The City of Windhoek seemed a promising partner, since it in itself wants to invest 17.4% of the 2003/04 budget on roads infrastructure (41mln N$). One of the decision-making criteria for road transport control and development is the assessment of traffic accident risks
3.1. Urban Hazards Data Management-driven potentials for UHII development

Involving dangerous substances. In this point the objectives of research on groundwater vulnerability and of traffic risk studies overlap, so as the requirements for spatial data support.

**Waste management** in Windhoek due to the growing population pressure and stimulation of spatial and economic development becomes slowly a problem. Although due to the high poverty rate the re-use of all goods is very high and the products are used to the limits of their life cycle, the deposition of waste creates lots of risks. It is so because of lack of awareness among the population on the dangers of illegal waste dumping and lack of sufficient education on waste management. Lots of illegal dump sites contain potentially dangerous materials, still the extent of problem is not known (state on November 2002) due to the lack of investigation in this domain. The status of legal dumpsite was said to be investigated in 2002 in order to assess its remaining capacity and to assure the safety of environment (e.g. in terms of groundwater vulnerability); the need to upgrade or expand the wastesite was observed, but during the fieldwork there was no existing information base identified that would support the investigation of the wastesite status. Due to the limitations of time and fieldwork possibilities the problem of waste management is not in focus of this research, but its importance is recognised. Unfortunately due to the fieldwork time constraints the topic of waste management and risk mapping was not investigated closely. The recommendations coming from the investigated stakeholders speak, however, for the further research on this issue and for brief acknowledgment of the problem within this research.

**Strengthening disaster preparedness** by provision of tool to analyse and monitor the urban and peri-urban environment of Windhoek in order to prepare emergency response plans for identified problem objects and areas; considering the risks of:

- natural disasters as drought (national and regional scale),
- flood (rare, but possible, rather local scale),
- fire (seasonal in the peri-urban fringe and within the areas of informal settlements, industrial fires),
- chemical accidents (very relevant for the industrial areas and for the transport network, connecting Windhoek with South-Africa, running over the aquifier),
- water contamination (very relevant considering the vulnerability of the water reclamation system in the drought seasons),

Summarising: The decision-makers could benefit from Urban Hazard Information Infrastructure provided that it links disaster management with spatial planning and development control processes via technical, legal and institutional framework for exchange and dissemination of data used for input in these processes. However, solving problems of data provision and access should be treated as the starting point for improving the disaster management processes. Exchange of data in its technical aspect is not the only key success factor for development of safer urban zones. It is the co-operation of spatial planners and disaster managers that has to be executed carefully with the support of all parties involved in production and analysis of necessary data to assure accuracy and reliability of these data supplied to decision-makers. Moreover, all stakeholders should be taken as integral parts of UHII, actively involved in its creation and maintenance, to assure that UHII answers their real demands.

3.1.2 Demand for improved access to- and sharing of spatial data

The driving force of information infrastructure initiatives is the visible need of access to spatial and non-spatial data, that is the need to be able to detect and retrieve required datasets from the stored resources (be it either an analogue catalog, digital database, or a drawer of an officemate) in a relatively short time. This need arises from the necessity to support the governmental decision-making on all administrative levels and in all domains, for as it has been investigated 80% of all
administrative decisions are taken based on the spatially related information (Budic and Pinto, 1999; Rhind, 1999; Lemmens, 2001; after (Williamson et al., 2003)). Local authorities, ministries, citizens and investors, both in the developing and developed countries, demand substantial amount of data to support their decisions, but as well to conduct their activities and processes in an efficient and effective way. Fast access to required spatial data may influence substantially the quality of services provided by private and governmental sector. The example can be the emergency response actions in the Netherlands, conducted currently (especially after the S.E.Fireworks explosion) by fire brigades, special emergency units, police and para-medics with the use of spatial information on the disaster area, the objects and people in risk and on the emergency response support infrastructure (hydrants, local extinguishing systems, local emergency plans etc.). These data are accessible via the risk information infrastructure (risk maps on the internet and intranet in the fire brigades) and via disaster models and information systems installed on-board in the fire brigade tracks. Due to the real-time access to the information many lives can be saved.

“People need to share spatial data to avoid duplication of expenses, associated with generation and maintenance of data and their integration with other data. Also, it is apparent that spatial data constitutes much of the data required for physical disaster planning, management and recovery work. Given that natural and human disasters will continue to occur, a major issue is the ability of various users to share and access necessary data and information to prepare for the effects and to minimise loss of life.” (Williamson et al., 2003)

The data on hazardous and vulnerable objects, their spatial relations, and potential risks constitute a very specific group among the spatial information. The demand for access to these types of data is seen relatively the most among regional and local disaster management and emergency response units that require it to fulfill their missions, i.e. to prepare disaster management plans, emergency response scenarios and to build disaster preparedness status, based on the knowledge on the potential risks. Other parties also can benefit using hazard data for decision support as described in the sections above. Unfortunately, according to the results of the fieldwork both in the Netherlands and Namibia, often there does not exist an awareness of the potentials of urban hazard information for application in domains other than disaster management. The attitude to the data on urban hazards changes to a more positive one, when discussing it in the context of support for spatial planning and development. When discussing the link between these domains, the evident need of access to urban hazard data is seen for supporting improvement of spatial planning policies and in restructuring land use patterns to mitigate potential disasters. In such context the exchange of a wide range of spatial data, not only the hazard data, is necessary to stimulate spatial re-development processes. To support such process a number of framework and application-specific datasets must be delivered.

The UHII, which potential of development is investigated for Windhoek, is considered in this research in the context of development of a wide, umbrella Spatial Data Infrastructure. The UHII then is supposed to play a role of an integral, application-oriented composite of a larger global-domain information infrastructure. The development of UHII can be seen as an initiative that may significantly strengthen the on-going projects on implementation of a National Spatia Data Infrastructures, provided that there is a clear link established between local, regional and state level of an NSDI project. Demand for access to different types of spatial data initiatives for the increased access to spatial data through NSDI, initiatives for data standardisation and exchange, and initiatives for improving data flows between domain-specific data providers (stipulating inter- and intra-organisational data flows) are expressed at different administrative levels an by different actors; they refer to the same framework and base data. UHII containing a GIS-based tool for data dissemination (i.e. UHEMIS) could allow different organisations to benefit on data exchange and sharing by:

- saving money and time for data collection and maintenance due to the usage of common datasets (no redundant purchase needed)
- improved quality of data, provided that there exist procedures of mutual external quality auditing and clear agreement on quality assurance responsibilities among the parties
• introduction of common data sharing standards which may lead to common efforts in data collection and processing for the common interest areas; this helps potentially to decrease the costs of data collection and processing; and may lead to co-operation in decision-making in complementing domains.

Demands for access to- and sharing urban hazard data expressed by particular disaster management actors, urban authorities and/or spatial data suppliers was analysed for in case examples of the Netherlands (the case of increase in demand for urban risk data after S.E. Fireworks explosion in Enschede) and Namibia (slowly arising demand for strengthening disaster management in the municipality of Windhoek). These actors were identified during both the preliminary and core study, though only in the core of the research the extensive investigation of their requirements was made.

3.1.2.1 Demand for access to- and sharing urban hazard data in the Netherlands

The preliminary study investigated the demand for establishing an information infrastructure providing access to reliable and up-to-date data on man made hazards and so called external risk extents. The tragic accidents such as explosion of fireworks, and the fire in one of the caffees during the New Year’s Eve Party, made public opinion, government officials and disaster managers aware of the lack of basic information necessary to respond fast and efficiently, preventing from the disaster spread, providing safety in the vicinity of the accident and taking control over the emergency. As mentioned in Chapter 1, the accidents were considered a (partial) responsibility of local authorities, held for not executing rules of spatial planning, but the findings of the preliminary study indicate that the availability and access to up-to-date spatial and non-spatial information on the disaster site was one of the major problems. In this case the demand for open facilities of access to hazard data has risen rapidly after the causes of emergency response bottlenecks were known. This was not any more the technology-pull and supply driven approach but very strong demand-pull, market-pull and even politics-pull approach. The public opinion created the pressure that had to be answered by local, regional and state authorities. People wanted to know what dangerous objects are in their neighbourhoods and what measures are taken to prevent from disasters. The demand for access to urban hazard data was expressed by:

1. Public Opinion - to make hazard management process transparent and to have an insight in the political decisions on spatial development and its monitoring and occupational safety control

2. Local authorities - municipal bodies; under the pressure of public opinion and held responsible for ineffective control of spatial and business development responded with increased demand for monitoring of urban hazards and risk situations, risk mapping was given a priority to support professionals (fire brigades) and citizens with relevant maps. VNG (association of Dutch municipalities) and the groups of municipalities independently initiated the supra-local co-operation to identify and map the risks.

3. Governmental bodies - Ministries of Internal Affairs (supervising the Fire Brigade units) and of Environment needed up-to-date and reliable information on the extent of risks, possible accidents and their potential causes, in order to prepare the new policies for development of ICT in disaster management

4. Independent bodies dealing with spatial data management and private geodata handlers were affected by the boom of requirements for spatial data supporting DM. It resulted in increased demand for an information infrastructure handling these data, making them available, accessible and shareable. This has put a pressure on Fire Brigades and governmental bodies to produce and disseminate the risk datasets for further use, re-distribution and creation of value-added products. One can say that the market for risk geodata has opened.
3.1.2.2 Demand for access to and sharing urban hazard data in Windhoek

During the fieldwork the information on the attitude to the potential development of UHII was collected. The analysis of interviews, questionnaires and opinions expressed during the workshop indicated the set of gaps in the awareness of what activities the integrated urban hazard management process refers to and what urban hazard data are. The explanations were given, a prototype example risk map was presented at each interview and additionally at the workshop a GIS application for spatial planning support was shown in order to give a reference to the inter-disciplinary aspect of urban hazard management. Since the presentations were of limited subject area the main focus was given on free suggestions coming from the interviewees, referring to the case-specific and relevant aspects of the problem. Therefore the assumptions made at the first stages of the research on the demands to investigate were validated and tailored to the real life situation. The strong suggestions of the interviewees were considered of outmost importance for the demand analysis and were noted down carefully. However, some of the opinions must have been modified or even disregarded at the later stages of the research, due to the bias introduced mostly by the lack of awareness of what is feasible and possible in the UHII development and due to the very much short-term project-oriented approach expressed most often by the interviewees. In this section the most general demand-drives for UHII development will be presented, in order to prove the relevancy of the research approach, which is the development of an information infrastructure to support urban hazard management, with the strong link to spatial development planning and control. The detailed demands towards UHII and its elements are the subject of user-centred requirements analysis, being a subject of a 4.

A number of actors expressed their demand, interest and the will to establish a common information infrastructure for exchange of spatial data on man-made risks in Windhoek. The preliminary study provided information on the expected groups of actors to address:

1. Decision-makers - both of the spatial development processes (in multi-institutional approach, directly and indirectly responsible for spatial development), and disaster management process - municipalities, ministries, regional authorities etc., other users of urban risk data

2. Emergency response professionals - paramedical and medical units, fire brigades, police or gendarmerie, crisis management units, etc.

3. Data producers/providers - land surveyors, Deeds Registry, Surveyor General’s Office, local authorities - the City of Windhoek and it’s respective departments collecting, holding or processing data relevant for integrated urban hazard management

4. Private and business bodies (community, investors, insurance companies and banks, etc.) producing or making use of the data relevant for integrated urban hazard management.

During the core research the interest in UHII was of investigated (directly and indirectly) among the following actors was:

1. Decision-makers:
   
   (a) Municipal Authorities - The City of Windhoek (CoW)

   - Planning Urbanisation and Environment Department: Planning and Urbanisation Division, Sustainable Development Division, Environmental Division, Geomatics Division, Housing and Properties Division, Valuation Services
   - Infrastructure, Water and Technical Services: Bulk water, Building Control Division
   - Community services: Emergency Services Division, Disaster Management Division, Health Services Division, Community Development
   - Department of Finance and Information Technology: Information Services Division
   - Transportation Department: Transportation Policy, Development and Coordination Division
   - City Police
3.1. Urban Hazards Data Management-driven potentials for UHII development

(b) Ministry of Transport - Road Authority Unit

c) Other potential risk data users
   - Insurance companies / banks
   - Private investors

2. Emergency Response Professionals:
   - Disaster Managers: municipal Disaster Management Division (DMD),
   - Emergency response: Emergency Services Division (Fire Brigades and para-medics)
   - Co-ordination and disaster management: Regional Emergency Unit (the latter was addressed only indirectly through the DMD)

3. Data providers:
   - The City of Windhoek, mainly Geomatics Division (source of digital large scale value added spatial data, coming from municipal surveys and outsourced data collection)
   - Survey General’s Office (provider of topographic maps, small and medium scale)
   - Deeds Registry (provider of land ownership data)
   - Remote Sensing Unit (regional RS data provider, addressed indirectly)
   - Individual land surveyors
   - Consultancy companies

4. Private and business bodies - see Other Data Users

The following general UHII demand-drives were mentioned during the interviews and the workshop:

- A need of a domain-specific information infrastructure initiative ("a clear starting-point for making agreements on data exchange and sharing, easy to grasp in terms of practical benefits"), that would stimulate local authorities and other spatial data providers and users to initiate spatial data sharing and exchange between all the interested parties, and co-operation in spatial data production between Survey General and the City of Windhoek.
- An interest in having a GIS analysis tool for the use in disaster management, with the possibility of an instant access, download and visualisation of the data provided by external institutions
- A need for an access to the catalogue of spatial and non-spatial data available at different institutions, and on processes in which these data are used
- A need to structure and legalise the issues of copyrights and quality of data available on the market and shared out of the market
- A need to monitor the contracted use of released datasets, i.e. the use and re-use of data by consultancy companies
- A need to speed up the process of digitising of base and framework data, to answer the demand of multi-institutional environment, as well as the need of legalisation of digital added value data made on the basis of the analogue data
- The need to integrate different urban management processes, to stimulate inter-process data flows and to create the space for integrated urban hazard management, linking spatial planning, water resource management, occupational health management, traffic management, etc.

The specific detailed needs as expressed by different actors are presented below in the table of comprehensive UHII drives analysis; the numbers are not quantitative measures but ordinal and qualitative; from 0 - no demand to 4 - very high demand.
### Chapter 3. Draft chapter 3: Urban hazard data management and requirements analysis

#### Table 3.1a: Demand for information, infrastructure, and demand drive

<table>
<thead>
<tr>
<th>Actor</th>
<th>Demand for Information Infrastructure</th>
<th>Demand drive (see as well Foreseen benefit of UHII in table 3.2)</th>
<th>Demand for access to GIS environment</th>
<th>Demand drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Geomatics Div.</td>
<td>4</td>
<td>A need to exchange the parcel data and cooperate in digitisation of parcel data with Survey General, a need of near real time update of municipal GIS-related information on land transactions, land use change and business activities as wanted by the CoW divisions, need for easier and faster exchange of spatial data with other institutions for timely updates of municipal IS</td>
<td>4</td>
<td>A need for an interoperable but low budget GIS environment to replace several CAD and GIS systems with an open system with common interface for easier data exchange, possibly with online data transfer facility, easy to use online GIS facility (unsophisticated data analysis functions for some divisions) as an option, more sophisticated GIS tool for Geomatics: data analysis and provision to the online (intranet/internet) system</td>
</tr>
<tr>
<td>2. Planning and Urbanization Div.</td>
<td>2/3</td>
<td>Support for planning process, integration of UHII into spatial planning by considering external risk factor in planning process, relevant especially for limits introduced by ground water protection need</td>
<td>3</td>
<td>Visual analysis of data for mapping new development possibilities</td>
</tr>
<tr>
<td>3. Sustainable Development Div.</td>
<td>1</td>
<td>Maybe support for planning process, rather opportunity not clear demand</td>
<td>1/2</td>
<td>Not clear opportunities seen, but interest expressed for visual support in planning</td>
</tr>
<tr>
<td>4. Environmental Div.</td>
<td>2</td>
<td>Support for planning process, as above, plus opportunity factors of environmental risk assessment</td>
<td>2/3</td>
<td>Visualisation of factors of environmental risk, opportunity to link with EIA</td>
</tr>
<tr>
<td>5. Housing and Properties Div.</td>
<td>0</td>
<td>No clear demand, current systems considered sufficient</td>
<td>0</td>
<td>No demand expressed</td>
</tr>
<tr>
<td>6. Valuation Services</td>
<td>1</td>
<td>No clear demand, current systems considered sufficient</td>
<td>0</td>
<td>No demand expressed</td>
</tr>
<tr>
<td>7. Bulk Water Div.</td>
<td>2/3</td>
<td>Opportunity of boosting inter-divisional data flows for better water management, both groundwater and water supply infrastructure</td>
<td>3</td>
<td>Interest in visual analysis of urban risks for water resources vulnerability and protection studies, for the reuse of data received from consultancy companies</td>
</tr>
<tr>
<td>8. Building Control Div.</td>
<td>2</td>
<td>Incentive for digitisation and dissemination of building infrastructure plans</td>
<td>1</td>
<td>No direct demand from this division, but for DM Div: Incorporation of building infrastructure plans into GIS seems very important. BCtrl Div. is already in process of digitising building plans to create a database, GIS would help in data dissemination</td>
</tr>
<tr>
<td>9. Emergency Services Div.</td>
<td>4</td>
<td>Need for a real time access to digital data on traffic organization changes, vulnerable and hazardous objects, building infrastructure data, business activities data etc</td>
<td>4</td>
<td>Need of access to building infrastructure data, detail data on hazardous substances stored or used for production, need to visualise these next to emergency response resources</td>
</tr>
<tr>
<td>10. Disaster Management Div.</td>
<td>4</td>
<td>Need for a real time access to digital data on traffic organization changes, vulnerable and hazardous objects, building infrastructure data, business activities data etc</td>
<td>4</td>
<td>Need of visual analysis support for emergency planning and emergency response, need of visualization of existing risks, need for database of emergencies linked to GIS, e.g. need of access to city and building infrastructure data for disaster mitigation, emergency response planning and recovery planning</td>
</tr>
<tr>
<td>11. Health Services Div.</td>
<td>3</td>
<td>Need of faster and easier exchange of business activities data and access to building infrastructure data and other data used in business development control, risk data of less importance</td>
<td>1</td>
<td>No clear demand expressed, but the interest to possess digital database of building infrastructure, attachable to the GIS tool for the use of other divisions</td>
</tr>
<tr>
<td>12. Community Development Div.</td>
<td>1</td>
<td>No clear demand expressed, but the interest to investigate the opportunities once initiative is in place</td>
<td>2</td>
<td>The only potential seen is of visual help for community education</td>
</tr>
</tbody>
</table>

---

**Figure 3.1:** Table 3.1a
3.1. Urban Hazards Data Management-driven potentials for UHII development

<table>
<thead>
<tr>
<th>Actor</th>
<th>Demand for Information Infrastructure</th>
<th>Demand drive</th>
<th>Demand for access to GIS environment</th>
<th>Demand drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Information Services Div.</td>
<td>2/3</td>
<td>An opportunity to analyse data requirements for many CoW divisions, opportunity to stimulate integrated data management and restructuring of municipal Info Systems (development)</td>
<td>0</td>
<td>Not relevant</td>
</tr>
<tr>
<td>14. Transportation Policy, Development and Coordination Div.</td>
<td>1</td>
<td>No clear demand expressed, but their data demanded by other divisions</td>
<td>1</td>
<td>No clear demand expressed, but their data necessary for mapping roads. GIS also can be useful for dissemination of information on road construction works</td>
</tr>
<tr>
<td>15. Municipal Police</td>
<td>1</td>
<td>For dissemination of data on security issues, monitoring of social risks</td>
<td>1</td>
<td>GIS support not feasible as seen now, although in the feature may be very relevant and feasible</td>
</tr>
<tr>
<td>16. Ministry of Transport - Road Authority Unit</td>
<td>3/4</td>
<td>Need to access data on local road development initiatives, spatial development, hazardous and vulnerable objects to support creation of new policies for transport of goods and international traffic</td>
<td>3/4</td>
<td>Emerging GIS initiative of the MinWTrCom needs support in risk analysis and dangerous accidents’ risk domains, inter-institutional co-operation may help RA to investigate how to use GIS efficiently in these domains, and how to facilitate data exchange</td>
</tr>
<tr>
<td>17. Insurance companies / banks</td>
<td>0</td>
<td>No demand found relevant, external risks aren’t in focus</td>
<td>0</td>
<td>No demand, municipality and private companies are seen responsible for accidents caused by man-made hazards, insurance company investigated did not see the need to analyse external risk themselves</td>
</tr>
<tr>
<td>18. Regional Emergency Unit</td>
<td>3/4</td>
<td>Regional initiative for strengthening DM is in place already, with the focus on food security and drought; UHM initiatives are seen relevant at local scale for water vulnerability monitoring</td>
<td>3/4</td>
<td>Indication from contacts between DMD and REMU: there is a need to support development of GIS tools for DM support in different domains</td>
</tr>
<tr>
<td>19. Survey General’s Office</td>
<td>3</td>
<td>Need for fluent and easy data exchange with the CoW and for strategic management of spatial and non-spatial data. UHII is seen only as a starting point towards bridging local and national level SDI development initiatives</td>
<td>1/2</td>
<td>No demand for a GIS base in UHII in particular, but the idea of integrating inter-institutional GIS environments was enthusiastically expressed; this demand is driven by the will of easier spatial data exchange in an open data environment</td>
</tr>
<tr>
<td>20. Deeds Registry</td>
<td>2</td>
<td>Exchange of ownership data facilitated by development of SDI on the base of UHII would be the drive for UHII as a starting point for local SDI initiative, still UHII domain is not relevant from the Deeds point of view, until general data exchange concepts are applied</td>
<td>0</td>
<td>No demand for the GIS base was expressed, since the Deeds Office does not deal with spatial representation of their data; ownership information is registered by Deeds Office in tabular datasets only</td>
</tr>
<tr>
<td>21. Individual land surveyors</td>
<td>3</td>
<td>Stimulation of geodata market, strong need expressed against the policy of the CoW of not releasing the spatial data in the soft copies, and not allowing for the re-use of framework and application-specific data in the surveying market</td>
<td>2</td>
<td>Need to access and purchase digital data coming from the CoW and SG, to avoid individual manual digitisation of hard copies, what introduces many added errors</td>
</tr>
<tr>
<td>22. Consultancy companies</td>
<td>3</td>
<td>The strong need for an open spatial data market, as in case of land surveyors</td>
<td>3</td>
<td>The need of access to digital, reusable and reliable data, a need of clear purchase options of GIS products</td>
</tr>
</tbody>
</table>

Figure 3.2: Table 3.1b
3.2 Analysis of stakeholders and institutional background as a base for methodology development

In the preliminary and core study a number of actors expressed their demand, interest and the will to establish a common information infrastructure for exchange of spatial data on man-made risks in Windhoek. These actors were identified during both the preliminary and core study, though only in the core of the research the extensive investigation of their requirements was made. The preliminary study provided information on the expected groups of actors to address:

1. Decision-makers - both of the spatial development processes (in multi-institutional approach, directly and indirectly responsible for spatial development), and disaster management process - municipalities, ministries, regional authorities etc., other users of urban risk data
2. Emergency response professionals - paramedical and medical units, fire brigades, police or gendarmery, crisis management units, etc.
3. Data producers /providers - land surveyors, Deeds Registry, Surveyor General’s Office, local authorities - the City of Windhoek and it’s respective departments collecting, holding or processing data relevant for integrated urban hazard management
4. Private and business bodies (community, investors, insurance companies and banks, etc.) producing or making use of the data relevant for integrated urban hazard management.

For the core research specification of actors to address see 3.1.2.2.

In the following section the classification of parties interested in development of UHII in Windhoek will be conducted to delineate the external and internal environment of focus of the research. Such analysis is necessary in order to decide on the best choice of methodology for UHII introduction, based on the characteristics of the target and external organisational environment. Moreover, it is crucial to identify the stakeholders playing potentially the role equivalent to the one of the leaders and coordinators of risk mapping and data infrastructure. This would be the base for future modelling of the structure of UHII and initially it would help to learn from the Dutch experiences and draw relevant guidelines for UHII implementation.

The evident expectation is that due to differences in organisational conditions and in the stages of implementation of spatial data management concepts, even similar data management demands in a different methodological approaches have to be chosen for introduction of such a technology as Urban Hazard Information Infrastructure. The institutional backgrounds analysed in the preliminary and the core studies were considered different and require different approach in demand and requirements analysis in order to avoid comparison of "pears and apples". This means that in order to benefit from the Dutch experiences in Namibian hazard data management, one has to consider evident differences in organisational setup of the two case studies, to be critical towards spatial data management solutions, the success of which can depend purely on the factors of institutional acceptance, and structural and functional adaptation. Therefore in this research the focus is to learn from mistakes and problems observed in spatial data infrastructures development and not to translate SDI development models from one case study to the other.

In such context the need arises to develop the framework of methodological steps for UHII introduction depending on the assessment of organisational characteristics. The external and internal environment is in the below sections analysed, and the criteria derived from organisational analysis are chosen for the development of UHII introduction methods.

To clarify here again, the term "methodology of introduction" of Urban Hazard Information Infrastructure refers to the sequence of methodological steps for diffusion of technological innovation in the organisation as seen in the Organisational Innovation Process Model (see Williamson et al., 2003 p.83) and includes the well known methods of System Development (SD, in reference to the development of information systems in organisations). It includes all stages of a technological innovation from the analysis of demand and relevance of the UHII, through identification of a focus of interest of different actors, with the delineation of internal and external system environments, a
3.2. Analysis of stakeholders and institutional background as a base for methodology development

simplified investigation of factors of soft (organisational expectation and acceptance, readiness to use and maintain) and hard nature (technological requirements, software and hardware related, requirements for functional shape of the application, etc.), specification and validation of user-centred requirements analysis till the development of a conceptual model of UHII. All the stages of the process can obtain different forms, depending on the institutional conditions, i.e. target and external organisations analysis gives the indications of how to tailor the UHII introduction method to the organisational setup in order to be aware of a bias of requirements analysis and to be able to correct for it.

The following factors are considered to identify target and external stakeholders in this research:

1. Stakeholder’s interest
   (a) importance of urban hazard data for support of stakeholder’s own processes
   (b) current level access of a stakeholder to urban hazard data
   (c) expressed willingness to play a chosen role in UHII initiative project
   (d) foreseen benefit form UHII

2. Stakeholder’s importance
   (a) Dependence of a potential UHII structure on a stakeholder in terms of base, framework and urban hazard data provision
   (b) Importance of stakeholder’s role in urban hazard management process (level of contribution to the process)
   (c) Influence of a stakeholder on urban hazard management actions conducted by another stakeholder, dependency measure
   (d) Importance of a stakeholder in terms of provision of human, technological and financial resources to setup UHII
   (e) Mandate-driven importance of a stakeholder for UHII setup
   (f) Level of authority given to a stakeholder by other stakeholders (acceptance for one’s services, products and actions)

The outcome of the analysis, conducted through the investigation of opinions expressed by different stakeholders in the interviews and during the workshop, can be seen in the following tables. The numbers presented in the tables are not treated as a quantification of an interest or importance of stakeholder, but as a representation of nominal, hierarchical legend, used for relative assessment of the actors.
Table 3.2. The Interest in Urban Hazard Information Infrastructure Development as Expressed by Investigated Actors

<table>
<thead>
<tr>
<th>Actor</th>
<th>Importance of UH Data for process</th>
<th>Level of access to UH Data</th>
<th>Willingness to contribute to UHII</th>
<th>Foreseen benefit of UHII</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Geomatics Div.</td>
<td>3 - for municipal GIS update</td>
<td>3 – producer of digital spatial data for DMD</td>
<td>4</td>
<td>GIS and data exchange system maintenance</td>
</tr>
<tr>
<td>2. Planning &amp; Urbanization Div.</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>Data user and provider</td>
</tr>
<tr>
<td>3. Sustainable Development Div.</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>Data user and provider</td>
</tr>
<tr>
<td>4. Environmental Div.</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>Data user and provider</td>
</tr>
<tr>
<td>5. Housing and Properties Div.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Data provider</td>
</tr>
<tr>
<td>6. Valuation Services</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Data provider</td>
</tr>
<tr>
<td>7. Bulk water</td>
<td>3</td>
<td>2 – ordered from consultancy company</td>
<td>3</td>
<td>Data user and provider</td>
</tr>
<tr>
<td>8. Building Control Div.</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>Data provider</td>
</tr>
<tr>
<td>9. Emergency Services Div.</td>
<td>4</td>
<td>1 – yet low data availability, but 4 in terms of UH data ownership</td>
<td>4</td>
<td>Data user and provider, value added data generation</td>
</tr>
<tr>
<td>10. Disaster Management Div.</td>
<td>4</td>
<td>1 – yet low data availability, but 4 in terms of UH data ownership</td>
<td>4</td>
<td>Data user and provider, value added data generation</td>
</tr>
<tr>
<td>11. Health Services Div.</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>Data user and provider</td>
</tr>
<tr>
<td>12. Community Development Div.</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>Data provider (informal settlements), data user</td>
</tr>
<tr>
<td>13. Information Services Div.</td>
<td>2 – techn. issue only</td>
<td>4 – technical issue only</td>
<td>4</td>
<td>Data user and provider, value added data generation</td>
</tr>
<tr>
<td>14. Transportation Policy, Development and Coordination Div.</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>Data user and provider</td>
</tr>
<tr>
<td>15. Municipal Police</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Data user</td>
</tr>
<tr>
<td>16. Ministry of Transport - Road Authority Unit</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>Data user and provider, value added data generation</td>
</tr>
<tr>
<td>17. Insurance companies / banks</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>None</td>
</tr>
<tr>
<td>18. Regional Emergency Unit</td>
<td>4</td>
<td>Yet 0 to local data</td>
<td>Not investigated</td>
<td>Not investigated</td>
</tr>
<tr>
<td>19. Survey General’s Office</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>Base data provider</td>
</tr>
<tr>
<td>20. Deeds Registry</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Ownership data provider</td>
</tr>
<tr>
<td>21. Individual land surveyors</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Parcel data update</td>
</tr>
<tr>
<td>22. Consultancy companies</td>
<td>1</td>
<td>1 – after authorisation</td>
<td>2</td>
<td>Data user and provider</td>
</tr>
</tbody>
</table>
### Table 3.3. The Importance of Actors for Urban Hazard Information Infrastructure Development as analysed from the workshop discussion

<table>
<thead>
<tr>
<th>Actor</th>
<th>Dependence UHII on an actor in terms of data provision</th>
<th>Importance of actor’s role in integrated UHM</th>
<th>Influence of an actor on various processes</th>
<th>Importance as a provider/initiator</th>
<th>Impor -tance by social recogniti -on</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base data</td>
<td>Frame-work data</td>
<td>Application UH data</td>
<td>Data spec.</td>
<td>In-put</td>
</tr>
<tr>
<td>1. Geomatics Div.</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>All CoW digital geodata</td>
<td>4</td>
</tr>
<tr>
<td>2. Planning and Urbanization Div.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Settlement upgrade plans</td>
<td>3</td>
</tr>
<tr>
<td>3. Sustainable Dvpnt Div.</td>
<td>0</td>
<td>0</td>
<td>2/3</td>
<td>Env dev plans, waste</td>
<td>3/4</td>
</tr>
<tr>
<td>4. Environmental Div.</td>
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<td>0</td>
<td>2/3</td>
<td>Transactions</td>
<td>2/3</td>
</tr>
<tr>
<td>5. Housing and Properties Div.</td>
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<td>0</td>
<td>2</td>
<td>Land value</td>
<td>1</td>
</tr>
<tr>
<td>6. Valuation Services</td>
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<td>0</td>
<td>2</td>
<td>Land value</td>
<td>1</td>
</tr>
<tr>
<td>7. Bulk Water Div.</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>Water infr.</td>
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</tr>
<tr>
<td>8. Building Control Div.</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>Building infr.</td>
<td>3</td>
</tr>
<tr>
<td>9. Emergency Services Div.</td>
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<td>0</td>
<td>4</td>
<td>Safety infr.</td>
<td>4</td>
</tr>
<tr>
<td>10. Disaster Management Div.</td>
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<td>1</td>
<td>4</td>
<td>DM infr.</td>
<td>4</td>
</tr>
<tr>
<td>11. Health Services Div.</td>
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<td>3</td>
<td>Business applications</td>
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<tr>
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<td>Community projects</td>
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<tr>
<td>13. Information Services Div.</td>
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<td>0</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>14. Transportation Policy, Dvpnt &amp; Coord. Div.</td>
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<td>4</td>
<td>3</td>
<td>Road infr.</td>
<td>3</td>
</tr>
<tr>
<td>15. Municipal Police</td>
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<td>0</td>
<td>2</td>
<td>Capacity</td>
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<td>16. Road Authority Unit</td>
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<td>2</td>
<td>Road infr.</td>
<td>3</td>
</tr>
<tr>
<td>17. Insurance comp. / banks</td>
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<td>0</td>
<td>1</td>
<td>Mortgage value</td>
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<td>Regional DM (drought)</td>
<td>1</td>
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<tr>
<td>19. Survey General’s Office</td>
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<td>3</td>
<td>0</td>
<td>Parcels, mid-scale topo-base</td>
<td>4</td>
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<tr>
<td>20. Deeds Registry</td>
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<td>0</td>
<td>2</td>
<td>Ownership</td>
<td>3</td>
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<td>21. Individual land surveyors</td>
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<td>0</td>
<td>Parcel update</td>
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<tr>
<td>22. Consultancy/private comp.</td>
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<td>3</td>
<td>Misc.</td>
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The following organisational issues are considered to assess the character of target institutions. This will be used in the section below to briefly characterise the target stakeholders in Twente and Windhoek. As well in the last sections of this chapter these criteria will help to match the methods of UHII introduction with organisational frame.

1. Structure and hierarchy in organisation
   - Shape and complexity of structure
   - vertical vs. horizontal dependence inside organisation
   - hierarchy pressure - what are the decision-levels? (freedom vs. order)(empowerment and discipline vs. lack of power and disobeying; inquiry and productivity, transformation and stability)
   - internal communication channels - formal vs. informal

2. Dynamics of functioning and resource base
   - human resources - staff turnover and capacity to deal with UHII problems
   - knowledge resources - experience of staff with the digital information systems
   - technological resources and their use in the organisation
   - character of processes (interchange vertical - hierarchical division of processes and horizontal - inter-departmental support of the processes, static, routine, long term processes or project based, dynamic, periodical processes)
   - financial resources and its change (static governmental support, dependance on external founding, project-based dependance)

3. Strategy and performance of organisation
   - legal base for functioning of organisation - organisational mandates, missions, visions, policies and strategies
   - organisational willingness to change /learn /restructure - flexibility of structure
   - willingness of inter-departmental and inter-organisational cooperation (competition vs. cooperation)

3.2.1 Target organisations - identification and characteristics analysis

The identification of the target and external actors for the preliminary study was conducted based on the interview, questionnaire and discussion with the representative of regional Fire Brigades, delegated with the function of risk mapping initiative coordinator, Mr Ron de Wit. His function was among the others related to identification and solution of spatio data management problems to support creation of standardised risk maps on regional level and to impose cooperation between municipalities on integration of their risk data. The outcomes of a discussion were cross-checked with the data from official information resources of other authorities involved in risk mapping. The problem in definition of target and external actors was caused by the complex interactions between the stakeholders and multiple ongoing risk mapping projects. The choice of who to treat as the target actor was based on the known defined responsibilities of the actor; the focus was to distinguish the local or/and regional coordinating body and a physical map maker. Therefore for the needs of the preliminary research the target actors were defined as organisational units holding power by co-ordination of activities in development of information infrastructure for DM and UHM or these actors that physically construct the risk maps. The coordinating body was the Regional Twente Fire Brigades (Regionale Brandweer Twente) and the subjects of co-ordination were the municipal authorities and local fire brigades.

The identification of a target stakeholder for Windhoek was conducted in a different way - there was no ongoing initiative to analyse, and no already established organisational structure to base on.
3.2. Analysis of stakeholders and institutional background as a base for methodology development

Therefore the basic analysis of interests and importance among the interested parties had to be conducted to identify best potential leaders and coordinators of the UHII project. This has been done based on the analysis of the criteria given in the first paragraphs of 3.2 and presented in the comprehensive tables of actors’ interest and actors’ importance. The nature of the analysis was very close to the known interest/vs. power matrix, and capacity vs. need matrix approaches. The target actors were basically supposed to be these ones who had high interest in UHII, and the importance of whose was significant. As well the favourable group would be of those actors who would provide high capacity (in terms of staff, technology and finance - indicated in the table 3.3 as importance of an actor as a provider of those factors) and in the same time high need for UHII tools, as geographic information systems, and UHII deliverables as geodata (see Table 3.1 on actors’ demands). For other combination of high/low interest/importance and capacity/demand the strategies could be developed to incorporate them in the UHII development initiative as members of the target group, but in this stage of the research only the most important parties are being analysed which had been identified as the City of Windhoek - Divisions of Disaster Management, Emergency Services, Geomatics, Planning and Urbanisation, Environment, and Bulk Water; and the Road Authority under the Ministry of Works, Transport and Communication (MinWTrCom). These are not only potential data providers but as well strong users of the potential UHII.

3.2.1.1 Target authorities in the initiative of risk mapping in Twente Region

In case of the analysis of Dutch institutional background it was not at all easy to distinguish and observe the target and external institutional environment. The structure of initiative became very complex in time when apart from the independent municipalities and fire brigades, the regional fire brigades, and ministries started contributing to the initiative. Due to the fact that the preliminary study focussed on partly implemented information infrastructure framework on local level and on its regional co-ordination, the analysis became more complicated, because even on these levels there is a big influence of a number of overlapping ministerial, provincial and municipal projects on risk mapping. The roles of actors were not yet clearly defined but despite of that the development of an organisational structure was progressing fast. The target actors in main preliminary study focus consisted of two subgroups

1. The regional Fire Brigades, with Twente Regionale Brandweer as a case study example and regional authorities as e.g. Friesland Province
2. Independent municipalities or provinces, physically building the risk maps, with and example of risk map application created by Friesland Province (regional) and another example of a risk map of the municipality of Enschede (local)

Both target groups are characterised by high demand for the infrastructure and high benefit expectations. Both target groups saw the advantages of GIS-based or online GIS application for hazard and vulnerability mapping. This was promising for the development of a regional and national broad information infrastructure for support in managing disasters. Unfortunately at the start it suffered from heterogeneous, unstandardised data management solutions, probably due to the very high level of independence of municipal bodies in terms of administration and decision-making and due to the low cooperation and narrow communication channels. Therefore, the independent municipalities had to be coordinated in the top-down approach in order to apply the concepts of regional interoperability and integrity of the datasets. The complex interactions between the actors and the intended provision of data and links between the spatial planning and disaster management processes will be pictured in more detail in the description of an As-Is situation of risk mapping in the Netherlands 3.3.1.2. There as well the full institutional context is presented. Hereby the brief image of organisational characteristics of target actor relation is given.

The Regional Fire Brigades (RFB) have created within their structure separate organisational units responsible for coordination of risk mapping on local levels. These units cooperate with equivalent units of Provincial authorities and these together check if the data on vulnerable and hazardous objects have been delivered by independent municipalities and large industrial companies.
from within a certain (potentially hazardous) domain. These units have clear and currently stable structure and mandates, they are independent from one another, with a lot of importance given to the RFB for their responsibility of accreditation of created risk map. The RFB has the power to accept or deny the risk map product from entering the market, they hold the guidelines on standardisation of the map and its format. The structure of this organisational solution can be considered as already mature and strong. During the fieldwork they were being created, but the process went very fast and it stabilised soon. By the maturity it is hereby understood that:

1. Structure and hierarchy in organisations is becoming clear:
   - the mandates and responsibilities are currently known well;
   - the cooperation among the RFB, municipalities and provinces has structured patterns;
   - organisational dependence in risk map making is known and logic (from obligations of data supply by local authorities to the accreditation of a final product). The vertical dependence of all target actors on the ministerial and data management authorities is nowadays as well clarified;
   - the empowerment of municipalities is shown in their freedom to choose the visualisation methods for risk representation, but it is followed by the discipline of complying with the standards of risk classification and standardised specifications of technical solutions;
   - the inquiry on data requirements and conditions of provision is done comprehensively and implemented by legal agreements, so that the productivity of regional and municipal risk maps was high (expected relatively short process of map update after implementation of all policies and technologies for risk mapping);
   - the transformation of the organisations (the RFB, municipal and provincial units) has been done fast, there has been initially a lot of chaos as regards to the awareness on the new division of responsibilities, but the situation stabilised;
   - the internal and external communication channels on local and provincial levels have been opened, not without an effort however, there was the top-down approach introduced to impose horizontal cooperation;
   - there exists informal and formal communication channels for risk mapping, but it was said that they currently overlap in large extent, since the people involved in the process become acquainted with one another, due to large focus on frequent inter-organisational meetings for reporting the progress (one of the effects of public opinion pressure)

2. Dynamics of functioning of organisational structures responsible for risk mapping is rather high, but it seems that the functional units are secured in their existence despite from that dynamic changes. The resource base is as well dynamic but secured:
   - the changes in human resources - turnover of staff was at the moment of the interview was relatively small, although there were still the changes in staff, but they were imposed by the changes of organisational structure, not by the lack of people capable of dealing with the risk information infrastructure, still there are opportunities for further training
   - there is a strong knowledge base in the RFB as regards risk analysis and it is supported by the data resource base of the municipalities. The knowledge of GIS and online spatial visualisation engines as tools for risk mapping and its dissemination was assessed by the interviewee as relatively good and still progressing boosted by the risk mapping initiative. Still the problems of open data transfer were not well supported in detail and the problems of integration of multiple different GISs were not easy to solve by the staff, but it was observed that the level of experience and knowledge is growing very fast under given conditions. The use of GIS in the municipalities, provinces and Fire Brigades on all levels has had a tradition already, and the management of integrated digital spatial and non-spatial data was not a novelty;
3.2. Analysis of stakeholders and institutional background as a base for methodology development

- Due to the above the technological resources were assessed as sufficient for the initiative, both as regards to the local governments and the RFB. The provincial governments however were said not to be as ready for GIS-based systems as the municipalities;

- Character of processes (interchange vertical - hierarchical division of processes and horizontal - inter-departmental support of the processes, static, routine, long term processes or project based, dynamic, periodical processes)

- Financial base, although not investigated deeply (not in the main focus of the research), but it appeared to be flexible and provided by different sources - municipal founds, provincial, MinBZK (Internal Affairs), RIVM (Institute of Public Health and Environment), etc. Partially the founds are provided on the project-base, but there is as well some amount of resources provided form the fixed organisational budget.

3. Strategy and performance of organisation

- All the organisational units involved in the risk mapping initiative were characterised by dynamic legal adaptation: policies and strategies supporting data exchange and sharing were being initiated as soon as the need arose, strategies for dissemination of the risk map products were established on different administrative levels, each organisation incorporated safety monitoring into their missions. Also all these organisations tended to have their own strategies (business strategies, action plans) developed including the points related to the risk mapping project. This was proved important for the creation of risk information infrastructure to be linked to organisational strategy (see (Clarke, 2001)), and the Dutch situation currently supports this.

- Organisational willingness to change /learn /restructure was from the beginning of the initiative very high; organisational changes were unavoidable for good execution of integrated risk mapping - the new processes of standardisation, quality assurance and data integrity assurance had to be considered as integral parts of organisational functioning patterns. New positions were created to coordinate the progress of initiative and new functions were assigned to the existing positions. The structure of organisations was therefore proved to be flexible.

- The willingness of inter-departmental and inter-organisational cooperation was enforced in a way by the character of a project and by the complexity of the institutional network involved in the risk mapping process. It was not easy to make the local levels cooperate and to make the provincial and local levels agree on the standardisation but slowly there came some achievements in these domains; there has been observed even a positive effect of the competition between the municipalities on the fast provision of risk data to the public - the data for creation of maps had were made accessible for other parties relatively fast.

To conclude the organisational environment of regional risk mapping initiative in Twente was strong despite its dynamics and problems. The problems of lack of information flows due to the competition (inter/intraorganisational), insufficient data interoperability, sometimes due to the lack of mutual co-operation in standardised data exchange, could have been solved due to the willingness to deal with supra-local disaster management issues even in international levels (international municipal partnerships). The decision processes are independent in terms of spatial development control and disaster management, but they are standardised in terms of risk assessment, and pre-cooked procedures for emergency response are present. The presence of regional unit responsible for hazard data management co-ordination among the municipalities, introducing issues of standardisation of data and information systems and monitoring development of new risk assessment maps proved to be a good solution for resolving heterogeneity in risk mapping environment.

Dutch municipalities and independent from them Fire Brigades nowadays still may have some overlapping functions, but legal responsibilities are divided either on the regional or local level through the regional disaster management policies or inter-institutional agreements, intra-municipal
tasks related to crisis management are executed locally, but under the monitoring of the higher level authorities. This structure allows for integrating on different administrative levels the spatial data infrastructure with risk mapping processes. It also allows for creation of hazard data infrastructure as a domain-specific part of spatial data infrastructure.

3.2.1.2 Municipal Fire Brigades and the City of Windhoek

The complete comparison of the background of hazard data management processes, based on some of the given criteria, will not be executed hereby, due to the very important institutional difference between Windhoek and Twente: Twente has an already established organisational structure dealing with risk data management, of which the characteristics were given above, whereas in Windhoek the hazard data management practically does not exist and the equivalent structures will have to be established. Therefore the organisational analysis of target actors focuses here on the potential initiators and coordinators of UHII in Windhoek.

It was not possible within the given time for fieldwork to collect the data on organisational characteristics of all target actors, therefore this paragraph will present the main characteristics of only the most important target stakeholder - the City of Windhoek and its divisions.

- lack of data return from consultancy companies, etc. Lack of information flows between divisions, lack of strategic approach for metadata and data dissemination, redundant data production, lack of multi-disciplinary approach in DM and SDC.
- no local awareness yet on the need of metadata and of data and information systems standardisation, no local entity dealing with that, nationally (global approach) and regionally (more application-specific approach) the policies are being developed for creating SDI framework;

1. Structure and hierarchy in organisation:

- The structure of municipal organs in Windhoek differs significantly from the Dutch structure especially in one aspect - the Fire Brigades are here an integral part of the municipal government, dependent on the City Council and the Department of Community Services. This implies entirely different approach when thinking of UHII implementation vs. the solutions given by the preliminary study, where the Fire Brigades were independent from the local governments, and were directed by The Dutch Association for Fire Fighting Service and Disaster Management (Nederlandse Verening voor Brandwerzorg en Rampenbestrijding (NVBR)) and were supervised by the Ministry of Internal Affairs (Ministerie van Binnenlandse Zaken - MinBZK). As well the paramedical help constitutes independent organisational body in the Netherlands, unlike in Namibia, what can shape in a different way the information flows in emergency response. This might lead to completely different strategic, administrative and financial solutions. As well the fact that Division of Emergency Services (containing Fire Brigades and paramedical units) and the Disaster Management Division are on the same administrative level, and share the need for UHII with about the same intensity, can influence the ways of introduction of UHII. The inter-dependency and quite high co-operation between these units was observed

- The City of Windhoek has different levels of decision-making, but the large projects like introduction of the new technology, as UHII, would be hierarchically placed on the top level - the City Council. The political power of the City Council is evident, this organ accepts or rejects important municipal policies under the advise of the relevant Divisions.

- The internal communication channels among the divisions are observed as coexisting with the formal data flows through the municipal information systems. There still are data not incorporated into the information systems that are the subject of hand-to-hand exchange as e.g. the ArcView files of the water vulnerability study that cannot be viewed through the network system.

2. Dynamics of functioning and resource base
3.2. Analysis of stakeholders and institutional background as a base for methodology development

- **human resources** - The CoW is characterised (situation in November 2002) by poor conditions of human resources - relatively low salaries, short cycle of staff turnover (for the young staff members even around 1.5 years), lack of experts on GIS and IT technology; lack of training possibilities (mainly due to the lack of financial resources); shortage of staff is caused by lack of encouraging opportunities for development of a career.

- **knowledge resources** - although there still is a significant knowledge base as far as domains such as spatial planning and development or environmental sciences but still there is a poor knowledge base in information systems among the average staff (except Information Division and partly Geomatics Division)

- The development of IT in the CoW is progressing fast, there are 33 information systems in place, very much utilised but mainly for querying and visualisation, and the staff members are used to this limited way of handling the data. There is no space for fast exchange of data between divisions, because most of these systems do not communicate with one another. Staff members depend on the Information Services Division to transfer the data from one system to the other. As well data input and update is done only by IS Division.

- The processes of spatial planning and disaster management are not linked integrally in the CoW. The disaster management is actually in the stage of initial development, with the draft disaster management plan having been released in August 2002. The emergency management has the standardised routine procedures, but during the fieldwork there was not yet any integral process connection observed between disaster management and emergency management. The latter was assumed to relate to the fires or accidents such as track accidents with dangerous substances. Disaster management was considered to relate mainly to the food security in the drought season, unexpected flood (e.g. in case of the damage of a dam) or large scale chemical accidents, etc. The common procedures to deal with emergencies were being created during the fieldwork. It is important to note that the Disaster Management Division was established relatively late in the CoW and its position among other divisions as regards to the responsibilities and mandate was just being established.

- The target Divisions of the CoW, including the Fire Brigades and para-medical units, belong to the same budget basket. There was no information obtained during the fieldwork on what is the total dependence of the CoW on the external founding sources as World Bank project founds or GSDI (Global Spatial Data Infrastructure) projects. It is however known that there is an access to the financial support for the development of information technologies in the governmental authorities of developing countries (WB), that the CoW could benefit from as long as there exist a cohered strategy for UHII implementation involving the cooperating institutions. financial resources and its change (static governmental support, dependance on external founding, project-based dependance)

3. Strategy and performance of organisation

- The legal status of the CoW is strong, it’s responsibilities are well defined in different domains, however the disaster management is one of the domains where there is not yet proper mandates set for the Emergency Services and Disaster Management Divisions as opposed to the activities executed by the other target divisions within CoW. There is no policies neither strategies regarding the data management and there is no awareness of these. The strategies of functioning of independent departments of the CoW in general do not include the digital data management aspect, due to the fact that it is considered to be a responsibility of Geomatics division and the Information Services Division. Moreover there is the lack of structured and formalised spatial information flows between departments outside the limited municipal GIS system, although not all the data can be entered into this system.
• The organisation is willing to accept the changes as long as there is financial support organised in the long term perspective (which is not always possible). Moreover the willingness and the readiness to change do not go together, as observed during the fieldwork: e.g. the Disaster Management and Geomatics Divisions are very much willing to introduce improvements to the existing GIS facilities to support UHII, but the idea is not feasible yet, as long as there is no money for long term maintenance of this new tool. The structure of CoW itself is in the opinion of the authors of this research not flexible yet enough to adapt the new technologies, that would have to support UHII implementation - although the need of new inter-divisional unit for UHII setup and maintenance was expressed enthusiastically, the feasibility of creation of a new council within the CoW is low, due to the financial and political issues. This may however change as soon as there is an evident, measurable proof of the benefits of the CoW arising from the UHII development.

3.2.2 External stakeholders’ environment characteristics
The external stakeholders environment is analysed for the preliminary case situation consecutively through this work. The goal is to observe the influence of external stakeholders on the execution of multiple projects related to risk mapping. It is foreseen that lessons learned form even such brief and implicit analysis can give better understanding of the necessary stages of risk information infrastructure development as regards to the involvement of external actors. The detailed analysis of the character and influence of the external stakeholders on the UHII initiative will be presented in Chapter 4.

3.2.3 Implications of institutional background for UHII introduction and requirements analysis methods
Assumption made in the research was that different institutional settings would impose the use of different approach in the analysis of hazard data management requirements and different ways of data management implementation. Therefore, in the following section the preliminary study is put as a reference to the core research in terms of organisational differences and their implications on the data management approaches and information infrastructure introduction methods. The experiences of the first will be taken into consideration when analysing the requirements in the latter, with the correction on the influence of the institutional setup. In this sense it is rather the recommendations arising form the preliminary study for the development of UHII in Windhoek, than the comparative analysis with implementation of some solutions from one ground to the other. The latter approach would lead to many inaccuracies due to the tendency of "transplantation" of case-irrelevant solutions.

   The detailed analysis of the links between the internal and external organisational characteristics and the implementation of UHII will be elaborated in Chapter 4, where the guidelines for introduction and implementation of UHII are made. The below paragraphs are supposed to highlight only the most important differences in data management arising from the differences of institutional conditions.

3.2.3.1 Risk data management requirements identification in a strong institutional environment of Twente
The results of the research show that the involvement of external and target actors in the risk mapping initiative was initially unstructured and relatively chaotic, the multi-organisational environment did not have a stable structure prepared in advance. Achieving the strength, stability of structure, clarity of mandates and to prepare the legal framework for cooperation took more than two years. In the Netherlands there appeared the situation where there existed the very strong organisational
3.3. As-Is Urban Hazard Data Management

willingness to adapt new technological solutions for risk control, and the information, technologi-
cal and financial means were already in place within single organisations. This gave an incentive
for a number of individual bottom-up initiatives, where e.g. the municipalities produced their in-
dividual risk maps and made them available online. In this stage the risk mapping project was not
yet seen as a risk mapping infrastructure development project; what means that there was the fo-
cus on development of separate, stand-alone risk information systems. Here the standard technical,
hard approaches could have been taken for analysing the system requirements, since most of the
problems were seen in terms of the lack of technical links between the spatial planning and hazard
management processes. The emphasis was given to provide the new municipal information system
architectures to link these processes, involving the municipal organs and local Fire Brigades. Soon
after the top-down approach had to be introduced for co-ordination of the heterogenous projects for
the benefits of regional and national level initiatives. The awareness of the necessity to cooperate
in the multi-institutional and multi-administrative-level setup was rising, and therefore different re-
quirements and different system development methods must have been introduced. The focus shifted
to the organisational aspects such as creation of policies and strategies for development of informa-
tion infrastructure supporting risk mapping and being supported by existing (strong already) Na-
tional Spatial Information Infrastructure. In this stage the standardisation of risk classification, open
standardisation of data formats and risk information systems (problems with resolving semantic,
schematic and syntactic differences), the quality and reliability of risk maps and other issues, related
to the feasibility, efficiency and speed of inter-institutional data flows, were raised. Here more of
the combined soft and hard approaches had to be used in order to link the human-related issues of
organisational cooperation and strategic management with the hard, technical issues regarding e.g.
data integrity and open data transfer standards. Therefore the development of risk information in-
frastucture could evolve from ad hoc and spontaneous development of non-interoperable systems at
municipal levels to a more homogenous, multi-level, standardised environment.

3.2.3.2 Lessons learned for Urban Hazard Information Infrastructure of a weak institutional
environment of Windhoek

In the multi-institutional environment of Windhoek there exist a necessity to combine different meth-
ods of situation analysis - soft and structured. First the soft methods Need for validation of views ex-
pressed in one organisation by the views of the other in order to set up the model of inter-institutional
UHII to develop. A need of compromising different demands, a need of confrontation between po-
tential stakeholders, a need of analysing UHII system boundaries and of choosing the environment
to start implementing UHII in. A need to choose together with the stakeholders the best compro-
mise method of UHII introduction and to set up a methodology for UHII implementation. Two main
methodologies are to be developed - (a)of requirements analysis for Windhoek, (b)of UHII introduc-
tion; the third would be a methodology for implementation and management of UHII, which will be
put in the final recommendations of this research.

"with the improved understanding of the SDI hierarchy has come the challenge to im-
prove the relationships between SDIs in different jurisdictions as well as between dif-
ferent spatial data initiatives. As identified throughout this book the key to building
successful SDIs is in establishment of these relationships, especially through mutually
beneficial partnerships, which are both inter- and intra-jurisdictional within the SDI hi-
ernarchy.” (Williamson et al., 2003)

3.3 As-Is Urban Hazard Data Management

One of the main concerns during this research was how to properly use the results of preliminary
study, conducted in the Netherlands, for support of the core research, conducted in Namibia. The
majority of comments was reflecting the approach ”you cannot compare pears and apples”, although
from the very beginning this research was supposed to prove that the awareness of lessons learned
from development of SDIs in the developed countries can be of outmost importance for the success of newly arising initiatives of SDI development in the developing countries. The idea of learning from the mistakes of others, by developing universal strategic guidelines based on such lessons learned seemed to be very promising. In order to support this idea a specific research methodology must have been developed, to be able to reflect on the evident differences in the environments in which SDIs are developed. The methodology allowed to avoid the "copy - paste" approach in applying the solutions, that are successful in one organisational setup, but can be absolutely irrelevant in the other. The analysis of institutional background and relationships between stakeholders in preliminary and core studies is provided prior to developing the model of methodology. It is done so to be able to identify the level of preparedness of certain organisations to accept, introduce and implement specific SDI concepts, and to assess the level of applicability of particular elements of SDI development process. The main assumption taken here is that every action related to SDI development changes the organisation that is involved in such development. The iterative subsequent changes are supposed to allow achievement of progress from obtaining acceptance of SDI concepts, through their gradual introduction and, finally, to total implementation of SDI tools. The evident help was the identification of universal pattern of SDI development based on the available literature, which pictured consecutive stages of SDI development by reporting differences in SDI implementation problems in developed and developing countries. The appendix provides the model of SDI development progress and table of different problems faced in developed and developing countries, based on the analysis of the work by Williamson et al. (2003) (Williamson et al., 2003).

"...highly developed countries ...may be considered to be positioned at the front end of the SDI development continuum"

"...even the poorest and least developed country can still adopt SDI principles and implement strategies which can lead them to develop SDI in the future, such as the creation of a common base map and reforming institutional arrangements of spatial data." (as above, p.5-6)

3.3.1 Access to national, regional and municipal hazard data in the Netherlands - the scene

In the Netherlands there is an integrated approach to hazard data management executed. Information systems for risk assessment and emergency management had to be linked with information on spatial development control (e.g. via cadastral information infrastructure, or via transfer of spatial planning data). The policies and governmental strategies for data sharing are implemented through creation of mechanisms for controlled access to information systems on municipal (run by VNG - Association of Municipalities) and regional (run by Regional Governments Association) levels. A number of risk maps and reports on hazard mapping and external safety control was given an open, web-based access, to stimulate dissemination of information to the public. The information on municipal spatial data resources is accessible for non-public users. The above can be executed due to the fact that there exists a complete state coverage of base and framework data, and the update of so called "Top10 vector" (topographic vector maps in scale 1:10 000) is being done periodically. All this was stimulated by the pressure of public and governmental bodies after the disasters - fireworks blast in Enschede and the New Year’s Eve fire accident in a Caf in Volendam.

3.3.1.1 National risk analysis and mapping initiative, the Netherlands

After the explosion in Enschede the level of demand for risk mapping at municipal levels was so large that a lot of bottom-up initiatives have emerged. It resulted in heterogeneous data and application environment, not allowing for effective regional co-operation. Different map standards and different approaches to risk classification made it difficult for the municipalities to communicate. Integration of maps and databases on regional level had to be introduced in the top-down approach in order to resolve the differences. It was executed as a response for regional demand by setting up
The conclusions drawn by IOOV (Dutch Inspectorate for Spatial Order and Safety Management) from such an initiative proved a necessity of strengthening disaster preparedness by improving inter-organisational cooperation between police, fire brigades, medical rescue units - GHOR, and governmental authorities. Dutch authorities at all administrative levels were increasing attention to conducting urban hazard assessment and strengthening disaster preparedness. Regional initiatives in risk mapping and emergency planning were followed by a cross-institutional initiative on setting up a framework for data management in multi-disciplinary risk assessment data (NIBRA, ) (voor Veiligheid, ). Sharing, exchanging and standardisation of information were considered crucial in disaster management and development control. New policies were established for handling information heterogeneity (see: "Strategies for strengthening information facilities in disaster management" at (voor Veiligheid, ).

At the start 4 regions were chosen to implement new disaster management policies - Gooi & Vechtstreek, Friesland, Limburg Zuid en Twente; these were the same first regions were official top-down co-ordination of hazard information management took place (IOOV, ). The processes disaster management and spatial development were integrated due to facilitation of inter-process data flows, executed through risk dissemination of hazard data through internet (e.g. see: Enschede municipal online resources) after risk mapping initiative has started.

### 3.3.1.2 "AS-IS" situation of Spatial Information Management for support in urban hazard management

**Spatial Information Management Reference Model (RSIMM):** Following the policies on disaster prevention and data sharing, the regional risk registers are being established (see: "Registratie risico’s wordt verplicht" - news on 23.01.03 at (voor Veiligheid, )) to store data on dangerous infrastructure (see: criteria of Ministry of the Interior published in "Leidraad Maatramp / versie 1.3", "fig 5.4 overszicht van enige relevante objecten waar Brandbaare of explosieve stoffen aanwezig kunnen zijn" - p.31; list of flammable gases - p.27; (MinBZK, )). The information on hazardous companies (so called PBZO and VR companies (RIVM, 2003) is maintained in a national register by RIVM (Institute of Public Health and the Environment). The databases of local urban infrastructure (utilities including hydrants, streets, etc.) and occupancy (numbers of people/room: numbers of children, disabled, elderly people) are being integrated at the regional level. Spatial data provision is obligatory for municipalities. Most of the data is acquired in the development control process from applications for Building Use Permit that include building information on:

a) Activities to be undertaken;
b) Average weekly time of use;
c) Numbers of people occupying it;
d) Type and volume of substances produced, stored or utilised inside;
e) Size, floor number and area, floor area ratio; and
f) Infrastructure (gas, water and electricity installations, fire warning and suppression systems).

Since the introduction of the "Repressive Dekkingsplan" (shelter planning) all the changes in building use, storage capacity or processes undertaken in the property have to be reported to municipalities. The data on precise location and delineation of a property, and tenure transactions, are maintained by standardised Municipal Cadastre organisations. The parcels’ data is an input to the municipal topographic databases, and is available on paper or via official municipal websites. Nowadays, based on data obtained from the municipalities, 12 provincial risk maps showing 13 categories of (spatially fixed) hazards are being created under the project MRK - "Model Risico Kaart" (Risk Map Model), run by the Ministry of The Interior and Kingdom Relations (MinBZK) (see e.g. the risk map for Province Overijssel at www.overijsselopveilig.nl). At the same time Ministry of Spatial Planning, Housing and Environment (MinVROM) and RIVM are responsible for RRGS project (Hazardous Substances Risks Register), closely related to MRK, in which all disas-
ters and emergencies are recorded and analysed in terms of spatial extent of risks. Risk causes are described as substances divided into 3 main categories: flammable/explosives, poisonous and nuclear (The Dutch Ministry of the Interior and Kingdom Relations, 2002) (see www.geodan.nl/nl/geodan/nieuws/risicoregister.htm, accessed August 2003). The outputs of both MRK and RRGS include documentation of potential or existing risks in a GIS environment. Both projects were steered in a way to provide easy data exchange between their data management systems. RRGS provides facilities for open data sharing through the use of OpenGIS interfaces (WMS: Web Mapping Server, WFS: Web Feature Server) and Geographic Markup Language (GML) in the web environment (for more information see: (van Katwijk, 2002), accessed August 2003 via www.xx4all.nl/ aign/gebouwersdag/november2002/rrgs.ppt). To allow RVIM to update RRGS and to be able to create up-to-date risk maps, all municipalities are obliged to submit the data on local risk objects to regional authorities responsible for execution of the MRK project. When risk sources and receivers (vulnerable objects) are identified, the risk map is examined against the risk extent change, the local emergency plans are updated. Municipalities, governmental authorities, fire brigades and companies are supplied with SERIDA database of hazardous substances and their environmental effects (RIVM, ), and the register of hazardous companies (PBZO/VR). Eventually, all these sources contribute to the creation of risk maps. Coordination of the information flows is done at state (CEV - Centre for External Safety of RIVM) and regional (Fire Brigades) levels. Standardisation of Risk Assessment Procedure.

Figure 3.3: Reference Model of Spatial Information Management for support in hazard management, the Netherlands.

Spatial data management problems in hazard management support:
After the national initiative for risk data exchange had started, it was observed that the lack of
3.3. As-Is Urban Hazard Data Management

Common risk assessment policies resulted in significant inconsistency of maps. The regional coordination had to be, therefore, introduced to control risk classification, mapping and visualisation methods.

The biggest bottleneck is the variety of spatial and thematic information systems applied by independent municipalities, where a number of incompatible GIS and CAD software platforms are used. Differentiation of available spatial and attribute data formats and models limits current development of the national risk information infrastructure, rooted in RRGS. The lack of inter-municipal cooperation to facilitate and standardise digital data exchange affects fluency of hazard data flows among the actors of hazard management (fire brigades, police, medical units, municipalities, RIVM, MinVROM, MinBZK, NVBR, etc). Nevertheless, regional authorities continue working on data exchange standards and specifications for digital risk mapping; considerable attention is paid to the standardisation of map maintenance.

A number of municipalities faced the problem of re-doing their risk maps when it was ordered that the spatial datasets must be integrated with updateable attribute information. The consistency and quality (reliability) of risk data is also controlled by regional authorities, but it is actually the local units who are legally responsible for spatial accuracy of created maps.

Emergency planning and GIS usage for emergency response: The emergency response decision-making process is greatly supported by detailed analogue emergency response plans, compiled in a guide-book, where step-by-step a type and capacity of emergency response crew is obtained given the risk criteria analysis (The Dutch Ministry of the Interior and Kingdom Relations and Dir. Fire Brigades, 1992). The risk assessment is done on simple graphic IF... THEN... ELSE models based on criteria such as: time of a day, numbers of potential victims, accident threat (accident source, relative vulnerability of vicinities), air conditions etc. The quantification of risk is performed and, subsequently, the response is modelled. The information management infrastructure plays a very important role in responding to emergencies. The Emergency Call System (“112 system”) registers all calls on the emergencies and redirects them locally. Further the local fire brigades plan the actual response in the “control centres”, where local GIS-based information management systems often help to locate the emergency, identify the closest resources (i.e., hydrants) and estimate the risk for vicinities of the impact area. Processed data are stored in a digital emergency databases. The digital hazard spread models are more and more often used for calculation of the disaster extents depending on weather conditions, construction materials, volume of hazardous substances etc. The latter, however, are in most cases installed locally in crew cars. The opportunity for development of risk information infrastructure is evident, considering the need to link existing GIS databases with crew car systems by wireless communication technologies.

3.3.2 Access to framework and hazard data in Namibia

In the light of the situation of African GI Legacy the Namibian, and, in the local aspect, Windhoek position can be described as average. Considering that Namibia gain independence in 1991, its progress in terms of SDI initiative can be assessed as above average. Since late 1990s there has been a strong demand for establishing a national spatial information infrastructure, with the main objectives to collect new spatial data and record the updated spatial coverage, making it available in the forms of maps and census data. In further steps the intention was to make available data resources digital and create the national spatial data clearinghouse as the core element of the infrastructure. As in the other parts of Africa also in Namibia the presented attempt to develop NSDI was at the start supply- and technology driven. The approach was unsuccessful, and although the prototype of Environmental Data Infrastructure (or rather the Environmental Information System) as a core of the NSDI development became operational, it was still far away from the completion of NSDI project. Some digital spatial data were acquired, but the project was frozen. Until November 2002 the capacity of Survey General Office was too small to handle both collection and digitisation of framework data. Even though the data collection was intentionally demand driven, there is still a big gap between the spatial data requirements of the market and spatial data supply. The large demand pressure comes nowadays from the private sector of different scales of investors. This tendency is
observed, according to the fieldwork record, on largest scale in the region of the capitol of Namibia, Windhoek, which is the most interesting investment area due to its administrative role and rapid growth. Despite that demand, the governments focus on establishing data resources first for northern Namibian regions, to create there the economic incentives and decentralise economic development.

As in other situations in Africa, the end users of spatial data were not well defined, neither their needs were surveyed or quantified, what proved to be a "Piecemeal Approach” to SDI development (Woldai, 2002). Like in other African countries (see (Woldai, 2002)), in Namibia there is a problem of poor documentation (no catalogue and often no awareness of existence) of a large number of data: maps, planning sketches, studies of environment, field notes and data, cadastral survey reports, aerial photographs, satellite images, building infrastructure sketches, etc. This lack of awareness induces inconsistency and duplication of data. One of the most important problems is no awareness of the need to record metadata, even in governmental institutions as municipalities:

"[...data usually was and still is only structured in the mental archives and models of the surveyor or investigators and therefore lost forever when he or she retires from the organisation” (source (Woldai, 2002) after Woldai and Schetselaar, 2002)

The lack of agreements of standardisation and redundant data production adds to the complexity of spatial data management problems. The amount of small scale spatial data available increases gradually due to the initiative of the Survey General. Still the access to these data is yet limited, the significant demand exists but for medium and large scale maps. Moreover, most of maps are in analogue format, being very slowly transferred into GIS, due to the low capacity of SG. In this situation the municipal authorities of Windhoek - the City of Windhoek, play relatively important role in large and medium scale data provision. Moreover, the COW has an agreement (currently informal) with SG that it can always digitise the cadastral parcel data for its use, and that it should provide SG with a digital copy of it when requested.

3.3.2.1 ”AS-IS” situation of Spatial Information Management for support in urban hazard management, Windhoek

The following problems regarding the attitude towards spatial data management, and in particular hazard data management, were observed during the fieldwork in the City of Windhoek (municipality) and among other institutions (Survey General, The Ministry of Works, Transport and Communication - MinWTrCom), and are considered very characteristics for Windhoek organisational background:

**Situation in The City of Windhoek:**

1. Gaps in municipal decision-making processes:
   (a) caused by unawareness of activities and of data produced among different divisions, not sufficient horizontal information flows, even in the informal background;
   (b) caused by organisational management problems - overlapping responsibilities in different departments, e.g. water resource management and disaster management: unclear division of tasks in case of the drought crisis response, unclear division of responsibilities for conducting measures against the lack of water supply in the crisis situation- lack of inter-departmental co-operation on the ;
   (c) caused by data management problems - lack of sufficient information exchange and knowledge sharing

2. Gaps in legal framework for restructuring process and data flows
   (a) Lacking policies for developing spatial data information infrastructure are the initial problem for integration of urban development process with disaster management
   (b) lack of internal strategies for (spatial) data management, exchange and sharing on different basis than through municipal information system
3.3. As-Is Urban Hazard Data Management

(c) lack of quality policies for digital data and no quality/reliability assurance system for spatial datasets, apart from the municipal parcel survey, which anyway according to law always has to be approved by Survey General in case of legal parcel division documentation.

3. Gaps in disaster management and urban hazard management process:

(a) The lack of integrated strategic and multi-disciplinary disaster management, hazard mapping, control and mitigation, although especially in such harsh climate and difficult economic conditions there should be an integrated hazard development control system, to identify, detect and mitigate hazards. There is a missing link between many divisions practically and functionally involved in hazard reduction (i.e. sustainable development, spatial planning and development control, urban survey and analysis, traffic control, environmental/occupational health management, fire prevention, ground water protection etc.). There is little or no willingness to acknowledge the overlaps in divisional functions; no clear organisational mandates adds to the problem.

(b) Lack of information flow between disaster management process and spatial planning and development control.

(c) Additional difficulty - possible simultaneous effects of natural and man-introduced hazards (e.g. factory fire in a draught season or drinking water contamination in a drought season)

(d) lack of integrated UHM strategies, addressing inter-departmental co-operation in case of emergencies, only recently (September 2002, revised in 2003) the general disaster management plan was released, but in practise there is no awareness on its issues in divisions other than Disaster Management Division. No inter-departmental strategies dealing with urban emergency management existed at the time of fieldwork execution (Sept/Nov 2002).

4. Gaps in functioning of the municipal information systems

(a) lack of interoperability of different internal municipal information systems (digital and analogue), problems with data exchange between the systems make the urban management processes slower and less efficient: manual change of data formats has to be performed to enable data transfer between the information systems of different departments. The multi-system environment is used below its potential.

(b) no metadata (management) system, no record of data lineage or origin, the only metainformation exists in the heads of the people dealing with the data.

(c) A fragmentation and duplication of data was observed within the CoW, which implies under-utilisation or difficulties in use of 33 existing municipal information systems.

5. Hardware and software support and data processing for disaster management

(a) The role of GIS is limited to visualising fixed number of layers of spatial data, that are fixed in the municipal intranet GIS system based on MapGuide: free licence software with limited visualisation and no actual data analysis capacity, linked to Oracle database with fixed and rather not so easily expandable data dictionary options (conditions service agreement)

(b) There is a separation between used CAD and GIS softwares, where CAD is used for generation of digital data layers, and GIS for visualisation, what diminishes the potentials of the two, no easy data transfer between them is provided, all operations have to be done manually

(c) Division of Disaster Management of the CoW (DivDM) relays fully on the capacity of Geomatics Division to manage spatial data related with hazard management in Windhoek: to capture data digitally, analyse (in different GIS environment, not MapGuide)
and subsequently add to displayable digital map layers, choose visualisation method, integrate with other data, etc.

(d) There is currently no hardware, software or human resources in the Disaster Management Division to create a separate unit handling data needed for emergency planning and support in emergency response, still there exist a plan and there is a strong need to create the Disaster Operations Centre, based in DMD and tightly related to the Fire Brigades emergency response centre, that operates in an analogue form and, in the time of fieldwork, was being provided with one computer of low capacity and no GIS base.

**Situation in Survey General and Deed’s Office**
The capacity of SG is very limited and the office faces the problems of the lack of sufficient staff resources to make existing cadastral and topographic data digital and to be able to incorporate these digital resources into the land management processes. The test digital spatial database is being created on the base of GeoMedia and Oracle8 solutions. In two separate databases sample cadastral(1) and topographic(2) data of Northern Namibian Provinces are stored, but not yet the central Khomas region with Windhoek, since the process of digital map making follows the priorities of process of acquisition of data for new topographic maps collection (with generalisation scales 1:250 000 and 1:50 000 in focus). The lack of official agreements on multi-institutional and even intra-institutional data exchange and sharing, as well as the problem of recording the metadata are noted. There exists, on the contrary to the CoW situation, some awareness of metadata importance, though it appears to be noticeable only at the lower management levels, where the details of data processing are known by the workers. The fieldwork observations indicated that there is a demand for creation of a structured digital metadata record - metadatabase, but still, this demand, as the awareness, is not organisation-wide. Moreover, at this date no human neither financial resources existed to initiate up the digital metadatabase project. From the point of view of disaster management process the role of Survey General is to provide reliable topographic information, on the base of which the local and regional authorities can address specific hazard management issues. From the broader point of view - integration of potential UHII with the initiative of National Spatial Data Infrastructure, the Survey General plays important role, bridging the local and state initiative.

**Situation in The Ministry of Works, Transport and Communication (MinWTrCom)/ Road Authority (RA)**
The Road Authority is in charge of road development policies and actions. It’s role is as well to monitor safety on national and international communication arteries and to create the new policies for transport of goods. Since Namibia obtained independence from South Africa the creation of national transportation rules has not yet been executed; the initiative was undertaken in late 2002. To one of the action points there belongs creation of the policy of hazardous goods transport and preparation of statistics for intensity and type of traffic on the international Namibian roads. One of these roads is of great importance for the research due to its local and international role - it is an artery linking southern Windhoek with South African Border, the artery of heavy track traffic. This same artery runs over the vulnerable acquifier and can be potentially very dangerous for the ground waters in case of an accident. The Road Authority Unit was not aware of this fact, due to the lack of information flows between the municipality, having the knowledge base on the risks for water resources, and the Ministry. In late 2002 the MinWTrCom initiated GIS project, trying to setting up the GeoMedia and Oracle8 engines. The RA did not have access to the details of the project, but it was supposed to be provided with some GIS facilities by this project. The dates of project completion were not known, due to the limited staff capacity to execute GIS implementation and due to the lack of sufficient knowledge base on the effective use of GIS in transportation planning. The interest in UHII and its elements was therefore even bigger. The organisational characteristics of RU were moderately supporting the idea, because in spite of enthusiastic approach of RU chief there was practically no possibility to identify within a Ministry’s structure a working unit capable of joining the UHII initiative in terms of spatial data handling. Staffing problem refers as well to the MinWTrCom, not only SG or the CoW. From the side of political, hierarchical acceptance of the issue, the UHII project would be secured, due to the growing interest of high level ministry officials in the risk management related to human and goods transport. From the point of view of support to
spatial data management

**Spatial data management problems in multi-institutional context:** Inter-organisational decision-making problems are caused mainly by lacking policies and infrastructure for data exchange and sharing, although the demand for this was identified and even acknowledge by some institutions. The problem of unclear organisational mandates makes impossible to set up the cooperation framework in which the responsibilities would be clearly defined based on the functional characteristics of an organisation. The lack of organised co-operation between large group of spatial data producers and users, and lack of requirements analysis for facilitation of information detection, sharing, exchange, creates situation in which avoidance of data redundancy is impossible. There is no policies on digital data copyrights, no policies for digital exchange and data sharing. None or very limited awareness of necessity to record metadata only adds to the problem. There is no standardisation of spatial data, apart form the case of Survey General and Deeds Office - they practically dictate standards for cadastral and ownership data. The City of Windhoek on the other hand has practically the largest spatial data resources on local level and has the capability of dictating standards for the framework and application data of middle and large scale. The only problem is the lack of internal CoW agreement on the standard for spatial data, and still some of the divisions own and use mixed data formats ordered from consultancy companies. To complete the picture, SG, MinWTrCom and Remote Sensing Unit are provided with relatively new versions of GeoMedia and Oracle and this may by the time become the standard for data handling. It is not said, however, that there is an operating open data environment used with GeoMedia possessed by these institutions. In general the spatial data environment in Windhoek is far away from chance of open data transfers due to the relatively large costs of open GIS and due to the practical approach applied in institutions, where there is no actual need for sophisticated spatial data analysis tools and the transfer and exchange of data is made still by the means of multiple conversions of formats.

**Simplified Case-specific Spatial Information Management Model (CSIMM) for support in urban hazard management:** The core element of CSIMM is the central information system of the CoW (target UHII actor), supplied with thematic data by divisional subsystems. Contrary to the Dutch situation, there is no National neither local Database of hazardous objects, neither of cadastral information. One could argue that the CoW owns the most important resources of digital information on Windhoek. It even holds for digital cadastral and tenure data, which, due to the lack of capacity of the Survey General (SG), are digitised by the CoW from SG’s analogue data upon mutual agreement. Most of important information still remains unavailable: details on building occupancy, processes undertaken and materials stored/used in the buildings, capacity of emergency response units, details on building infrastructure. Also missing are important information flows due to the lack of link between the CoW and the Road Authority, the Remote Sensing Centre and the Ministry of Health and Social Services. The lack of co-ordination of spatial data flows results, therefore, in redundant production of datasets among these institutions.

### 3.4 How to successfully analyse requirements for a hazard information infrastructure - theoretical underpinning.

The theory for development of information infrastructure, is seen here as an extension of the System Development (SD) theories, studied in the context of Operations Research (OR) and Organisation Management (OM). The process of development of a System which is here an information infrastructure in question, is treated as an evident incentive for a substantial organisational change. Consequently the introduction of an information infrastructure to an organisation is seen as a process of diffusion of a new technology in an organisation, what has been given a substantial coverage in the literature.

It therefore requires a very careful analysis of its possible influence on the institutional performance. And vice-versa: the organisation itself may in a negative or positive way contribute to the performance of developed system, either neglecting it or using it in efficient way in long term.

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1 as in Daellenbach, 2001; Morgan, 1986; Williamson et al., 2003
This as well puts the following research in the context of Critical Social Theories applied for system development and targeting the non-technical changes to be implemented in order to provide the environment of sustainability for the system. The theoretical framework as given in chapter 2 is hereafter operationalised to support the "HOW" of the UHII development in a complex, multi-institutional environment of Windhoek, Namibia. The goal is to provide a clear link between theoretical underpinning and chosen methods, justification based on the criteria of UHII introduction. The theoretical framework as well is to help in an interpretation of outcomes of the latter executed UHII requirements analysis, to provide a fundament for a quality model of UHII, fit for long-term efficient use and for the benefits the stakeholders.

3.4.1 Soft or hard, positivist or interpretative, quantitative or… - mixed methods dilemmas

During the review of existing extensive literature on methods of information Systems Development the conclusion was drawn that there is no single "best" successful way, moreover the best combination of methods neither exists. Still there always must be a clear underpinning for the methodological choices made during the initial phases of SD, the criteria for such choice have to be made clear before, or sometimes in practice even during, application of a single method. The assumptions of this research state that the proper combination and interpretation of the set of methods gives better results than separate analysis of one method at a time and that some methodological choices are made only during the execution of the research itself, dependent on the preceding SD requirements analysis results. The SD process is shaped in an iterative way to allow for flexible choices, the chronology
of method application is never set before the actual investigation of the environment in which the system is to be implemented. This makes it different from the traditional Systems Development Life Cycle based approach, where the process is done step-wise, and the subsequent steps can be foreseen in advance.

The discussion on the choice of methods for SD is meant to support the decisions taken in the further steps of methodology development for UHII introduction. We do not aim to prioritising one of the discussed theoretical solutions, but to highlighting the importance of certain aspects and criteria considered during creation of combined SD methodology.

### 3.4.2 Implications of organisational analysis for methods applied

The functional system approaches, cannot deal with complex human-related problems, where conflicting subjective views are being observed, since they require objectivity of view and common goal expressed by stakeholders. The same approaches deal well with technical complexities and structured problems.

The interpretive approaches, since they are based on subjective attitude to system development, can tackle multiple opinions and even to some extent the conflicting views. Possible compromise between different demands and views can be investigated in an interpretative way, however some common interest and mutual benefit of stakeholders is necessary in order to achieve good results in system development using this approaches. Technical complexity is problematic to be handled in an interpretative way, functional approaches are a lot more relevant.

When there are conflicting views at the base of the organisational and information management problem, and its complexity is increased by variety of non-compatible demands and interests, the emancipatory system approaches can be very useful. The main assumption made using these approaches is that the existing systems (either in the understanding of the social systems with their hierarchical relations and divisions of tasks, as much as existing information systems) have to change in terms of boundaries and hierarchy. In other words: the investigated organisation may have to undergo reforms to change power distribution, tasks division or even existing business strategies. The changes imposed by emancipatory approach address the social, human-related factors, related to the problems of moderate complexity. Combination of technical and human complexity is a lot more difficult to handle with this approach, but even very complex social problems can be addressed in an emancipatory way quite successfully.

In case of COW as one of the target UHII actors, the emancipatory approach can be applied only with regards to the very strong position of the Geomatics department as a data keeper and data processing unit. The accumulation of data and the evident knowledge base on how to manage them, without any recorded metadata, can be very dangerous when the main spatial data manager quits, or changes the position. As well the municipal authorities themselves have the power of the only local spatial digital data owner, and in the same time they do not see an opportunity in releasing these to the market. This monopoly constraints the development of open environment for data exchange and the emancipation from that would be recommended for stimulation of UHII development with the contribution of other units than the governmental ones only. Still this approach gives rather recommendations for UHII development strategy and does not give an explicit answer for requirements analysis method or UHII introduction methodology. Daellenbach states that the main application domain for emancipatory approaches is public policy issues, what is supported by Clarke stating after Habermas that these approaches target the change of power and authority distribution.

It is very important to note that such emancipatory, as well as critical approach can directly affect the existing information systems of target UHII actors, by questioning their boundaries and functionalities obtained during user-centred requirements analysis. The critical and emancipatory system approach state that the results of user-centered requirements analysis are very likely to be biased due to institutional background conditions, accepted by survey respondents as rather constant than changeable factors. The assumptions of respondents on the status quo of their legal, institutional and technical structures should be detected and the conditions themselves should be made the subjects of change model.
Another important implication for this research is that soft situation analysis and system requirements analysis methods should be considered more relevant than the structured functional approach, due to the unclear and/or conflicting demands of a number of investigated actors. The boundaries of the system, its functions and specifications are seen from different points of view: the very much technology-push view by the Disaster management division, with the view of the Geomatics Division that would not see the “GIS freedom” of independent divisions as an advantage, to still be able to control the spatial data resources, their usage and modifications, and where independent land surveyors would see the great opportunity to change the approach of the CoW on the limited accessibility to the digital cadastral sources. In this situation the soft analysis of the data flows their bottlenecks and processes and their gaps should be performed. The SWOT analysis for UHII development may be a very good solution for indicating the necessary domains of organisational change and it would as well allow to think of possible strategic solutions involving different actors. The SWOT as well can be very sensitive for the critical approach guidelines - the assumptions made by the respondents can be validated by the group discussion on the strengths, weaknesses, opportunities and threats, as seen from different points of view. The core of conflicting views can be detected e.g. via cross checking the conducted interviews with the opinions given in the workshop discussion involving more actors, and via rich picture analysis done during the discussion. The formula of workshop would help to identify commonly accepted solutions to the organisational, legal and technical and UHII introduction problems.

As well to overcome organisational problems one needs more than the systematic and functional analysis proposed by "classical school", rooted in Taylor’s theory, where people and conditions in which they work are perceived as objective, and the solutions are given rather in the shape of mechanical, nowadays technology-based tools. The functional and objective approach, represented by structured, hard methods of System Development is, not sufficient, when dealing with experienced soft problems - complex and undefined, originated from bureaucratic, cultural or social character of institution. The so called "triangulation” of methods, in the meaning of supporting the hard, structured, and functional methods of requirements analysis and system development by the addition of soft and human centered ones, seems neither to be sufficient for the case of Windhoek due to one particular aspect: the necessity of introducing a complex organisational change. To improve the situation of Urban Hazard Management analysed by the core research, the institutional change is required with restructuring the processes of spatial planning and disaster management. To support this, the legal (mandates, policies), structural and functional changes among Windhoek stakeholders are necessary. In the context of multi-institutional co-operation, the more institutions would like to create an alliance to contribute to the UHII development, the more organisational changes will be imposed to coordinate the common efforts in data integration, standardisation, exchange and maintenance of technical tools supporting the initiative. The more these institutions differ from one another the more complex these changes become, and the more effort has to be put in proper analysis and prioritisation of the needs of the stakeholders. Simple triangulation by soft and structured methods may still give a biased view of the requirements. The Critical Systems Thinking and Critical System Approach can be very helpful to select and correct user views of the system in the cases when the user’s view is affected by his or her lack of knowledge or awareness of importance of certain aspects of spatial information infrastructure.

The relation of the Nominalism vs. Realism discussion with the methodology of this research is evident, concerning that the UHII requirements analysis should be shaped in a way to balance the individual, subjective opinions collected from a small, finished set of stakeholders via semi-structured and structured interviews. An objective approach should be introduced somewhere in order to prevent from obtaining significantly biased picture of the reality of organisational background and UHII potentials within it. The role of objective reference is intended to be played by the first pillar of the research - the preliminary study.

The meaning of positivist and anti-positivist dimensions for the development of UHII introduction methodology can be seen on the example of expectations of stakeholders for UHII functional subsystems, i.e. UHEMIS. The requirements analysis for UHEMIS prototype would have to reflect
these two dimensions. The positivist one would relate to the "what" of creation of risk maps (what elements should be included, etc.), provided that they are desired by the potential users, and to accuracy of following the expressed requirements. The anti-positivist view would lead to the discussion on the "how" of communicating - how to visualise the risk to different groups of users, how the users would understand particular symbols representing urban hazards and how would it influence their perception of risk. As well the anti-positivist approach would impose more focus on creating the easy-to-follow and understandable interface of the prototype.

Implication of the voluntaristic vs. deterministic discussion for development of the methodology for UHII introduction can be seen in the need to analyse and put under critical view the organisational structures and relationships between stakeholders to decide on when to opt for voluntaristic approach. There should be a set of criteria applied to decide which of the observed circumstances in the investigated environment are considered to remain constant, viewed as objective and unchangeable (either positive - opportunities or negative - constraints), and which circumstances should be seen as a subject of voluntary change, maybe necessary as prerequisite for UHII implementation. Both approaches are very relevant to consider and decide upon during creation of guidelines for policies and strategies for UHII implementation.

For the needs of this research the nomothetic and ideographic approaches to methodology would be taken into consideration respectively by testing the use of objective analysis of multiple reference cases and of investigation of subjective opinions of stakeholders and user-centred requirements. Both approaches will refer to existing As-Is and desired To-Be situations. The preliminary case study would provide in a nomothetic context the universal guidelines on how to avoid problems in UHII development, extensive core research would allow to implement the guidelines in a case-relevant way by studying the opinions on the appropriateness of proposed solutions.

The application of four paradigms model as adapted by Clarke and Lehaney (with categorised and positioned different methods of system development in the matrix) to the choice of UHII methods would be relevant provided that there exist a set of criteria arising from the background case situation. Knowledge of the characteristics of institutional and technical environment of Windhoek before the start of the study would be definitely an advantage, however in the given situation the investigation of the background case study conditions is a part of the research itself. Therefore the two-tiered shape of the research is necessary to structure the core research and give it a wider reference. In relation to the Clarke and Lehaney’s approach the first pillar of the research - the preliminary study, which regards looking for universal guidelines for application-oriented information infrastructure development in a well known and relatively structured background, would be positioned on the objective and regulative side of the matrix, in the functionalist cell. The core study, with its soft focus on organisational change and concerning introduction of UHII in the environment of multi-stakeholder views, within the context of (yet assumed in this stage and validated during the fieldwork) intended global change of institutional approach to data sharing and exchange would have to be positioned in the subjective side of the matrix. Still the question has to be made on to what extent it is possible to preserve the status quo of the Windhoek authorities, being a core target in UHII development. Is the regulative, interpretative approach to be taken a feasible and a good enough solution taking into consideration the weak pre-fieldwork knowledge on institutional environment and relations among potential stakeholders?

Development strategies of ISs and, arising from the tradition of IS development, SDIs as well, are mostly based on a number of local requirements analyzes, objective and positivistic in their nature. As investigated in section 3.2 only in few cases (i.e. NRW-GDI) the reference is made to the global experiences in information infrastructure development. The attempt of this research is to expand the awareness of the need for a wider approach to the validation of local requirements analysis via the functional preliminary studies, soft approach to situation analysis and critical view on existing environmental / institutional conditions.

The proposed combination of methods will have to incorporate not only the soft system analysis, since this will be useful only to identify and guide to the solutions of soft (multi)organisational
problems in UHII development. The analysis of assumptions made by the interviewees has to refer to more structured approach in order to avoid the ad hoc decisions on correction of "assumed bias".

The first pillar of the research - the preliminary study may seem to be a good reference for the lessons learned in urban hazard management supported by risk mapping initiatives. Still as an only example it can lead to very limited view on the problems of UHII development. From among the functionalist approach methods one seems to be promising as a complementary element of this Critical System Approach based methodology: the analysis of reference studies (or called as well benchmark cases) can be used for detection of system development limitations expressed by the actors due to their assumptions or the lack of knowledge. Performing such a reference case analysis would lead to the definition of lessons learned from initiatives similar to UHII or from global-domain SDI development cases. These, if correctly used, can help to interpret both the soft statements obtained for SWOT analysis and the functional/interpretative analysis of user-centered requirements for UHII. It is expected that the modifications introduced due to such critical approach, as the third pillar of the research, should provide with the more sustainable model of UHII architecture and management, due to the use of wider knowledge base than the one obtained by interested actors. In such way the guidelines for strategic implementation of UHII can be obtained.

The next step therefore would be to analyse the detail requirements for the elements of UHII such as the proposed UHEMIS, with the example hard, technical elements such as network systems, databases, on-line mapping applications, etc.

In the question of potential UHII architecture and the method of it's modelling the approach of Veeke is very useful. The analysis of Veeke (see: 2.3.2.1), in terms of CATWOE and multi-purposive characteristics of the system, lies in line with the concept of Urban Hazard and Emergency Management Information System UHEMIS as a potential element of UHII. More then one target discipline would be able to use it for their purposes: namely Urban Hazard Management but also Spatial Development Control, Spatial Planning, Environmental Control or Transport Control. The main objective of UHII (and consequently the umbrella objective for UHEMIS) is management of spatial data, used commonly by the target disciplines.

Consequently after Veeke’s guidelines (see: 2.3.2.1) the current UHII conceptual model should be built with the application of:

- A soft approach to define organisation sensitive UHII objectives and processes or functions of the UHII subsystems (i.e. UHEMIS)
- A functional approach to describe UHII as a system (e.g. functional system analysis) with crisp boundaries (delineated internal and external environment) and identified required data flows
- A structured data supply/demand analysis with regards to the interactions between external and internal environment
3.5 Methodology model for UHII development in Windhoek, Namibia

3.5.1 Global view - Two-tiered research and Critical Systems Approach

3.5.1.1 Literature Review - how to detect problem areas in UHII development?

The problem of management of urban environment in Twente, the Netherlands, is investigated in this phase in terms of detection and mitigation of man-made hazards. The bottlenecks of disaster management process are identified and the situation analysis is performed. The possible analogue urban hazard management problems are being foreseen for dynamically developing cities, especially in developing countries. Moreover, to provide the base for critical approach in the latter phases of the research the extensive literature review was conducted on the experiences with spatial data infrastructure development and projects related to hazard data management, infrastructures and information systems. The lessons learned were used to verify the outcomes of latter methodological approaches (SWOT, user-requirements analysis), and due to their importance they were treated as a separate methodological step (see: 3.5.1.4).

3.5.1.2 Preliminary study - “As-Is” of risk data management in Twente

This preliminary phase of the research addresses one unit of Dutch Fire Brigades responsible for regional data management. The interview and discussion is conducted with the staff in charge. In order to validate the results of the interview the information is cross-checked with the official up-to-date information published on the websites of Dutch Fire Brigades Association and other important actors involved in development of information infrastructure for urban risk management. The spatial and non-spatial data flows are being identified and described in this stage; the responsibilities of different institutions in risk mapping initiative are observed after the deep analysis of the evolution of the risk mapping initiative with its bottlenecks and repaired faults. The conclusions are drawn on the basis of lessons learned to try to prevent UHII from the faults experienced in the Netherlands. The organisational analysis is briefly performed to link the faults of the initiative with the institutional context, and to be able to find the reference to the UHII development in a different organisational setup. This phase of the study questions the assumptions on the success of technological innovations (as spatial data infrastructures) in an environment with good technological base and in institutions of high level of organisational development (in the meaning of high empowerment on different management levels, freedom of project actions within a disciplined range, good legal base of actions - mandates or policies, existing strategies, etc.). The non-structured, non-functional aspect of the risk data management is shown.

3.5.1.3 Core research - the scene, the actors and the problems

In this phase the analysis of the “As-Is” background situation and target actors relationships are performed. The main problems of spatial data management are identified and their causes pointed out. The potential of UHII introduction therefore arises. The analysis of the scene, actors and the problems is made in a soft and semi-structured way; starting from a rich picture situation modelling to finishing with a test on potential data flow model or functional system analysis, in case the systemic approach can be applied. The analysis of strengths, weaknesses, opportunities and threats is performed during the workshop discussion, to obtain some prioritisation of the statements and to prepare guidelines for policies and strategies. This soft approach, regulative in it’s character and conforming to the knowledge and assumptions of the respondents, has to be validated by other method, to obtain critical social and structural point of view. Further on the requirements analysis for UHII can be performed, and subsequently the detailed information system (UHEMIS) user-centred requirements analysis can be completed. In this stage these requirements may be biased or inaccurate as well, until they are validated with the critical approach. The factors influencing UHII and UHEMIS development, that are taken for granted by the actors, are identified and left for validation and emancipatory analysis, involving observation of subjects of necessary organisational change.
3.5.1.4 Reference cases - functional study for Critical Windhoek assessment

In this part of the research the reference to the soft analysis of Windhoek situation is obtained. This is to provide a functional and structured reference to the results of the soft, human-centered and possibly biased approach. The criticism towards results obtained in the previous stage is presented, by the positioning them against the universal guidelines drawn from the multiple case study on SDI and IS development and SDI/IS support in disaster management. These universal guidelines can change the view of users on the policies and strategic steps necessary to successfully implement UHII. The correction can be made either during or after creation of the SWOT table. As well the modifications on the user-centred UHII or UHEMIS analysis can be made on the basis of this reference experiences.

3.5.1.5 Global methodology model

The two tiers (preliminary and core) and a reference critical approach create the base for the detailed, structured and soft user requirements analysis for UHII introduction and implementation. The literature review at the beginning aims to

3.5.2 Methodological phases - detailed approach

3.5.2.1 Preliminary study - requirements and tools applied

During this phase of the study the general knowledge on spatial data management and use for risk mapping and emergency management was acquired. The issues addressed were:

1. Demand for GIS-based decision support and for multi-institutional management of spatial data to support disaster management in the Netherlands; the case study Region Twente was in focus

2. Investigation of disaster management activities and procedures and their requirements regarding the use of spatial and non-spatial data in different phases of disaster management cycle (from prevention through mitigation, preparedness and response).

3. Investigation of telecommunication and information infrastructure (radio, GPS, www etc.) used for gathering and management of data necessary for risk mapping, emergency planning and emergency response.

4. Investigation of existing policies for shaping hazard preparedness; and for multi-institutional cooperation both in risk data sharing and in emergency management support

5. Investigation of existing rules in hazard mitigation and emergency response planning (safety measures and their data requirements)

6. Creation of risk maps - investigation of rules for risk classification and data standardisation, data requirements (vulnerable and hazardous objects) and data collection principles.

7. Emergency response plans - investigation of rules for their creation and their data requirements.

8. Exploration of the case of S.E.Fireworks explosion to illustrate the shortcomings of existing management of urban hazard data in Twente.

The tools applied for data collection in this phase were primarily 2 interviews with the representative of Regional Fire Brigades, responsible for coordination of Risk Mapping initiatives and preparation of the policy for standardised regional risk maps and for standardisation of digital risk data formats for improved information integration and sharing, Mr Ron de Wit. The interviews were cross-checked with the information available via official online sources of Dutch Fire Brigades, ministries, institutes, municipalities and other entities involved in the risk mapping initiative. The extensive
literature review was based both on Dutch language texts and their English language summaries. The case of S.E.Fireworks explosion was used as a starting point to identification of the problems in disaster management process caused by ineffective spatial data management and related to that organisational issues.

3.5.2.2 Preliminary study - As-Is situation modelling

During this phase, based on the outcomes of the above mentioned literature reviews and interviews, the bottlenecks of risk data flows were identified and their influence on the disaster management was identified. The soft approach and rich picture modelling were used to create the model of complex multi-institutional relationships in terms of process and data flows. The emphasis was given to the organisational background and to the identification of stakeholders and their roles in a number risk mapping projects, contributing to the national Model Risico Kaart (MRK) initiative. The Reference Spatial Information Management Model was created and the soft (organisational) and hard (technical) problems were identified.

3.5.2.3 Reference cases analysis - requirements and outcomes

This part of the research constituted the analysis of a number of initiatives for setting up information infrastructures (for handling spatial and non-spatial data) either in general "global domain" context or application-oriented disaster management domain. The focus was given to the ways of structuring the initiatives and problems envisaged during their implementation: the objectives and scopes of information infrastructure or wide information system development projects, their initiators (main demanders), and faults were investigated where it was possible. The lessons learned created the reference for validation of the strategic SWOT analysis for Windhoek and for validation of the bias in user-centered requirements analysis for UHII and its elements (i.e. Urban Hazard and Emergency Management Information System).

3.5.2.4 Core research - data, knowledge and tools required

Based on the Preliminary study the requirements for information to gather in the fieldwork in Windhoek were assessed. The focus was put on investigation of availability and access to spatial data needed for urban hazard assessment and emergency response planning. The additional aspect of the fieldwork regarded the possible link between the on-going initiative on spatial data infrastructure development and potential UHII. Expected problems with supply of base and framework spatial data influenced the requirements on the investigation of data flows and processes involved directly and indirectly in the integrated disaster management. The following issues had to be investigated in order to picture As-Is situation of urban hazard data management in Windhoek:

1. Demand for decision support and for multi-institutional management of spatial data to support disaster management in Windhoek; with the special attention given to the possible development of Urban Hazard Information Infrastructure - demand for UHII and for the supply of base, framework and application-specific data, coming from different urban management processes.

2. Characteristics of the disaster management process, policies (if existing), spatial data usage (in analogue and digital form), requirements and gaps regarding spatial data supply and regarding the process flows. Level of integrity of the disaster management (in particular urban hazard management) process with other urban management processes.

3. Shaping the preparedness status - the level of awareness of exiting urban hazards and spatial relation between vulnerable and hazardous objects, what relates to

4. Existing rules in hazard mitigation and emergency response planning (safety measures and their data requirements),
5. level of availability and accessibility to the data necessary for urban hazard management (framework and base data, land use, building functions and building infrastructure data, road network, infrastructures and utilities in the proximity to hazardous and vulnerable objects, especially water supply infrastructure, occupancy and population distribution, vulnerability assessments (environmental, social, etc.), capacity and location of emergency response units - fire brigades, paramedics, police, etc., evacuation areas, etc.

6. Institutional aspect of availability and usage of spatial data - existing tools and ability of staff to use them, technical and social aspects of introduction of an information infrastructure in multi-organisational environment, etc.

7. Institutional and individual requirements for development of an information system to support UHM, and to prepare the framework for spatial data exchange and sharing.

The methodological tools applied were the semi-structured interviews, cross-checked with the open discussions, a workshop with the presentation of main concepts of SDI, information systems and their support in risk mapping - presentation of a prototype risk map of province Friesland and a prototype application for support in spatial development control and spatial planning. The workshop open discussion on the SWOT aspects of UHII introduction to the Windhoek environment, data supply bottlenecks and gaps in urban management process. Three types of questionnaires were prepared, one directed to the DM Division and ES Division of the COW regarding UHM process requirements (completed in the form of a structured interview), one with respect to the spatial data flows and their requirements (addressing as well data quality and metadata aspects) among the stakeholders, and the last regarding the specific requirements for an information system supporting UHM - UHEMIS. The analysis of the collected data followed the below described flow, from the introduction of relevant concepts to the targeted stakeholders, through analysis of their demands, selection of internal and external stakeholder environment, description of As-Is situation of urban hazard data management and supporting base and framework data management in Windhoek, analysis of organisational characteristics of the main stakeholders, analysis of UHII user-centered requirements with the validation provided by the chosen methodology - analysis of reference cases, SWOT analysis and validation, UHII modelling, UHEMIS requirements analysis and validation and UHEMIS modelling. These methodological steps can be described as follows:

3.5.2.5 Core research - Introduction of UHII to Windhoek environment - SDI concepts and demand

The objective of this phase of research was to investigate the demand for UHII arising form the needs of different actors for support of their processes and decision-making. During this phase the potential stakeholders of UHII are getting acquainted with the concepts of spatial data infrastructure and their needs of improvement of spatial data management are investigated. The following methodological tools are used in this phase - personal semi-structured interviews with the introductive presentation of the concept of UHII and example online GIS application for support in UHM (prototype of the Risk Map of the Province Friesland) and the workshop with the presentation of the concept of an SDI and spatial data service centre (clearinghouse) and a complete presentation of the prototype Risk Map application (in the context of creating application-oriented spatial information infrastructure) and a presentation of an example prototype application of a GIS based application for spatial development control (in the context of integrated UHM linked to spatial planning and land use management).

3.5.2.6 Core research - identification of internal and external stakeholders

The internal and external system environment are defined in this phase based on their demands and expectations. The importance of a stakeholder from the UHII point of view (capacity of actors’ resources and its potential role in setting up the infrastructure) and the interest of the stakeholder in UHII (the need of a stakeholder to use UHII) are being considered as main criteria analysed.
3.5. Methodology model for UHII development in Windhoek, Namibia

3.5.2.7 Core research - As-Is situation analysis

In this phase the detailed identification of data flow bottlenecks causing the process constraints was conducted, a soft approach and rich picture modelling were applied, the Case-Specific Spatial Information Management Model was developed and the relationships between the stakeholders in terms of data flows were analysed.

3.5.2.8 Core research - Organisational characteristics analysis

Organisational issues analysed on the base of observations and primary and secondary information received in interviews. The performance and structure of organisation taken as main criteria together with the problem statement characteristics (complexity, divergence of opinions of stakeholders, etc.). The attitude of organisation towards spatial data management is investigated here as well in terms of awareness of the problems. The issues as data availability, accessibility, informal vs. formal information flows, data reliability, political power in data management, data dissemination formats, legal base for data management, characteristics of multi-institutional contacts (cooperation vs. competition) are taken into consideration. The source of information on multi-institutional relations is mainly the workshop discussion.

3.5.2.9 Core research - Methodology choice

Based on As-Is and situation analysis, with the reference to comprehensive literature review on the application of a multi-methodological approach to information systems development, taking into consideration organisational characteristics.

3.5.2.10 Core research - SWOT analysis

Workshop for UHII requirements and SWOT analysis as a tool in this phase of the research allows for the confrontation of stakeholders and the identification of their common and conflicting requirements as well as the internal organisational weaknesses and strengths of target actors and opportunities and threats arising from external stakeholder environment. The SWOT is performed in the high level context of UHII development, UHEMIS as an element of UHII is implicitly considered in the discussion, and UHEMIS relevance and the real demand for it is therefore tested. Strategic guidelines are created after SWOT to support or reject UHEMIS development, and to properly choose the ways of UHII implementation. The link between UHII and SDI is established and the outcome of this SWOT analysis is prepared: guidelines for policies and strategies for UHII development with the model of institutional co-operation and operational model for diffusion of UHII in organisations.

3.5.2.11 Core Research - Structured UHII and UHEMIS requirements analysis

SWOT is a pre-requisites for structured system requirements analysis of UHEMIS, conducted at the end of the workshop. Moreover the requirements of the Urban hazard management process are investigated next to SWOT (inner process requirements and process input/output requirements - with the link to other urban management processes; information requirements analysis, and related to it process change). The above allows for final identification of the boundaries of UHII and its elements (scopes/ further functional analysis). Here the UHII architecture can be modelled.

3.5.2.12 Critical System Approach - validation of the structured requirements analysis

The requirements for UHEMIS are validated against the recommendations from the reference studies and the preliminary study. The context of recommended strategic approaches is considered as well as the modification incentive. This allows for final phase of conceptual modelling of UHEMIS.
3.5.3 Requirements Analysis Methodology - Summary of a practical execution of the combined methods

In the preliminary study the requirement analysis was greatly structured and did not require application of new methods. Most of information on regional SDM for hazard management was acquired via the structured interview and questionnaire directed to a person in charge of SDM (Mr. Ron de Wit, Regionale Brandweer Twente, Hengelo, the Netherlands). The outcomes of the interview were periodically crosschecked with the information available through official websites of National Council for Geo-informaiton (Ravi) (Ravi, 2003)(Ravi, 1999b), Ministry of the Interior and Kingdom Relations (MinBZK)(MinBZK, 2003), National Institute of Public Health and the Environment (RIVM)(RIVM, 2003), Association of Municipalities (VNG)(VNG, ), Inspectorate of Spatial Order and Safety Management (IOOV)(IOOV, ), The Dutch Association for Fire Fighting Service and Disaster Management (NVBR)(NVBR, ), and The Dutch Institute for Fire Fighting and Disaster Management (NIBRA)(NIBRA, ). The current projects related to hazard and emergency information infrastructure development were described; the legal policies and strategies for its development were identified. The RSIMM model represents the numerous elements (related both to framework data provision and risk-specific and development-specific data analysis) of SDI that currently is in the implementation phase. In the core research it was neither possible to conduct the analysis of spatial information flows for the CoW in a conventional structured way nor in a soft way. It is the lack of respective organisational entity acting in charge of multi-disciplinary SDM and the scattered information resources, what made the analysis of spatial information accessibility very difficult. The actual lack of data flows or unavailability of data also constituted a significant problem. To identify the responsibilities of departments their information needs and the level of interest in potential UHII development, the series of semi-structured interviews were supplemented by crosschecking meet-
ings and by inter-organisational workshop. The crucial role in establishing methodology for UHII introduction played the workshop during which the main SDI concepts were introduced to all potential stakeholders. UHII was presented as the example of the application-specific SDI. During the workshop the questionnaires were filled and the outcomes of interviews were corrected. The SWOT analysis was performed. The workshop provided the complete UHII requirements analysis: the discussion between representatives of different organisations resulted in the accurate SWOT analysis; proposed UHII initiative was assessed by potential beneficiaries; the feedback for the UHEMIS development and implementation was obtained; and the elements of the CSIMM were identified. The open discussion indicated necessary modifications of existing GIS tools and Database Management Systems (DBMS) to comply with the concepts of interoperability and open GIS.
Chapter 4

From the lessons learned to system modelling - the Critical Approach to Urban Hazard Information Infrastructure for Windhoek

The application of mixed methodologies of system development supported by the Critical Systems Approach is described in this chapter in order to arrive to the UHII development model. This stages of the research reflect implicitly the model of diffusion of information in organisations as represented by Williamson et al. (2003) (p.) . As indicated in the Organisational Innovation Process Model(see: section 2.1.4), the process of diffusion of technology consists of 2 main phases: namely the Initiation Phase (analysis of organisational problems resulting with the need for geo-information and matching the organisational problem with the SDI development idea) and Implementation Phase (alteration of organisational structures and modifications of both the initiative of SDI development and organisational settings). For the needs of this research adaptation of this model was made, to link it to the Critical System Approach. The sub-phases of Initiation and Implementation stages (mostly referred to as the Introduction and Implementation) were seen as a cyclic, iterative development process, in which the critical references are introduced at every stage. It was done to correct the possible bias in outcomes of requirements analysis, that from the point of view of Critical Systems Thinking is seen as an effect of uncritical acceptance of the status quo of organisation. Based on the Critical Framework for Information Systems Strategy see Chapter 2, the ”critical cycle of learning and action” was applied. The Critical evaluation of the outcomes of interpretive analysis and organisational conditions was done in order to allow the structured analysis. In the practical meaning the Initiation Phase regarded the introduction of SDI and UHII concepts to the environment of Windhoek, via the presentation at the workshop and demonstrations of the during the interviews, and collection of data on organisational demands and UHII requirements. The critical evaluation of user needs was done by initial reference to the lessons learned from the S.E.Fireworks case and Risk Mapping Initiative in the Netherlands (preliminary study) and by the extensive use of recommendations arriving from the set of reference cases. This was the transition stage between the Initiation and Implementation phase. The role of the SWOT analysis is seen here as a very important step in critical analysis of demands for UHII, as the exploration of the strengths, weaknesses, opportunities and threats in the light of critical approach allows for modification of the UHII requirements. Such approach is expected to influence the cycle of continuous change of user requirements, caused by the introduction of new concepts and tools, new organisational structures and new workflow models (see 4.1), that are necessary to implement demanded technology. The critical assessment of identified user requirements for UHII is expected to help to shorten the re-iterative cycle of system development and organisational change (see: 4.1).
A Critical Framework for Information Systems Strategy

Boundary of IS
Strategic System

Interpretive analysis (IS)
Structured analysis (IT)
Critical cycle of learning and action
Organisational climate
Critical evaluation

Source: Clarke et al. (1999)

Figure 4.1: The cyclic change in system development process and organisational environment, as given in the framework of critical approach.

Cycle of interaction between Information System Development and Organisational Change

New Demand
Incentive
Technology Initiation
Organisational Change
Technology Implementation
Requirements analysis

Figure 4.2: The cycle of interrelated system development and organisational change.
As well the strategic guidelines arising from SWOT, when placed in the critical context, would aim to altering the organisational structures, as recommended by the reference cases. Therefore the reference cases studies are analysed in this chapter in order to validate the outcomes of demand and As-Is analysis used to construct the statements for SWOT analysis for the introduction of UHII in CoW. The SWOT analysis aims to creation of recommendations and guidelines for policies and strategies for UHII development. It is performed with the Critical Approach to the organisational structure of the CoW, to the current information management and to the supply of spatial data for integrated UHM process. Finally in this chapter the structured verified analysis of UHII process and data flows requirements is given, and the guidelines for policies and strategies of UHII development are presented. The conceptual model of UHII is presented at the end.

4.1 Towards structured management of spatial data - lessons learned from reference cases

Spatial data management in the view of this research refers not only to the rather technical management of the data (related to hardware and software support for storage, update, sharing, exchange transfer, quality control) but to establishing the framework in legal (policies, rules of data use) and institutional (standards, technical and legal co-operation) aspects to facilitate access to the datasets, and operations being undertaken on them by multiple users and providers. It is evident that a careful strategic approach has to be applied to achieve integrity of datasets and fluency of data flows in multi-institutional environments. Both a conceptual level (policies and strategies) and a detail operational level (actions and tasks) have to be addressed in user requirements analysis for SDI development. Step-by-step new concepts and solutions have to be introduced and re-evaluated. Analysis of the experiences of SDI development in different countries is used in this research as a very important reference to the drawbacks and problems appearing during the process of structuring data management. The main assumption is that similar problems envisaged in developing Spatial Data Infrastructures appear in different institutional environments, whereas the methods of SDI implementation as much as the development strategies cannot be copied due to the very different institutional, economic and legal conditions being the base for different SDI. It is so due to the fact that information management is considered as complete characteristics of organisation; changing the information role and data management patterns affects directly the organisational structures ((de Man, 1990))(The implication is that the organisational problems should be resolved first before implementation of the information system or infrastructure, to avoid the situation where only the symptoms of the information problems are being addressed and not the real communication bottleneck causes. These can be rooted in bureaucratic structure, inter-departmental or inter-organisational competition, non-clear organisational mandates, lack of awareness of data management role for organisational performance, lack of consistent vision of organisation on it’s different hierarchical levels, lack of inter-divisional (horizontal) or inter-hierarchical (vertical) communication, etc. Only after solving above stated problems, implementation of the information management systems or (as approached in this research) an information infrastructure can diminish the problems and bottlenecks in the current data provision and utilisation system, which is the data flows, channels, providers, creators, and different groups of users.

4.1.1 Global-domain approaches in SDI development

Structuring management of data, especially spatial data, due to variety of their syntactic and semantic characteristics, is a complex problem, approached differently by different organisations. One, thus, can observe different reasons for- and approaches to development of spatial data infrastructures depending on characteristics of institutional background and individual stakeholders interests. In this research the so-called “global-domain” and “application-specific” approaches are distinguished. The first one refers to such incentives for SDI development as economic growth, knowledge dissemination through spatial information exchange, and use of wide resources of spatial and thematic data
in various disciplines, being addressed by both public or private commercial sector. The global SDI development approach focuses on strengthening the accessibility of spatial and non-spatial data coming from various domains and being used for various purposes; either the framework data flows are of primary concern, or equal weight is given to any of the thematic data domains. The latter approach is called "application-specific" due to the very clear SDI development incentive originating from the specific domain’s need to share data, exchange them, and first and most of all make existing datasets known and available for all the domain-related actors. In such case, the need for establishing information infrastructure may be expressed first at the low administration levels, where the accurate information has to be prepared for support in further decision-making processes.

4.1.1.1 Dutch experiences in Spatial Data Infrastructure development

((Groot and McLaughlin, 2001), (Ravi, 1999a), (voor Geo-Informatie / Dutch COuncil for Geo-information, 2003), (Kok, 1999))

**Purpose and scope of infrastructure:** The Dutch National Geo Information Infrastructure (NGII) has been established in order to offer better accessibility and improved flow of data supporting decision-making processes especially in public sector, involving all government administration levels. The NGII is suppose to provide

"coordination of supply and demand from public bodies as well as private businesses, to acquire of support for activities, target the marketing of products, as well as bringing in both knowledge and business experience"

(Ravi, 1999a) Organisations involved in NGII development aim to improve the spatial information management by means of cooperation and agreement, leading to improved, efficient use of spatial information infrastructure, through which the access to data is facilitated for reasonable price. The backbone of NGII is the National Clearinghouse Geo-information (NCGI), through which the metainformation on Dutch spatial datasets is made available via internet (www.ncgi.nl).

**Initiative level:** Dutch National Geo Information Infrastructure (NGII) initiative has been coordinated by national public bodies, after voices of demand were raised independently by numerous public and private organisations. The government gave the rights of an advisory/consultative body for geoinformation to Ravi (Netherlands Council for Geographic Information), to better co-ordinate development of national spatial data infrastructure. NGCI was initiated by Ravi in 1995, but in 2001 Geodan organisation (www.geodan.nl) became the clearinghouse’s co-operative advisor and executor. The NGII (with NCGI) is a public domain driven infrastructure, run in a top-down approach (decisions taken at the governmental bodies to address public and individual users).

**Responsible body:** Political responsibility for coordination of geo-information matters is given to the Minister of VROM (Netherlands Ministry of Spatial Planning, Housing and Environment), who communicates messages on NGII progress between the government and NGII strategic body - Ravi: The National Institute of Public Health and the Environment - association of collaborative public organs, including the Dutch Association of Municipalities, Provinces, Waterboards and utility companies, that became together the governmental consultative body for Geo-information in 1993. Ravi

"comprises all public services and local authorities with an important role in the provision of real estate and geographical information.”

(Ravi, 1999a) and therefore is responsible for harmonisation of strategies for NGII development and specifically for:

- Intensification of geo-information use by professional users
- Promotion of knowledge exchange via stimulation of geo-information flows between governmental authorities, business organisations, scientific organisations, and international geo-information network
• Further development of the NGII
• Promotion of use of standardisation among NGII members/users
• Promotion of economic and legal conditions for efficient and fare NGII use

The GI Business Platform of Ravi links private business organisations with public bodies to facilitate national level cooperation between them with regards to geo-information provision, especially focusing on real estate information. There are already more than 30 private companies within GI Business Platform.

**SDI Application type:** The NGII is a global-domain infrastructure, where all types of spatial data are taken into consideration for use in numerous applications. Although there is no one-domain-focus, the cadastral and real estate information can be considered as the real core of the infrastructure. The issues of cadastral information management have been given a lot of attention among other SDM issues.

**Problems envisaged:**

• privatisation of the clearinghouse services and mixed private and state control over the NGII raised the question on how to distribute the responsibilities for the quality of service. Full privatisation would not assure the control on the quality of spatial products and services, therefore some state influence was kept.
• The co-ordination of the initiative by Ravi experienced some difficulties, due to the large number of stakeholders involved in the NGII initiative. The standardisation of spatial services and products provided by numerous organisations was a challenge;
• Moreover to provide the interoperability in spatial IT environment and in parallel to keep the business objectives of the contributing parties, the strategic approach had to be expanded to the multi-institutional context. This means that the business strategy for NGII should have corresponded with the strategic goals of its contributors. This was an environment vulnerable to appearance of conflicting business goals between NGII its contributors.

### 4.1.1.2 Northrhine Westphalia Geo-Spatial Data Infrastructure

**Purpose and scope of infrastructure:** The creation of the Northrhine Westphalia Geo-spatial Data Infrastructure (GDI-NRW) (Brox et al., 2002) has been initiated in January 2000 on a rising demand for development of geographic information market, built rather on the so-called "value chains" connecting users, service providers, service enablers, integrators, data producers, and infrastructure providers. Because of it's market-oriented approach GDI-NRW is not meant to be based on sectorial policy measures or technology measures. The goal of the infrastructure is as well to shift the focus in existing GI market from provider-oriented to consumer-driven. The user will evaluate geoinformation products useability and drive to re-shaping geoinformation supply.

**Initiative level:** The GDI-NRW is an initiative of the Land Northrhine Westphalia, German regional administrative authority. The authorities related to the project include as well the Survey and Cadastral Authorities of the Lands (Laender).

**Responsible body:** First 10 sub-projects for GDI-NRW were initiated by Interior Ministry of Northrhine Westphalia, the execution of the sub-projects was a responsibility of independent companies or consortia. The maintenance and provision of continuous process and metadata/data quality assurance in GDI-NRW and a day-to-day development of GDI is planned to be given, based on Australian and British experiences, to two organisations: first to one of member organisations and second to a neutral and independent organisation. Both will execute business tasks of GDI-NRW.
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Application type: GDI-NRW would be developed for all types of spatial data and related thematic information, no particular application is given focus. This global-approach to GDI development arises from the very clear demand for stimulation of data flows between institutional, commercial and research organisations present in the GI market, where stakeholders should become members of a structured business network.

Problems envisaged:

- Geo-information supply does not reach demand specifications, offered products are not fit for use.
- The technical problems of transferring different formats of data will be mainly solved by interoperability standards (co-operation with OpenGIS Consortium), but a lot more problems come with translating different semantics (definition of data classes)- GDI-NRW is challenged to provide the solution; the service view of conceptual framework for resolving semantic heterogeneity is in place already.

4.1.1.3 Namibian initiative for Environmental/Spatial Data Infrastructure

Initiative level and some background on SDI demand: The demand for Namibia Spatial Data Infrastructure (NSDI) was first expressed in 1999, but due to the disagreements in National Geographical Systems Committee, the initiative was frozen until June 2002, when leaders of Environment Monitoring and Indicator Network (EMIN) recommended development of NSDI again. EMIN project was initiated by Ministry of Environment and tourism after it’s Environmental Information Systems Unit was established. Still, due to the political and organisational issues the problem of NSDI development has not been discussed until June 2003. This governmental level idea was not linked to the ideas already existing in the lower administrative levels, where demand for common platform for geo-information exchange had been being expressed since the implementation of the first CAD and GIS tools. Primarily the City of Windhoek together with Survey General Office discussed opportunities of exchange of cadastral and real estate information, but implementation of the ideas was constrained by poor institutional capacity, lack of broader view on the problem and lack of legal and institutional instruments to deal with the problem of data sharing and exchange. The peculiarity of Namibian spatial data management situation lies in the very specific distribution of power, capacity and knowledge of the data management issues. There exist as well different understanding of the spatial data management needs among local and state governments. Municipal authorities most often have too less financial resources, and legal power to act as driving forces for NSDI development, but they often have more knowledge on local datasets and processes. The state level organisations, however, have the legal rights for initiation of NSDI, but do not have enough structured data resources for it’s physical development, neither they have deep understanding of local social needs, which in fact are the real driving forces for initiating appropriate decision-support in the shape of SDI.

Local authorities of Windhoek - the City of Windhoek, physically possess the biggest local spatial data resources, also in digital format. Governmental organisations, such as Survey General Office, due to their structural and knowledge-base transition, did not yet have enough technical and human resources to focus on local datasets; they are mainly pre-occupied with completing national mapping initiative to assure availability of (first analogue, later on digital) framework data (called fundamental datasets). As a result, two distinct data management approaches could be seen in Namibia, where the first regards top-down governmental initiative on management of rather small scale data, whereas the latter reflects the need of local authorities to stimulate larger scale data flows between different local, regional and state administrative units.

In this research the focus is given to the local spatial data management needs due to the fact that the status of NSDI initiative was still very much uncertain during the local situation analysis. The assumption given was that at the base of NSDI development there will be a lot of local initiatives, to which attention should be given equally as much as to the state level NSDI co-ordination activities.
During later stages of research execution the top governmental authorities revived NSDI initiative influencing the scope of this study. As a result a very important consideration is given in “Conclusions” section to the way of harmonious link between state and local approaches to the improvement of spatial data management.

**Purpose and scope of planned infrastructure:** As seen by the government the NSDI should be

"a 'forum of stakeholders’, a loose configuration of data users and producers, which will coordinate the development of geo-spatial information and the establishment of mechanisms for the exchange of geo-referenced information from different sectors”

(Noongo, 2003). The same source presents main scopes of Namibian NSDI as

- Lowering information management costs by reducing redundant data production, linking existing information systems together and with international infrastructures, and clarifying data custodianship

- increasing use of geographic information in environmental management (especially due to the EMIN base for NSDI) and development planning

- Serving as an “information hub” for improved access to and exchange of data, providing metadatabase via documentation of existing and new datasets.

- Support for improving efficiency of investments in spatial data management; helping to assure value and quality of the information available to government

- Support for improved integration of data through standardisation

**Responsible body:** Responsibility for investigation and re-creation of NSDI conditions for data production, access, sharing and exchange, and standardisation is given to the inter-ministerial NSDI Committee, established in March 2003. The committee consists of ten persons from six institutions involved in spatial data management on supra-regional level. The leading role in the committee is given to the Ministry of Land, Resettlement and Rehabilitation, coordinating Committee’s actions. The Ministry of Environment and Tourism (MET), however, with it’s Directorate of Environmental Affairs (DEA), is the main NSDI and EIS implementation leader, so to say "executive” organ. The important task of the NSDI Committee is to prepare the national data policy (state for July 2003 - in process; available at http://www.gysi.org/docs/SDIA/namibia_draft_data_policy_july_2003.doc).

**Application type:** Since the governmental NSDI initiative is based on existing broad Environmental Information Systems the infrastructure itself will first support the domains of environmental management. Still, it is planned to create a consistent national base of framework data as an input for the infrastructure and an answer for data availability problem. Nowadays the focus areas for data collection are the Northern Namibian regions, both topographic maps and census datasets are being updated and matched with existing environmental data. Subsequently the focus will move to the Central and Southern regions of the country, continuing in parallel framework, census and environmental data collection and integration.

**Problems envisaged:** Making data accessible through computer network imposes first the acquisition of the digital data, either by conversion of existing analogue datasets or by direct use of digital inputs coming already from GPS or GIS tools. Problems in data digitization and supplying GIS with them are complex due to involved issues of quality of digitization process, reliability of its digital outputs and legal responsibility for the final product quality. The current most significant problem is, however, the lack of integrity in inter-institutional efforts to provide digital datasets. A lot of redundant efforts in data production appears, since there is no mechanism of checking availability of existing datasets. The same information can be produced by different organisations; at the same time the same analogue data if put in digital form by two different users can differ in output significantly and adjacent datasets are very often incompatible. This affects further exchange and sharing of data as much as the common lack of metadata (although currently the National Metadata Directory is being established at http://www.dea.met.gov.na/data/publications/Databases/MetaDB/metadataEnv.htm -
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Lack of efficient coordination is considered currently the biggest bottleneck in the progress towards NSDI, what reminds of the initial problems of both global-domain spatial data management and risk information management in the Netherlands.

4.1.2 Experiences in hazard management-oriented SDI development

Examples of research on disaster/risk management and preparedness raising in urban areas are described in numerous sources, e.g., the Best Practices Database, UN-Habitat (Habitat, ).

Recently the subjects of disaster prevention and mitigation are more and more interlinked with data management and technology transfer concepts, both for natural disasters and for urban environment management. GIS tools applied in DM are used nowadays not only for visualisation but as well for (initially limited) spatial data management purposes. As well the aspect of transformation of analogue/manual urban management information systems into digital form (e.g., building information systems in Helsinki) is addressed in the research.

In the Dutch situation there is a number of projects for spatial and non-spatial data management, including risk data management. The initiatives were undertaken on multiple administrative and governmental levels, and in multiple institutions. The analysis of relations between these projects, and especially their connection with "Space for Geo-information" and NGII, appeared to be difficult, due to the lack of access to the information on this topic. Still, NGII is considered in this research as an umbrella for all the other smaller data infrastructure development initiatives, regardless of whether they appear departmental, institutional or multi-organisational level. It is so due to the fact that NGII can focus primarily on providing an access to base and framework data, and on giving the rules for handling datasets of all types and classes, whereas the application-oriented datasets are usually addressed in lower level initiatives and institutions involved should in general comply with the general rules already established for NGII.

4.1.2.1 Dutch information management projects for support in risk assessment

After the disasters in Enschede and Volendam (i.e., S.E.Fireworks explosion in May 2000 and extreme fire in de Caf 2001 New Years Eve) specific measures were undertaken to improve external safety in the Netherlands:

- revision of rules for registration of hazardous businesses, with obligation for the municipalities to provide the data on the hazardous companies and their safety measures to the national "PBZO/VG companies” register,
- Risk mitigation and preparedness policy with 150 action points was prepared by The Board of Ministers and the Second Chamber; it addressed as well standardisation of risk-analysis methods, and improvement of data management framework.

In relation to these measures a lot of projects were executed on different administrative levels, to support information and communication management for risk analysis and mapping, and for emergency response. The two main projects this research focuses on are: Model Risico-Kaart (MRK), on standardised mapping of risk extents, and Register Risico Gevaarlijke Stoffen (Risk Situations Hazardous Substances; RRGS), on registering risk situations involving hazardous substances. These projects cannot be, however, treated separately from the number of such hazard data management initiatives as:

- National Geo-spatial Information Infrastructure together with National Clearinghouse for Geo-spatial Information which create the information base for further production of application-specific spatial data;
- "RIVM Data Portaal” for exchange of environmental information, supporting external safety data exchange;
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- SERIDA database containing information on hazardous substances, their health and environmental effects, and hazard categorisation;
- ICT-IB (Netwerk ICT en Informatiebeleid - ICT Network and Information Policy; NVBR) sectoral project of fire brigades for creating technical and legal framework for data exchange;
- POIRE (Project on Operational Information Resources for Emergency Management, MinBZK) regional level multi-institutional project for stimulation of hazard and emergency information flows between all actors involved in emergency response phase: Medical Assistance for Accidents and Disasters (GHOR: Geneeskundige Hulpverlening bij Ongevallen en Rampen), The Dutch Association for Fire Fighting and Disaster Management under MinBZK (NVBR: De Nederlandse Vereniging voor Brandweerzorg en Rampenbestrijding), and its ICT-IB unit; Association of Dutch municipalities (VNG: Vereniging van Nederlandse Gemeenten) and Police. POIRE and ICT-IB projects are meant to be developed in co-operation, since they are meeting common objectives from both multi-disciplinary and sectoral perspective;
- LNP (National Network Pro-Action; MinBZK) the state level information management project for disaster prevention,

A. Model Risico-Kaart (MRK) project. The initiation and first steps of development of the MRK project was recorded during the execution of this research, as an answer and solution to observed low risk communication measures.

Scope of the project:

- spatial planning and spatial development control in the planning phase by responsible local planning units,
- monitoring of existing development and checking it’s compliance with legalised plans and rules by local development control units,
- emergency response and emergency response planning by fire brigades.

The risk maps show 13 (out of initial 18) categories of (spatially fixed) hazards. The maps are being incorporated into the "control centres", where the GIS already supports emergency location, identification of response infrastructure (e.g. hydrants, shelters) and initial estimation of the risk. Further on the MRK maps and existing detail risk assessment systems, installed in fire brigade crew cars, can be connected by the means of wireless communication, to support on-site emergency management.

The second important objective of the project is to inform public on the actual risks present in urban environment. Separate methods of risk visualisation and communication are being developed for public and for the professional hazard management related actors.

The last but not least scope is creation of the strong link between the External Safety Portal of the RIVM Ministry and the MRK outputs. It will be executed through common data exchange between RRSG and MRK; in the long run the information from RRSG should be integrated in the regional risk maps.

Initiative level and project background: The incentive for MRK is rooted in numerous independent and incompatible projects of risk mapping at local levels. The Dutch municipalities responded to fireworks explosion by putting more pressure on control of spatial situation, in particular in urban areas. Investigation of risk objects and tests of their compliance with safety rules were necessary for building up emergency preparedness. The pressure of population to be given information on actual risks in the living areas became a driving force for establishing web based geographic information systems (GIS) or at least a draft overview of existing hazard management situation with sketches or maps in local or regional governments. The examples can be recent official risk map websites of (1) Municipality of Enschede (http://www.enschede.nl/nieuw/bedrijven/risico_bedrijven/kaart/kaart.html),

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(2) Province Friesland (http://www.friesland.nl/risicokaart2/risicokaart/risicokaart.htm)
(3) Province Limburg (http://risicokaart.limburg.nl/).

The decisions on GIS implementation were initially taken ad hoc, mostly without considering regional integration of datasets. The need emerged to link newly created, incompatible systems; disasters and emergencies do not keep to administrative boundaries, hazard information flows should neither be limited to administrative units. The commissions analysing past disasters (Commissie Oosting for Enschede fireworks and commissie Alders for Volendam case), governmental authorities and Inspectorate for Public Safety (IOOV) proposed common co-ordination of regional and national level projects. This can be achieved among the others through the POIRE activities, where IOOV, VNG and IPO (Interprovinciaal Overleg, inter-provincial consult platform), NVBR ICT-IB and regional fire brigade commandants should communicate on the cyclic bases through such media as website news, paper bulletins, and direct meetings (van Capelleveen, 2003).

After setting up by the government the risk mitigation action points, a need for standards was discussed for risk object classification, ways of visualising the risks and for hazard data exchange procedures. The questions were raised on how to standardise risk mapping on different administrative levels and what general rules to introduce for a framework for wide hazard data information infrastructure. The Cabinet released the guidelines for registering risk situations with hazardous substances, advised creation of internet risk maps and insisted on improvement of inter-municipal communication for risk management (see: the letter of Minister of VROM, Minister of VenW (Transportation and Water Works) and the General Secretary of MinBZK from 13th of March 2002, and the letter from 15th May 2003 of the Minister of VROMand General Secretary of MinBZK).

Responsible bodies: The project is run nationally by the Ministry of The Interior and Kingdom Relations (MinBZK). The responsibility of coordinating the MRK execution, however, is given to the regional fire brigades. The final products of MRK, regional risk extent maps with spatial database of risk sources and receivers, are being developed under the control of regional MRK coordinators. Regional supervision is realised by integrating municipal activities and assuring integrity of locally developed maps to create the consistent provincial map sheet.

Problems envisaged: An example of problems faced during the integration of existing risk mapping systems was a case of the Province Friesland for which the interactive risk map was created as a Flash application. The map was presenting all the potential hazard sources (e.g., gas stations, chemical factories, breweries, etc.) as well as important hazard receivers (schools, buildings of different public use, residential areas) and was assessed positively on the regional level as far as the risk analysis criteria, but the negative feedback was received in terms of useability of the map for disaster management purposes. It is required that a risk map should have an link with a database storing information on the risk objects and their vicinity (i.e., including data on water infrastructure and safety management systems), which was not the case for the Friesland Risicokaart.

B. Register Risicosituaties Gevaarlijke Stoffen (RRGS) project. Register Risk Situations Hazardous Substances - it is conducted parallel to the MRK project, and is based on the measure of obligatory reporting of the use or deposition of hazardous substances by the companies and institutions. RRGS extends the tasks of the PBZO/VG companies register by

"recording data on high-risk situations in the Netherlands concerning the usage, storage and transport of hazardous substances."

() which is one of the scopes of the project. The other scopes regard 2 aspects: risk inventory and open spatial data management. The first aspect is realised by classification of hazardous substances into 3 main classes - explosive/inflammable, toxic and nuclear (corresponding to Dutch disaster classification types 4, 5 and 6) and by grouping risk situations into 15 categories, based on the source type (13 specific, “others” and "defence objects”). The latter aspect regards a way in which

Inspectie Openbare Orde en Veiligheid: Directorate of Disaster Control and Fire Brigades (RB)(directie Rampenbeheersing & Brandweer) of the Ministry of Internal Affairs (MinBZK) (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties), the Inspection of Public Housing, Spatial Planning and Environmental Conservation (IVROM), and the Inspection of Transport & Waters of the VROM ministry, and the Inspection for Public Health (IGZ) of the ministry of Public Health, Wellbeing and Sport.
data should be made available for users. RRGS is being created in the form of so called geo-portal, based on internet technology. Data on risk situations, stored in a central database, can be viewed via an interactive map, through a standard browser.

**Initiative level and project background:** The reasons for RRGS development are the same as in case of MRK project, both projects support and are supported by the disaster mitigation and preparedness measures introduced or strengthened after Enschede and Volendam disasters.

**Responsible body:** RRGS was initiated by the VROM Ministry, but the management of the register is performed by RIVM, specifically it’s Centre for External Safety and Fireworks (Centrum voor Externe Veiligheid en Vuurwerk; CEV). Execution of geo-portal was outsourced to Geodan and PinkRoccade companies, of which the first specialises in GIS based services and the latter provides ICT services (information systems development) for private and public sector.

**Problems envisaged:** There were many decision problems regarding the value of quantified risk thresholds to be introduced. Restrict values would impose obligation for a very large number of risk sources to register, what may cause the flood information into RRGS, and in consequence may be an impediment for efficient use of the system. The institutional and technical capacity of RRGS has to be modelled depending on such decision, the economic aspect of RRGS development had to be as well taken into consideration. Data exploration, transfer and download options should be kept in a quantity and complexity level that is acceptable for the user-organisations. Moreover, it was a requirement to allow the use of existing systems and independent datasets within RRGS, which is a challenge for its operationalisation.

C. Other related projects:

**RIVM Data Portal (RIVM Dataportal) project.** RIVM (the National Institute of Public Health and the Environment) is in charge of environmental safety management and for management of environmental information, including information used for disaster management. This offers RIVM a role of an umbrella organisation for wide range of projects and activities connected to management of both hazard and environmental information. Since 2002 RIVM has focused on introduction of a RIVM Data Portal (RIVM Open DataPortaal) project, foreseen to address all RIVM information resources. Although this project is coordinated entirely independently from Ravi’s NGII projects (such as ”Space for Geo-information”), it should be, in the light of this research, seen as one of projects developing the most crucial application-oriented NGII elements. RIVM Data Portal will serve for on-line search, view, exchange and management of spatial and non-spatial information, and its metainformation, based on Oracle DBMS and ESRI ArcGIS products.

**Scope of the project:** The ”RIVM DataPortaal” project objectives support multi-institutional efforts for hazard management knowledge exchange, by the means of foreseen internet access to the external safety data. Still, it serves primarily as intra-institutional tool, for making internal data flows more fluent. The prototype is meant to be a base for development of complete RIVM information infrastructure, supporting all processes and projects carried out in the institute, mainly related to analysis and management of environmental information. The aspect of data provision and better accessibility to the RIVM information for the external users should be given a lot of attention.

Among the RIVM processes an important domain is the ”External Safety”,” relating to population and property exposure to external chemical, industrial and other spatial risks. This is as well the main focus domain of this research, concerning availability of- and access to datasets on:

1. dangerous substances, their characteristics and on assessed quantified risk given by them to different environmental elements;
2. dangerous companies, i.e., using large quantities of dangerous substances;
3. potentially dangerous and dangerous spatial objects (point, linear or 2dimensional) together with their potential risk extent; to be linked in the future with information on potentially dangerous investments, next to the land use and spatial development planning and control information.

**Responsible body:** RIVM - the National Institute of Public Health and the Environment runs the Data Portaal project as it’s own institutional initiative, with the main goal to improve primarily
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**Intra-institutional data exchange.** Execution of project implementation was outsourced to Geodan.

**Application type:** All environmental datasets that are produced in RIVM are addressed as a domain of the portal, both in a geographically referenced (maps) and/or thematic (tables, documents) form.

**Problems envisaged:** not referred to in the available bibliography sources.

**SERIDA Database project.** Access to the data on dangerous substances, their characteristics and risk is supported by already operational digital database SERIDA (Safety Environmental Information Database), provided by RIVM and Royal Haskoning company following the order of the Ministry of Housing, Spatial Planning and Environment (VROM). After approval of the Dutch Committee for the Prevention of Disasters (CPR), SERIDA can be accessed via official RIVM/SERIDA website (http://arch.rivm.nl/serida/index.html) for free, to download or update the chemical substances register. SERIDA provides accurate and reliable information nearly on 700 substances and their risk effects in different environments (water, air, soil) and on the different classes of hazard rankings. This database is meant for use by governmental authorities and risk-related enterprises. The risk assessment methodology and the description of chemicals was prepared on the base of wide research carried out by RIVM, VROM, numerous scientific institutions and fire brigades. SERIDA can calculate risk values based on given criteria that are compliant with legal EU or Dutch requirements for risk assessment. Individual users can therefore see if the risk caused by amount of used substances is higher than given safety threshold, and subsequently, whether they fail under the category of dangerous companies.

**Register of ‘dangerous’ companies.** A national register of all companies using hazardous substances was created by RIVM to address emergency preparedness and mitigation and to support monitoring of environmental risks. The register divides companies into 2 categories: so-called “PBZO companies” and “VR companies”. Both are obliged to establish a Safety Management System and the latter is obliged as well to provide Safety Reports (including local disaster management and emergency response plans). Unfortunately there is only limited web-based access to the information on these companies; only the list of PBZO and VR companies dated from the year 2000 is currently available via RIVM websites. The important information exchange aspect as regards to PBZO and VR companies is the obligation of any of the companies in the Netherlands to report their status (PBZO or VR) to municipal authorities, which have to pass this information further to RIVM to assure update of this national register. As well local and regional fire brigade units have to have this information provided in order to control safety management in the companies and to be prepared for emergencies. For interested organs to be provided with reliable information via the register there should be a mechanism established for timely data flows between companies, governmental authorities, fire brigades and RIVM. A part of this mechanism remains in focus of the preliminary study of this research, during which development of currently independent information infrastructure elements for urban hazard management support (see the paragraphs above) was investigated.

**Findings.** The general finding of the analysis of Dutch initiatives for urban hazard information management is that it is difficult to control integrity of tasks in case of such multiplicity of projects, relating to similar objectives but run on different administrative levels and within different sectoral boundaries. This can lead to duplicated efforts in creation of information systems and bases for information infrastructure, not necessarily compatible, not necessarily following the same standards and not always giving the same focus to importance of standardised metadata management. The very big motivation for development and implementation of hazard information support tools (GIS, intranet, extranet or internet based infrastructures or information systems) became both the threat and the opportunity for Dutch organisations. To picture the problem, there were no documents available (state for June 2003) on the coordination or relation between National Geospatial Information Infrastructure development actions and all attempts for hazard information infrastructure creation. In this term the Dutch situation becomes close to Namibian state top/down vs. local bottom/up approaches for application-oriented and base data infrastructure initiatives. The main focus should be given to successful merging of these two streams of actions both in the Netherlands and Namibia. On the other hand, the closer look at the execution and maintenance of the NCGI/NGII and the RRGS and MRK shows that the same private parties were outsourced to
take care of these projects - i.e., Geodan company was an executor of both NCGI and RRGS (see http://www.geodan.nl/uk/project/rggs/index.htm), and local elements building base for MRK project (Noord-Barbant Province). This may bring an assumption that both projects were easy to integrate due to the deep knowledge of differences and similarities in implementation tools possessed by the developer.

4.1.2.2 European regional initiatives on management of data on natural hazards

European efforts for mitigating natural disasters and strengthening disaster preparedness were expressed through numerous cross-boundary initiatives within European Union. Among these were:

1. CLIFF project, under EU IST programme, executed by European Space Agency, ESRIN Centre (Italy),

2. FORMIDABLE project, under EU IST programme, coordinated by DATAMAT group, followed by EGERIS project, under the support of European Commission, coordinated by EADS (European Aeronautic Defence and Space Company) Systems & Defence Electronics, together with several European software manufacturers, in association with the Var Fire and Rescue Departmental Service,

3. GMES joint initiative of the European Space Agency and the European Commission

Within CLIFF project (CLuster Initiative for Flood and Fire emergencies) there were 18 flood and fire management projects analysed for "harmonization of different critical components for Disaster Management (DM) activities" (van Bemmelen, 2002). The issue of possible standardisation of both the procedures, and information used in disaster management, was investigated. In particular, CLIFF addressed existing disaster management applications, investigating their possible improvement. Among the objectives there was as well establishing of simplified approach to the development of new systems, mainly based on the use of Earth Observation (EO) data. It was intended to create a base for further European supra-regional initiatives on disaster management, such as GMES (Global Monitoring for Environment and Security) and the Civil Protection and Environmental Emergencies European Network (PROCIV-NET), that links the civil protection and environmental emergency centres of Europe. The project was conducted under the 5th Framework of the European Commission’s Information Society Technologies (IST) Programme, Systems and Services for the Citizen, action line: Environmental Risk and Emergency Management Systems (ESA-ESRIN, 2002).

Lessons learned: The analysis of interviews and situation statement showed the main causes of problems in efficient disaster management were "(1) the lack of a common language, (2) the grade of interoperability, accessibility and availability of information, in particular during the crisis phase, and (3) lack of involvement of end-users during standardisation process" (van Bemmelen, 2002). The following conclusions were drawn:

- standardisation of DM terminology and procedures in different EU countries is necessary before actual development of information infrastructure for DM support.

- Meteorological domain is more developed in terms of standardisation and international cooperation than fire and flood management. The management of terminology, data policies, data-exchange formats and other institutional agreements can be taken as templates for fire and flood DM.

- Taking standardisation process of meteorological data management as an reference, the same process for different domains of DM can be supported, due to many similarities in data management recommendations.

Under the 5th Framework the CLIFF (CLuster Initiative for Flood and Fire) project was carried out, contributing to the base of international (EU) initiative of GMES (Global Monitoring for Environment and Security, based on satellite-based information services).
FORMIDABLE project; Friendly Operational Risk Management through Interoperable Decision Aid Based on Local Events. The project works towards a single methodology for many European countries to deal with data provision for emergency response (operational co-ordination centre). It is one of CLIFF cluster projects, focusing on natural disasters data management, but it's recommendations are also applicable to man-made disasters. The set of guidelines was developed addressing criteria for identified functional domains (called Auxiliary Functions AF: e.g. AF10 Dangerous Materials, AF6 Telecommunication, AF4 Resources, AF3 Mass media and Information etc.) common for all investigated Civil Protection Authorities. Criteria and guidelines were created among the others for such sub-domains as Data Collection, Information Preparation and Distribution, definition of Most Vulnerable Critical Objects, etc. within Emergency Planning phase; Periodical Update reporting, Data Requests or general Communication Management Criteria for Emergency Control phase; and e.g. Reports Generation criteria for the post-event phase. The prototype of Operational Centre developed based on the requirements analysis following the established methodology was successfully tested in Italy and Spain for flood and earth quake events.

Lessons learned:

- Translation of different emergency management procedures into the standardized FORMIDABLE procedures (to comply with FORMIDABLE methodology) was a very complex process preceding prototype modelling. It was due to the legal, administrative and cultural differences among the participating Civil Protection Authorities.

- After tests, the guidelines for implementation of the prototype indicated chronology of the steps: 1. adaptation of organisational structure (tasks and responsibilities) to FORMIDABLE requirements model; 2. analysis of external and internal Coordination Centre information flows and definition of interfaces, according to the FORMIDABLE criteria; 3. Configuration of information system accordingly; 4. last is the integration of a prototype with existing spatial data and existing information systems

- checklist for Emergency Planning phase indicated great importance of inventory of existing datasets, stressing the issue of metadata (although not mentioned explicitly), to identify the quality, timeliness of (both attribute and spatial) data, as well as compliance of the available datasets with the event scenarios. Moreover the availability and easy access to the up-to-date information on the division of DM responsibilities and contact data importance was mentioned.

- The exchange of both informal (documents, messages) and formal (official documents, directives, requests) communication should be supported by the information systems, assuring the integrity and interoperability of information and standardisation of key aspects (system architecture, data modelling, interfaces)

GMES initiative Global Monitoring for Environment and Security, based on cooperation of 18 organisations - spatial data providers, governments, industry; including among the others 3 thematic lines related to risk management and information infrastructure:

1. Systems for Risk Management: project DISMAR "Data Integration System for Marine Pollution and Water Quality", coordinated by Nansen Environmental and Remote Sensing Centre

2. Systems for Crisis management and Humanitarian Aid: projects RISK FORCE "Accompanying Measure on Natural Risks Management", coordinated by Astrium SAS; and ISIS "Intelligent Systems for Humanitarian Geo-Infrastructure", coordinated by keyobs SA

3. Information Management Tools and Contribution to the development of a European spatial data infrastructure: projects EOLES "Combining GIS and Web", coordinated by Spacebel SA; and EUFOREO (on access to spatial, mainly RS, data, and information services) coordinated by Telespazio.
Chapter 4. From the lessons learned to system modelling - the Critical Approach to Urban Hazard Information Infrastructure for Windhoek

(see http://www.gmes.info/projects/index-them.html). GMES aims at integrated approach for spatial data collection, dissemination and analysis, trying to match the EO (Earth Observation) data supply and demand needs (www.eurisy.asso.fr/events/desertification/Rabatpresentations/Euforeo.PPT). The last thematic domain is very important for the following research, giving a direct connection between European Spatial Data Infrastructure and Hazard Data Management systems. It mirrors required, but not always explicitly present (see above paragraphs on the Namibian and Dutch experiences), strong relations between development of global and application-oriented information infrastructures. EUFOREO’s tasks included identification and selection of 17 thematic information services for GMES (e.g. Flood risk assessment, management and damage assessment, forest fire risk and damage assessment, information support for disaster management, urban expansion assessment, etc.), relating them to analysis of Hindering Factors (HFs) on EO data use (e.g. EO data potentials and its awareness among users, data availability, impact of policies and accountability, data suitability for use - time, scale, data representation and quality, data accessibility and price etc.), and shaping solutions and scenarios to overcome the HFs. EUFOREO was intended to serve as fundamental added value product of GMES.

Recommendations from on-going GMES development process:

- structuring GMES capacity has to be executed via establishing a partnership of the key European actors - GMES Partnership with GMES Secretariat; division of tasks, ownership of data and information should be structured in common legal agreements, legislative layer should be in place to support all data and process management activities; strategies and programme of GMES Shared Information System have to be agreed, GMES Memorandum of Understanding (MoU) has to be prepared for shared use of information assets.

- a standard mechanism for managing dialogues between different stakeholders is required to assure meeting user’s requirements; the exchange of data among national and regional level organisations should be channelled via European level entities, shaping the supra-national level information infrastructure;

- development and implementation of national and supra-national information policies should be monitored to assure integrity of the actions undertaken by GMES members, and to provide harmonious development of domain-specific elements of GMES infrastructure

- Maximisation of GMES added value (stimulation and assurance of efficiency of information production and management) by the Partnership should be achieved by acceptance and fulfillment of fundamental information infrastructure management principles (present as well in INSPIRE initiative: best suitable decentralisation of data collection and maintenance, avoidance of unnecessary data reprocessing;

- GMES Shared Information System requires development of procedures and mechanisms for standards and interoperability; the focus are weak links of the information production chain to be restructured, with the provision of long-term investment and operation support coming e.g. from European Spatial Data Infrastructure; re-engineering of current IS facilities is necessary, but it has to be followed by improved management of documentation on data modelling for GMES sub-systems.

Above recommendations are based on the analysis of the report on GMES visions and targets (support team, 2003).


The Southern African Development Community initiated the internet service for provision of information used for monitoring of environmental conditions to predict, prepare or respond to, and monitor the natural disasters as drought, flood or cyclone. Through the website the member countries are updated by SADC meteorological, hydrological, food security and disaster management units with news, reports, articles and flood risk maps (Stream Flow Model Flood Risk Map Page).

The structure and content of the website are primarily influenced by a regularized process that SADC follows throughout the year that reviews food security, rainfall and water level conditions
4.1. Towards structured management of spatial data - lessons learned from reference cases

Throughout the region, two focal points within this process are SADC’s regional Pre and Post Rainy Season Fora in which both regional and national-level disaster, hydrology, meteorology, and food security officials identify issues, planning needs, and assistance required by SADC river basin and other networks that have been established to provide alerts in the event that threatening conditions arise during each rainy season. SADC hopes that the information provided in this website is also of value to donors and its other partners. It welcomes comments that will help make this website as useful as possible in facing the common challenge to protect life and property and ensure food security in the face of threats posed by climate, weather, and related hazards.


SAFNet is the Southern Africa Fire Network http://safnet.umd.edu/ which is part of the Global Observation of Forestry Cover;


The goal of SAWIN is the monitoring and management of the flooding and drought events in Southern Africa. This is to be done, among the others, by collection, exchange, and dissemination of information related to flooding, drought, agriculture, and disease to multiple stakeholders by the means of IT. It requires improved coordination between stakeholders managing water in Southern Africa and integration of data and tools to support them as decision-makers.

The SAWIN initiators and stakeholders come from among governmental bodies, NGOs, Local and External Facilitators (CSIR, RSI), Water Resource Sector, and other sectors, World Health Organization, FAO, USGS, etc.

The requirements focus on hydrometric and meteorology data and satellite imagery - SAR; there is well the requirement to provide Geo-Spatial Information Network that integrates multiple data sources from different other networks (i.e. HYCOS, FEWSNET, FANR-DU) and is that would operate on the collection of the new set of base and framework data, as well as flood and drought specific data. (for details see http://www.oosa.unvienna.org/SAP/stdm/2002_africa/presentations/session04/speaker04/tsld031.htm, last accessed in September 2003)

4.1.2.3 Conclusions from the Dutch experiences for Namibian situation

1. To assure reliability and overall quality of data used by authorities for decision making, there has to be a legal engine provided for binding the private data providers, making them responsible for checking quality of their spatial products.

2. Although the quality of framework spatial data produced in the national agencies responsible for state mapping (Survey General, National Mapping Agencies) is usually well controlled, still there should be a mechanism to validate the added value products based on their information-processing lineage; such metadata information must be provided to control the quality of spatial data infrastructure elements.

3. Privatisation and outsourcing of the SDI services (i.e., clearinghouse, information systems, and web GIS for local governments) can successfully supply the information infrastructure only if the following conditions are fulfilled together:

   - There is a legal policy on copyrights implemented, not allowing for illegal use of data by outsourced companies.
   - There is a legal policy on operation for wide spatial data dissemination, binding local authorities to make their data available for use for the third parties (initially only other authorities), and enforcing availability of data from the other authorities to the municipality. The conditions on data use (including very important aspect of data pricing) should be carefully set on the common basis.
   - Outsourcing if the maintenance of the core of information infrastructure gives an advantage of political independence of data, legal contract obliges the executor of the clearinghouse to make provision of data available and puts the responsibility for the
quality of data service. The contract should take into consideration the situations, when a single party wants to withdraw their data from the clearinghouse, then the executor should provide the history of previously accessible datasets with the reference to the direct provider. The executor should not take responsibility for the situations caused by direct data providers.

4.1.2.4 Recommendations for Urban Hazard Information Infrastructure development in Windhoek

- Since there already exists a need for stimulation of economic growth in Windhoek, the UHII initiative can be used for its support via possible involvement of private sector actors in spatial data exchange and production. There should be policy allowing to build up added-value products on top of the state and municipal spatial data, and to have these products incorporated into the infrastructure.

- The coordination of multi-institutional UHII initiative should be in later stages executed by an entity not entirely dependent on one of the UHII partners only (e.g. a steering committee consisting of main or all member representatives), to avoid growing and imbalanced information power of one of the member institutions.

- UHII should be during it’s whole development process tested against the objectives and visions of Namibian NSDI, to assure that UHII can be treated in the future as a consistent element of NSDI. Thus UHII members should operate based on common agreements on implementation of open data exchange formats, common quality standards (compatible with NSDI) and mutually accepted terminology. There should be legal framework created to support development of policies on the above issues.

- To support interoperability within UHII the alliances could be arranged among data providers and between data providers and software/hardware companies, this is still an issue for further research. The development of strategic alliances, however, in terms of creating common data management strategies and dividing tasks and responsibilities in UHII development, should be considered as a fundament for successful information infrastructure introduction. before introduction of UHII there has to be the metadata policy in place, common for all UHII actors, creation metadata infrastructure, with the prototype of a UHEMIS metadata service centre is considered as an absolute prerequisite for further development of GIS application base for UHEMIS system.

- Memorandum of Understanding for all UHII actors has to be prepared as an agreement on terms of use of shared data

- Since a lot of successful SDI development initiatives are, according to the studies of Masser (1998), to promote economic development, stimulate better government and to foster environmental sustainability, the awareness of SDI related benefits and its impact on organisational performance should be spread in Windhoek, to give an incentive for organisational changes to adopt UHII.

- UHII should serve as a connection between Urban Hazard Data users (i.e. the CoW divisions involved in spatial planning and control) and producers (Geomatics Division, Disaster Management Division, Health Services Division, etc.), imposing their wide cooperation in terms of linking urban management processes, not only in terms of data exchange.

- One of the objectives of UHII should be the maximization of interaction with the already developing Namibian Spatial Data Infrastructure, assuring the integration of data flows between different administrative levels of spatial information infrastructures. The recommendation is to create an umbrella relationship between the state level infrastructure (global-domain) and locally developed application-specific infrastructures creating the network of local SDI components.
4.2 SWOT analysis for UHII introduction in Windhoek - a need for a Critical System Approach

The SWOT analysis consists of the external organisational environment scanning (analysis) to identify opportunities and threats, the internal organisational scanning (target stakeholders) to identify the existing strengths and weaknesses, the generation of alternative strategies and the formulation of a strategic choice (Groenendijk, 2003). In this research the following questions were asked with regards to SWOT analysis in the light of Critical Systems Approach:

**Strengths and weaknesses** - does the organisation assess them in the light of ongoing internal changes (critical continuous assessment), or is the current situation taken for granted (preserving the status quo of organisation)? Is the organisation aware of their weak and strong points in spatial data management?

**Opportunities and threats** - is the role of organisation among the other stakeholders analysed from one or many points of view? Are the target organisations aware of the opportunities given by external environment? Are there any under-estimated threats?

The analysis of SWOT statements leads to the identification of lacking policies and strategies to develop the UHII. In order to identify these lacking elements correctly the "To-Be" situation of spatial data management for decision support in UHM has to be pictured. The goals to achieve put against the assessment of existing situation give the idea of Gaps to overcome; these gaps are reflected very clearly in the SWOT statements. The picture of "To-Be" situation can be usually extracted from the expressed demands of the actors, however the more stakeholders are involved in the process, the more complex view of their requirements is made. As well the bigger possibility exists for observing conflicting views, or the views not belonging to the scope of the research (based on individual organisational interests). When the soft approach is taken to analyse the "To-Be" requirements, as it is in this research, the use of lessons learned from reference studies gives a more functional base for requirements analysis. It provides a set of universal guidelines for a solution of information management problems. However, the recommendations and lessons learned from the case studies are not necessarily relevant to the local situation observed in a core research. The Critical Systems Approach (CSA) was hereby proposed in order to use the knowledge obtained from the case studies. The point of the CSA is to question the status quo of the target and external actors when referring to the lessons learned. This means that the doubt is cast on such factors as:

- the role (expressed in legal mandate or as accepted by other stakeholders) of organisations as a spatial data provider (for support in UHM and consequently in Spatial Development Control)
- the political and social constraints for the dissemination of a new technology (i.e. UHII and UHEMIS) in organisations (resulting e.g. from the lack of political interest in urban hazard management or lack of awareness of urban risks in Windhoek population, or the lack of staff acceptance for the use of a new tool)
- the power of organisations and their hierarchical units to dictate data standards and impose technological solutions (i.e. GIS and DBMS formats, data exchange formats)
- the power of organisations and their hierarchical units expressed by the possession of spatial and non-spatial datasets, limiting the access of external actors to the data
- the mandate-based control over spatial datasets with respect to limiting the opportunities for opening the spatial data market (limiting release of spatial data to the external users due to the reasons other than data confidentiality)
- the performance of existing processes (application-specific: UHM, Development Control; and the global domain: spatial data production) in the organisations and the relevance of existing information systems supporting them
The fieldwork provided the analysis of relations between stakeholders, existing data flows and data flow bottlenecks. The target and external stakeholders were identified in Chapter 3 (see: 3.2) on the base of their demands for UHII and hazard data management information system (see: ??). The Case Study Spatial/Hazard Information Management Models (CSIMM) described the As-Is situation in section 3.3.2.1.

4.2.1 Environmental scanning for SWOT analysis on Windhoek UHII introduction

The scanning of internal and external organisational environment was performed to identify the Strengths and Weaknesses (inside target stakeholders’ organisations) and also the Opportunities and Threats (arising from the interactions of the target actors with the external environment). The base for the internal and external organisational scanning was obtained during the interviews (demands and As-Is situation) and during the workshop on spatial data management for UHII in October 2002 (hosted by the Disaster Management Division of the CoW). The demand of change of internal and external organisational conditions can be pictured in the prioritisation of the SWOT statements, giving them the priority ranking. However, there was no quantitative assessment of the weights of the SWOT statements, due to difficulties in obtaining a proper feedback during the workshop. This means that a quantitative external/internal strategic factors analysis (see B.1) could not be performed. Instead an ordinal assessment was performed: the importance of SWOT statements is given on a scale from 1 - (the most crucial factors) to 5 - (the least crucial of the quoted ones, but still significant for the discussion). Based on importance of SWOT factors the guidelines for policies and strategies are created. Below he generalised SWOT statements are presented, the extensive record of the SWOT discussion is in the Appendix B.2.

4.2.1.1 External environmental scanning: Opportunities and Threats

The Opportunities and Threats refer to the multi-institutional environment potentials, CoW benefits or competitive threat of external factors on CoW. The external organisational environment can be analysed using different criteria and different models. All of them, however, take into account the actual situation and possible trends and developments with regards to the influence of the external stakeholders (in our case spatial data producers and users) onto the performance of the target stakeholders. The opportunities are such external factors that can have a positive effect on the performance of the target organisations (demand for the products and services, possible cooperation, regulations giving an advantage to organisation etc.). The threats, as negative factors which impose preventive actions from the side of target stakeholders, can constraint the possibilities of realisation of organisational mission and can affect badly organisational performance (weakening one’s position in the market by competitive actions of an external stakeholder, legal limitations imposed by other institutions, loss of dominant function in the scene due to the action of other actor, etc).

For the purpose of this particular research the following factors were considered important from the perspective of the CoW and MinWTrCom:

**Interest of UHII users in UHII-based services** stipulating the market from the perspective of spatial and economic development, where the need exists to have access to information on development-limiting factors (i.e. urban risks);

**Opportunity of the leadership for the local SDI development** as based on the UHII initiative

**Roles of significant data suppliers** with regards to the urban hazard data (hazardous and vulnerable objects, dangerous traffic, etc.) and framework data (large scale, up-to-date topographic coverage for Windhoek)

**Threat of the substitute products** (a) to the information for urban risk assessment and vulnerability studies, or integrated spatial planning assessments including urban hazard information
4.2. SWOT analysis for UHII introduction in Windhoek - a need for a Critical System Approach

e.g. by consultancy companies, other regional and national competing agencies (REMU, ministries, research institutes, etc.); (b) to the large scale digital spatial information for support in spatial development control and UHM.

Threat of the top-down standards imposition for the technical (GIS, DBMS) and organisational solutions in spatial data management, conflicting with the main objectives of UHII, as accepted in multi-institutional environment.

THREATS:
• Unclear organisational responsibilities and mandates 3
• Lack of data dissemination and sharing policies 1
• Staff leaving to competitive institutions 1
• Heterogeneity of GIS used in organisations 2
• Lack of sufficient cross-institutional DM cooperation 4
• Consultancy companies use better GIS/DBMS 2

OPPORTUNITIES:
• Increasing demand for reliable Risk Maps to support spatial planning 1
• Elimination of costs of consulting expertise 4
• Increase in preparedness, reduction of emergency management costs 1
• Benefits from efficient use of urban data resources 2
• Linking development control and disaster prevention 2
• Leader role in standardisation of data exchange 3

4.2.1.2 Internal environmental scanning: Strengths and Weaknesses

The Strengths and Weaknesses refer to the analysis of the following elements:

Mandate of organisation here the point of view of the target stakeholders (see Section 3.2.1) will be taken into account, in the context of inter-institutional and multi-institutional setting; the missions and visions of organisations are addressed

Products (spatial and non-spatial) as seen from the mandates; the customers demand test against the supply

Functions/activities vs. Process approach in the organisation - identification of the gaps in the process flows, redundancy of activities, etc.

Internal organisational structure and performance reflecting the elements already analysed during the stakeholder identification process

Legal framework for process and data flows with respect to UHM, spatial planning and development control, and access to- and flows of spatial data

Spatial data management in terms of supply of data to the processes and to the users/customers; assurance of data quality, data integrity, reliability, metadata provision, effective use of spatial data, etc.
Technology IT and GIS usage patterns in the organisation, the role of technology, and level of its utilisation

STRENGTHS:

• IT facilities (hardware and software) for data management are in place, they only have to be improved 2
• Central municipal data storage (in place) and Business Intelligence System for assuring interoperability (to be developed) 1
• AutoCAD environment of spatial data input and transfer, local institutional standard of data transfer
• Access to the base and framework data through central municipal information system 2
• Strong personal knowledge base and strong local spatial data resources 2
• Initiated development of data quality and security control 4
• Ongoing cross-divisional and cross-institutional initiatives on data exchange 3

WEAKNESSES:

• Lack of information on data availability 2
• Dispersion and heterogeneity of non-spatial datasets and non-reusability of spatial data 1
• Lack of metadata for available information, causing the lack of awareness on what data are available where and in what conditions 1
• Lack of policies and standards for data sharing 1
• Lack of opportunities for experienced staff and shortage of human resources capacity 1
• Lack of integrated, cross-dept approach in DM 3

4.2.2 As-Is vs. To-Be situation requirements and Gaps Analysis

According to Gregoriadou and van der Molen (2002) the demanded future of the organisation can be altered by addressing such questions as:

1. The current status of organisation: What the organisation IS? (“As-Is” analysis, current mandate and performance)
2. The foreseen performance of organisation, as desired: What the organisation SHOULD be? (“To-Be” situation, mission goals)
3. And the limitations in achieving the desired state: What the organisation can be? (Gaps and limits, feasibility of the process of achieving To-Be situation)

The "As-Is” situation for spatial and urban hazard data management was modelled in Chapter 3. What was completed in this chapter was a use of the critical approach to the SWOT statements in clarification of the requirements of the multiple stakeholders and the common relations between them.

In this research the initial attempt to analyse the requirements of the Windhoek actors with the help of the lessons learned from the preliminary study only was insufficient to obtain clear and non-conflicting user views of the UHII and its elements. Although the stakeholders have been guided
during the discussions and despite the introduction of concepts related to SDI and spatial data management, their ability to foresee the problems in UHII development was small. Moreover the tools used in requirements analysis and SWOT discussion influenced the view of the stakeholders on their needs. Therefore the critical evaluation of the collected data was necessary, and the use of Critical Approach was crucial.

UHII is treated in this approach as an organisation-to-be on its own, an entity built up on the base of the target stakeholders with its own mission, vision and goals, with (A) its own organisational structure composed of the target and external stakeholders and (B) its data resources. In order to make the stakeholders use the data resources such elements of the UHII as (a) Access Network, (b) Policies and (c) Standards are necessary, and their functioning should be reflected in the mission statement.

**UHII Mission** To facilitate the access to- and use of- spatial data in Windhoek to support Integrated Urban Hazard Management by the provision of organisational, legal and technical solutions for spatial data exchange and sharing through the urban hazard information system.

**What the UHII should be?** The UHII should be an official local, application-oriented spatial information infrastructure, built upon the multi-institutional policies and standardised procedures for data sharing and exchange, operating on standardised or open formats of spatial and non-spatial information. It should contain the data access network component - a technical infrastructure to integrate existing data stores or complete information systems (e.g. GIS) into the data exchange network. It should contain a tool for spatial/urban hazard data access, exploration, visualisation and dissemination among the processes related to the integrated UHM. It should provide the legal base for data multi-institutional data management (policies, agreements), and it should foster the development of standardised procedures for spatial data handling, assuring their quality and reliability.

**What the UHII can be?** The “To-Be” situation to be drafted completely has to base on the analysis of demands of the stakeholders and on the guidance of the lessons learned from the preliminary and reference cases. The below description combines both views. The UHII can be utilised as:

1. the facility for exchange of the urban hazard data (on ground water vulnerability, fire risk, transport of dangerous goods)

2. the facility for exchange of base and framework data, used for preparation of the base for urban risk maps.

3. if necessary agreements and policies are in place, can become the initial element of local spatial data infrastructure, under the umbrella of the National SDI initiative

4. the facility supporting the municipal one-stop-shop with the maps of urban hazards

5. with regards to the UHII elements, it can serve as a connection between different information systems of municipal, regional and national use.

6. It can provide the interface for spatial data and metadata exploration, retrieval (transfer) and visualisation

7. For the support in UHM decision-making it can provide the interface for collection, registration and dissemination of the basic urban hazard datasets, considering data flows from- and to different urban management processes.

8. If provided with an appropriate information system and an interface it can help in conducting a spatial analysis for risk analysis and planning an emergency response scenarios.

9. the incentive to open the market of spatial data, and to provide the easy access to digital spatial datasets for investors, independent land surveyors, consultancy companies, etc. to stimulate the economic growth in Windhoek based on dissemination of information on local planning.
4.2.2.1 Gap analysis:

From the analysis of "As-Is" situation and desired "To-Be" situation the Gaps are being identified for the strategic guidelines to address these gaps. In the core research the current situation in disaster management in Windhoek, was investigated. The focus was so called integrated Urban Hazard Management process, defined as such management of man-made hazards occurring in the urban environment that integrates the activities of other municipal management processes (i.e. spatial development control and spatial planning, or land management) into the disaster management cycle (i.e. activities of disaster prevention, mitigation, preparation for response) in order to provide better disaster and emergency preparedness. The existing disaster management process was screened together with existing spatial data management activities, and spatial development control. In terms of the urban hazard data management the recommendations from the Dutch situation were taken into consideration due to the lacking risk assessment procedures. The following gaps were observed:

1. The disaster management process is in its initial development, with the disaster management plan being drafted in August 2002, and referring mainly to the natural disasters as drought and flood or to the risk of cargo cars accidents on the international roads.

2. The integrated Urban Hazard Management process does not exist yet in the form (with the activities) observed e.g. in the Netherlands; there is no link between management of potential man-made disasters in the area of Windhoek and the spatial planning or development control.

3. the emergency management is limited mainly to the fire accident response and car accident response, no activities of pre-impact disaster cycle were recorded during the fieldwork, although there is a policy being prepared for strengthening prevention and mitigation of emergencies;

4. There was no direct requirement expressed with regards to the preparation of emergency response plans, but the awareness of the possible urban risks is being initiated due to the strong pressure for economic, and the same spatial development (i.e. location of a textile factory in the centre of the city, told to be in proximity to the city ground water collection points)

5. There is no procedures to collect the data required in UHM for assessing the risk and for planning emergency response, as recommended by the Dutch case: occupancy data, data on business activities taking place in the industrial and commercial buildings, information on dangerous substances stored, etc

6. There is no legal background to allow inspections of Fire Brigades to provide the necessary information on the status of internal safety and external risk of old industrial buildings. Neither the spatial development control processes includes the collection of detailed occupancy data or data on the use of dangerous substances in production processes, etc.

7. There is not yet up-to-date data available on the building infrastructure (emergency systems, structure, inner utilities etc.), the data on evacuation possibilities are available yet only in analogue format

8. There is no up-to-date information available on current developments of traffic network, neither on the state of utilities (water, electricity); there is no procedure to provide these

9. the Emergency Services Division and Disaster Management Division do not have required human and technical (computer) capacity to actively initiate the development of UHII; moreover the pre-impact phases are addressed by ES Div. only in a limited extent (technical inspections for fire prevention, that support as well the spatial development control process)

10. the currently used classification of the urban area in terms of risk and vulnerability is based on mixed or unclear criteria of internal and external risk assessment; there are only 3 general classes (high risk - incl. e.g. hospitals or schools, medium - business zones, and low - other areas), apart from that the single risk points are observed but only with regards to the traffic within the city.
11. the municipal information systems are not compatible and do not allow for the exchange of data, the Business Information System that was supposed to be introduced after January 2003 was not investigated due to the changes on organisational structure of the CoW, making the retrieval of further information not possible. The introduction of desired GIS-based support for emergency response planning and risk mapping would be in contradiction with the objectives of UHII if there was no interoperable data environment provided.

12. To arrive to the situation where implementation of UHII is possible there have to be the solution provided for metadata recording and management in the external and internal organisational environment (the awareness and acceptance have to be achieved first, since there are not in place yet) and the data quality and reliability assurance system.

13. the knowledge on the concepts of spatial data information infrastructures, including the dissemination of knowledge on the national and regional initiatives, should be disseminated in different administrative authorities of Windhoek in order to provide the awareness, understanding and acceptance for the proposed UHII solutions as a start for local SDI. Moreover, the training with regards to the setting up and maintenance of the technical framework of the infrastructure (hardware, networking, mobile solutions, GIS software use, etc) are not in place due to the financial and strategic limitations. These should be in place to be able to initiate the UHII.

14. one of the biggest gaps is the lack of the proper and clear strategy for ICT development and spatial data management in the CoW and other stakeholder institutions, what makes impossible to align properly the proposed strategies of UHII development with the strategic objectives specific for stakeholder organisations.

15. Last but not least, there is a gap in the expectations of benefits coming from UHII and the lack of the business approach to the management of spatial data in the multi-institutional environment; in other words there is no approach taking into consideration the possibilities created by spatial data market, potentially opened with UHII, no awareness of the opportunities given by UHII in this manner limit view on the possible UHII model.

From the SWOT statements and based on the gap analysis also the strategies for UHII introduction were developed (for details see Table I). These strategies, together with data management requirements, constitute the basis for the "TO-BE" UHII Model, which was developed in parallel to the functional and process models of UHEMIS, indicated in the requirements analysis and SWOT discussion as a potential core of UHII.
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<thead>
<tr>
<th>STRENGTHS</th>
<th>WEAKNESSES</th>
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<td>- IT facilities for data management (2)</td>
<td>- Lack of information on data availability (2)</td>
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<tr>
<td>- Access to core data through central system (2)</td>
<td>- Dispersion &amp; heterogeneity of datasets (1)</td>
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<tr>
<td>- Strong personal knowledge base (2)</td>
<td>- Lack of metadata for available information (1)</td>
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<tr>
<td>- Business Intelligence System for interoperability (1)</td>
<td>- Lack of policies &amp; standards for data sharing (2)</td>
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<tr>
<td>- Development of data quality and security ctrl (4)</td>
<td>- Lack of opportunities for experienced staff (1)</td>
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<td>- Ongoing cross-dept and cross-inst. initiatives (3)</td>
<td>- Lack of integrated, cross-dept approach in DM (3)</td>
</tr>
</tbody>
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<tr>
<th>OPPORTUNITIES</th>
<th>S/O STRATEGY</th>
<th>W/O STRATEGY</th>
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<tbody>
<tr>
<td>- Increasing demand for reliable Risk Maps (1)</td>
<td>- Improve internal and external accessibility to the municipal data</td>
<td>- Introduce strategic data management training; followed by metadata and archiving workshop;</td>
</tr>
<tr>
<td>- Elimination of costs of consulting expertises (4)</td>
<td>- Introduce IT training as a standard, cyclic procedure for new and old staff</td>
<td>- Increase efficiency of the CoW inform. systems, eliminating redundancies and integrating spurious systems</td>
</tr>
<tr>
<td>- Increase in preparedness, reduction of DM costs (1)</td>
<td>- Make risk assessment data accessible via UHEMIS to external actors</td>
<td>- Create interfaces and software modules keeping track on data integrity (semantic and schematic);</td>
</tr>
<tr>
<td>- Benefits from efficient use of urban data resources (2)</td>
<td>- Introduce inter-departmental UHEMIS system, with regional standards on SDM and exchange;</td>
<td>- Develop a metadata management system based on inter-institutional standards;</td>
</tr>
<tr>
<td>- Linking developm. control and disaster prevention (2)</td>
<td>- Introduce multi-discipl. workshops on UHM &amp; development ctrl, use UHEMIS to teach on metadata and SDM</td>
<td>- Test new data management solutions within UHEMIS;</td>
</tr>
<tr>
<td>- Leader role in data exchange standardisation (3)</td>
<td></td>
<td>- Benefits from efficient use of urban data resources (2)</td>
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<tr>
<th>THREATS</th>
<th>S/T STRATEGY</th>
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<tr>
<td>- Unclear organisat. mandates and responsibilities (3)</td>
<td>- Start implementing data exchange policy in a test, interdivisional environment of UHEMIS;</td>
<td>- Attract new employees by IT oriented courses;</td>
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<tr>
<td>- Lack of data dissemination &amp; sharing policies (1)</td>
<td>- Introduce UHEMIS in the CoW first, as a test of new GIS and DBMS platforms, when tested expand UHEMIS into UHII;</td>
<td>- Automate archiving data and metadata creation processes</td>
</tr>
<tr>
<td>- Staff leaving to competitive institutions (1)</td>
<td>- Assure independency of UHEMIS from differences in data formats - implement in interoperable environment or with data translation modules;</td>
<td>- Create new human resources support - introduce training opportunities combined with organisational loyalty measures;</td>
</tr>
<tr>
<td>- Heterogeneity of GIS used in organisations (2)</td>
<td>- Provide an easy-to-follow interface in UHEMIS, to enable its usage for new staff</td>
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</table>
4.2.3 Guidelines for policies and strategies

4.2.3.1 Policies to develop in the internal and external UHII environment

Based on the gap analysis and SWOT statements the following lacking policies were identified from the SWOT analysis with the reference to the lessons learned from the preliminary and case studies:

(A) Policies for the internal CoW environment:

1. Policy on metadata production and management
2. Policy on information systems integration (assuring interoperability) or/and standardisation of data formats;
3. Policy on integration of Urban Hazard Management and the Spatial development control / spatial planning processes to support emergency preparedness
4. Policy on development of a collaborative, inter-divisional Urban Hazard and Emergency Management Information System, built upon the concepts of OpenGIS and interoperability and constituting the core of UHII;

(B) Policies for the co-operation alliance in the multi-organisational environment:

1. Policy on standardisation, exchange and sharing of analogue and digital data through UHEMIS, to resolve syntactic, semantic and schematic data heterogeneities;
2. Policy on quality management for metadata, data, and data digitization process;
3. Policy on developing of an inter-institutional UHII, for the facilitation of data sharing and exchange with external actors;
4. Policy on the use of IT, GIS, GPS, expert systems and other technologies in the multi-institutional disaster management
5. Policy on (digital) data security and copyrights.
6. Policy on multi-institutional support for public participation in data acquiring and sharing awareness on urban risk prevention and mitigation.

4.2.3.2 Strategic Vision and goals of UHII and its core UHEMIS

The strategic visions and goals were developed based on the SWOT Analysis. The guidelines for strategic UHII implementation, however are presented here with the relation to the model of technology diffusion (as referred to in 4 and in section 2.1.4). This creates guideline on how to prioritise the strategies in time, step-wise, in order to assure harmonious implementation of the UHII and its elements (i.e. UHEMIS). This is necessary to support SWOT since the environmental scanning did not provide measurable indicators of SWOT prioritization. The proposed goals and strategies are referred to the model, what is manifested as follows:

A. Initiation/Introduction phase

A.I. Problems analysis in organisation This phase relates to the identification of the problem in organisation that requires information infrastructure as a possible solution. It is reflected in this research by the soft problem analysis with the As-Is situation description. It does not require the strategic approach yet, instead it needs a proper methodology to analyse and understand the problem and requirements for its solution. This has been solved with the Critical System Approach on the base of the preliminary study, core research and reference cases.

A.II. Matching Creating a link between the problems faced by organisations with UHII development idea. Here the particular information problem is faced to be addressed in further strategies, which is the awareness of the organisations of their problems and the awareness and knowledge of the staff on the proposed technological solution (UHII). The SWOT analysis is addressed in this phase, involving
the stakeholders into strategic planning for the next phase, as described in the sections above. What is very important it is that in this phase, when approaching the problem form the business perspective, the analysis of organisational strategies is done to match the technology implementation strategies with them (strategic alignment). In the next phases the evaluation of matching is done and strategies are prepared to assure that organisational and UHII goals are aligned. These strategies reflect the concern of the proper matching between organisational problems and UHII development (G - goals, P - performance indicators, S - Strategies):

- **G1:** Achieving mutual understanding among stakeholders and within organisations on spatial data management
  - P1.1: Common glossary of terms used and agreement on common actions related to UHII development
  - P1.2: Number of multi-institutional meetings for UHII co-ordination
  - P1.3: Number of contributors to UHII initiative and amount of data made available by them
  - P1.4 Number of stakeholders contributing to creation and implementation of the policies from the group B and policies 1-2 of group A (see: above-section 4.2.3.1)
    * S1.1 Initiate creation of common classification of spatial data and common data model
    * S1.2 Introduce multi-disciplinary workshops on data exchange, metadata, SDI issues (see S/O strategy E)
    * S1.3 Form a multi-institutional collaboration body for UHII introduction
    * S1.4 Develop the policies for spatial data management for UHII and policies for UHM integration

- **G2:** Achieving multi-institutional understanding and co-operation for performing integrated urban hazard management
  - P2.1: existence of the disaster management plan and specific attachments on urban hazard and its integration with urban spatial planning
  - P2.2: Number of divisions actively involved in co-operation with Disaster Management Division and Emergency Service Division on the regular basis
  - P2.3: Number of reports on process-based approaches to urban hazard management and number of regular meetings for UHM process support
  - P2.4 Number of stakeholders contributing to creation and implementation of the policies 3-4 from the group A (see: above-section 4.2.3.1)
    * S2.1 choice of UHM collaboration body from within Emergency Operation Organisation members, and making it operate on regular basis
    * S2.2 Introduce multi-disciplinary workshops on integrated urban hazard management
    * S2.3 Form a multi-stakeholder body responsible for core UHEMIS introduction and implementation

- **G3:** Human resource and knowledge base development (both in UHM and Spatial Data Management)
  - P3.1: Workshops and training sessions attended (quantity of workshops)
  - P3.2: Number of staff trained in IT/GIS/SDI concepts and UHM application practise
    * S3.1: IT training as a standard, cyclic procedure for new and old staff (see S/O strategy B, W/O strategy A, W/T strategy A)
4.2. SWOT analysis for UHII introduction in Windhoek - a need for a Critical System Approach

* S3.2: Creation of employment opportunities by opening internships, short training programmes and staff exchange with other institutions (partnership co-operation)

B. Implementation phase

This phase leads to utilisation of UHII and its further institutionalisation, according to the first decisions taken on the shape and main scopes of UHII.

B.I. Redefining and restructuring

Here the alteration of organisational structures and modification of innovation idea is performed. This is done by the implementation of strategic analysis supported by Critical Systems Approach. Here the already developed strategies are being introduced to organisational development.

- G4: Achieving the integrity of disaster management and spatial planning (SP) and development control (SDC) processes
  - P4.1: Amount of data produced in UHM and used in SDC/SP (and vice versa)
  - P4.2: Number of the SDC/SP processes involved on UHM
    - S4.1: Make urban hazard and risk assessment data accessible via UHEMIS to external actors (see S/O strategy C)
    - S4.2: Make data of external and internal actors available for use in the UHM process
    - S4.3: Re-engineer the processes of SP, SDC, and DM/UHM into independent and UHM-integrated processes and activities

- G5: Development of decision-making support for integrated UHM process
  - P5.1: Amount of data used for emergency response planning and urban risk mapping
  - P5.2: Time spent in UHM decision-making on the usage of GIS and non-GIS data gathered through UHII
  - P5.3: Number of people using the UHII core Information System UHEMIS for UHM decision-making
    - S3.1: Development of an inter-institutional urban hazard and emergency management information system (UHEMIS) providing access to the data for support in UHM decision making: exploration and visualisation of urban hazard data, and for data exchange between different stakeholders
    - S3.2: Create the standards for urban hazard data exchange through UHEMIS

- G6: Reducing redundancies in data produced among different stakeholders
  - P6.1: decrease in the number of redundant data classes and data types among different information systems in the CoW
  - P6.2: Decrease in the number of the redundant data types and classes among external and target stakeholders
    - S6.1: Integration of municipal information systems
    - S6.2: modelling and introduction of concepts of a central data management system, imposing the integrity of data among different databases

B.II. Clarifying

Definition and modelling of relationship between UHII and its stakeholders

- G7: Improve internal and external accessibility to the municipal data
  - P7.1: Amount of municipal analogue and digital data accessible for the external and target stakeholders
    - S7.1: un-bureaucratize and speed up the process of accessing the data
    - S7.2: make the metadata available for data discovery for all users
S7.3: set up the mechanism for accessing the digital datasets, and possibly the Spatial Data Service Centre (SDSC) to visualise data samples and download (for authorised user groups)

S7.4: Develop the data exchange and sharing policies

G8: Customization of UHII use, guidance and control on data access by different user groups
  - P8.1: frequency of the use of guided interfaces
  - P8.2: percent of successful user authorisation procedures ending up with the data transaction or viewing
    * S8.1: Identify different UHII user groups and specify their user views, create relevant interfaces
    * S8.2: create customizes authorisation interfaces securing the access to the data and data transactions
    * S8.3: create user guidance through the interface, in learning-by-doing modules

B.III. Routinizing Implementation of UHII in terms of strategic integration

G9: Step-wise development of UHII, based on GIS modules and clearinghouse/SDSC facilities
  - P9.1: Operational UHEMIS implemented
  - P9.2: Number of the users of the SDSC module of UHEMIS
    * S9.1: Introduce UHEMIS in the CoW first, as a test of new GIS and DBMS platforms, when tested expand UHEMIS into UHII;
    * S9.2: Assure UHEMIS interoperability - implement the OpenGIS environment or translation modules (Spatial Data Service Centres)

G10: Facilitated and easy management of UHII and UHEMIS
  - P10.1: Number of data transactions registered successfully in UHII environment
    * S10.2: Automate archiving data and metadata creation processes
4.3 Structured UHII system requirements analysis

4.3.1 Urban Hazard Management requirements: Process and Information flows analysis

The As-Is situation of the City of Windhoek, main target organisation for UHEMIS handling, was assessed as not relevant for structured modelling, until the clarification of the institutional gaps and until soft approach does not give the strategy guideline for UHII development. The boundary of the UHII system was delineated step-wise, from the analysis of stakeholders (internal and external) till the SWOT analysis, where the guidelines on collaboration between departments creating the UHII were mentioned. The pre-conditions for the execution of a structured analysis of UHII requirements are solved organisational structural, soft problems. Hereby we assume that according to the strategic guidelines the organisational and functional structures for developing UHII are set already and it is possible to conduct the process and data flows analysis.

4.3.1.1 Requirements for creation of UHM process, functional approach

The initial phase of the fieldwork indicated the lack of integrated urban hazard management process in the City of Windhoek. The disaster management process, as a wider approach in managing hazards, was yet not clearly defined. The draft of the Disaster Management Plan was released, with general functional indications and a framework of responsibilities being set. The Emergency Operation Organisation, created from the representatives of different municipal divisions, City Councillors, higher level government representatives, is supposed to take care for “identifying and obtaining additional assistance/resources for emergency response agencies” in case of significant emergencies and crisis situations. The role of EOO has an executive character in the direct post-impact phase. The daily activities, disaster prevention, mitigation and preparedness are within the scopes of Disaster Management Division, and, independently, of all the administrative units, that should be ready to conduct their local emergency operations. The City of Windhoek takes care for these emergencies that require the service of CoW employees to support the safety response. As it is evident from the above description the focus of the disaster management plan, as refers to the operational level of DM (practical execution of the tasks), is co-ordination of the response to the emergency event, although the total DM cycle (see Chapter 2) was addressed in the policy level. but from this the data requirements and functional responsibilities of divisions can be obtained to conduct pre-impact risk assessment, and thus support disaster preparedness with emergency response planning. For example, it is explicitly mentioned that the building, zoning and transportation regulations have important role in disaster mitigation. From these the UHM data requirements can be read (see: the section below).

Although during the time of the fieldwork the integrated UHM process did not actually exist, but the development of disaster management process was rapid and the inter-disciplinary character of DM was sketched. Integrated UHM concept was enthusiastically accepted. The following process and data flow requirements of integrated UHM indicate the possible process shape. The design of the process itself is not within the scope of the study, but it is significant for UHII concept to assume that such a process will be in place when the implementation phase is reached. Currently the UHM is executed in terms of the fire prevention, mitigation and emergency response, and it is in responsibilities of Emergency Service Division (Municipal Fire Brigades). The risk assessment os done on the base of the internal risk factors (building infrastructure, occupancy statistics, etc.). There are yet no operational links between spatial planning and UHM - nor in the area of data exchange, neither in the aspect of involvement of urban hazard assessment into the planning process.

The main specific functions of the integrated UHM processes in the focus of this study are: (A) major - the urban risk mapping (i.e. fire risk and groundwater contamination risk) and (B) minor - emergency response planning. The specific activities should be respectively:

Ad.(A) - investigation of the vulnerable and hazardous objects in the area of Windhoek, investigation of internal risk factors (i.e. building infrastructure, occupancy), spatial analysis for investigation of external risk factors (threat from the hazardous objects, placing vulnerable objects at risk, distance...
dependent risk extents, etc.), classification of types of risks, quantification or qualitative representation of the risk value (based on the relation between the vulnerable and hazardous object), assessment of the risk extent (based on the type of hazard, substances and elements involved);

Ad.(B) - assessment of emergency response capacity depending on the type and extent of risk foreseen, planning for evacuation (when relevant with routing plans) and provision of shelter and health service, planning for supply of electricity and water for controlling the emergency; planning response in case of complex social disruption in the crisis (food and water provision, information on the calamities, resettlement planning), plans for securing vulnerable objects from looting and destruction, analysis of synergy of risks and re-allocation of necessary response resources, etc.

Required outcomes of these processes were indicated during the fieldwork as the interactive maps of urban risks, database of vulnerable and hazardous objects (preferably spatial database matching the geo-for visualisation needs), updated maps of urban utilities (such as hydrants) and their capacity with respect to the emergency response, register of the dangerous substances and scenarios of dealing with them in case of emergency.

4.3.1.2 UHM information supply needs

According to the research there was no sufficient spatial and non-spatial information flows directed into the Disaster Management Division through the municipal information systems, to support sufficiently the prevention, mitigation and preparedness phases. It was observed already during the SWOT analysis, that there were the gaps in availability of data for man-made hazard assessment. This lacking and required information was identified, together with the processes from which these data should be obtained and with actors responsible for process execution. This was described on the basis of the core research with additional recommendations from the preliminary study, targeting the types of data and possible processes through which these data may be collected. The focus of the UHM, as it was strongly required by the CoW, was the fire hazard management and the hazard of ground water contamination for the southern Windhoek aquifer. The processes and sub-processes that should supply data to the integrated UHM should contain:

Spatial planning process as an outcome having the land use or zoning plan with specifications of land uses and business activities allowed and/or recommended in particular areas. This process supplies UHM in the data on land use (details of legalised parcels usage, % of cover by buildings, % of green and concrete cover, allowed building height, , maps of utilities - location of electricity installation, water pipes, water sources/hydrants, gas pipes etc.) and land use zonation (general level, or detailed, e.g. investment zones), from which the potential urban hazards and vulnerabilities can be detected in case there is no detailed data on land use activities on-going on different parcels. As well the spatial plans or topographic maps indicate the location of some of the vulnerable and hazardous objects or emergency response resources (e.g. location of emergency units, health care facilities, police, public objects, location of gas stations and large gasoline reservoirs, etc.)

Spatial development control process This sub-process involves analysis of applications of citizens for changing existing land use or changing a detailed use activity within the same land use type, or even just changing the extent or type of building.

- Business registration sub-process is one of the main processes supplying data for UHM. From the information on business activities carried out in the buildings or assigned to the plots, the implication can be drawn on the types of materials used and stored, their volume and most of all the class of hazard. Currently these types of data are not yet collected in Windhoek, unlike in the Netherlands. The data collected when applying for registration of business activities are not sufficient to assess the extent of potential hazards. The required information would optimally contain the building types, occupancy data/daytime, register of industrial objects (with the information on hazard classification, materials used in the production processes, EIA, installed emergency systems, etc.)
Building inspection process This process records the building construction elements and inner building infrastructure, as well as compliance with fire and other safety regulations. It is a primary source of the data on the types of buildings in Windhoek urban area, and on the possible internal risks, caused by the structure of the block itself and its utilities. Internal risks can add on top of the external risks magnifying the total risk, causing the threat of life for the occupants of the building.

Transportation management process Road infrastructure development and transport patterns is managed by different stakeholders on local (Transportation Department) and national level (MinWTrCom, Road Authority unit). Transportation issues were considered in the core research with regards to the transport of dangerous goods in the context of an accident threat for the acquifier groundwater. The Ministry of Works Transportation and Communication should deliver the plan of roads development with a policy for dangerous goods transportation, indicating when and where it is allowed to transport different types of goods. The planning for the routes of hazardous transportation would be executed on both national and local level with involvement of spatial planning and environmental authorities. The important data not available yet, but in the plans of acquisition by MinWTrCom are the statistics on the volume and types of the hazardous goods transported through Windhoek area, together with the traffic load patterns. This, together with the environmental data on the vulnerability of groundwater in the acquifier, would be a desired data input for the emergency response planning and for assessment of the risks for groundwater contamination. This links directly to the spatial planning process, in which such factors as securing the natural resources of water are significant constraints for the urban development, and the proper transportation planning in the populated area should diminish the external risks caused by the potential accidents.

The other processes significant for the UHM but not related directly to the urban hazard management domain, providing the base and framework data are:

- Land management process: providing parcel value and ownership information, dynamics of development and upgrade of informal settlements, what may affect the distribution of the urban hazards
- Topographic mapping process: providing the base and framework spatial data in the form of topographic maps; here the survey generals Office supplies the small scale data and the CoW acts as a provider of the large scale Windhoek maps and plans.

The Disaster Management Plan explicitly states the main requirements for different phases of DM cycle, in the focus of this research there are disaster prevention/mitigation and preparedness. Disaster mitigation phase includes among the other building regulations (fire resistance of construction), land use management and zoning, restricting construction in flood-plain zones and regulation of transport of hazardous cargoes, preventive health care (occupational health); Preparedness phase should be supported among the others by emergency response planning and response resource preparation, early warning, emergency communication systems and mutual aid agreements. These requirements prove the need to support on the above mentioned data. The information flows for UHII can be described in the for the To-Be situation as presented through SDW functional analysis diagram: figure 4.1a nd 4.1b SDW functional analysis for UHII, concept diagram and top-level diagram

4.3.1.3 UHII boundaries: scopes and their implications

From the proposed functions included in the integrated UHM the most interest was shown towards groundwater contamination risk analysis and mapping, less stakeholders saw benefits of the urban hazard mapping in total. The man-made disasters were initially treated by the interviewees and discussion attendants as a non-probable and remaining in the scope of the EM Division, or DM Division. With the increase of awareness of the concepts of integrated, inter-disciplinary hazard
management, more interest was shown and the potentials of the use of urban hazard data were explored. This has changed the approach of the stakeholders on the UHII: initial view of the UHII as a global-domain spatial data infrastructure, started in an application-specific field has given place to the idea of an application specific data infrastructure, facilitating in its core the exchange of data between 3 main processes: disaster management, spatial planning and spatial development control. This created the domain-specific view of the UHII as a set of such components as information system network (hardware, software, data transfer protocols), spatial datasets and metadata arranged in a local clearinghouse, data sources and end-users, policies and standards and institutional arrangements, of which all of them have relation to at least one of the three mentioned processes.

The other view of UHII, is strictly connected to the general aspect of spatial data exchange and sharing, aiming to providing accessibility to the base and framework data, as much necessary in mapping urban risks as in spatial planning or other urban management processes. Since there is a very strong will to initiate the local development of an SDI, and from the other side to open the opportunity for exchange and multi-institutional management of urban hazard data, then the introduction of an application specific UHII is seen as a starting point of the global-domain SDI development. These two aspects are therefore addressed in the policies and strategies for UHII introduction in parallel.

From the point of view of disaster managers and spatial planners the UHII must contain a disaster-management-specific information system, that could be used for emergency response planning as much as for support in spatial development control and spatial planning. This would be intentionally the role of UHEMIS, as indicated in the SWOT analysis and interviews, the idea of UHEMIS development (see Chapter 5) in the institutional environment of Windhoek was proven relevant, but only provided that it complies with the requirements of UHII and of local spatial data management needs.

Moreover, in the discussion on the boundaries of UHII and its institutional arrangements, the issue of different involvement of stakeholders was raised. It should not be assumed that UHII limits its implementation to Disaster management Division or to the City of Windhoek only. It is the Ministry of Works, Transportation and Communication as well that should be taken into consideration as a target actor, only in this research it was unfortunately not possible to investigate the MinWTrCom in detail due to the constraints of the fieldwork resources and limited opportunity post-fieldwork contact. What is very important is that there should be a link established with the regional and national disaster management authorities, in order to provide the compatibility of UHII development with the supra-local disaster management data handling initiatives. During the discussions and interviews, the role of REMU (Regional Emergency Management Unit of the Khomas Region) was described as coordination of information management on the regional and inter-municipal scale, but the scope of interest of REMU is out of the man-made hazard domain, it focuses on natural hazards with the priority given to drought and food security. The important aspect is the lack of large scale local data in REMU, and the lack of basic experiences on other DM issues, which means that in case of targeting the local DM issues even REMU will be dependent on the CoW data resources. The growing importance of local hazard data is seen due to the initiative of strengthening disaster preparedness on different administrative levels, which has been reported as heard in the cross-administrative disaster managers’ meetings. The conclusion is here, that UHII boundary should be set in a flexible way, with the objective to comply with and adapt to the foreseen information infrastructure initiatives of the higher administrative levels, both in the domain of disaster management and in the general spatial data infrastructure context. The proposed conceptual model of UHII extent shows this relation: Figure 4.2 UHII development in an organisational context

4.3.2 Institutional requirements for UHII

The prerequisite for implementing the UHII is achieving the common level of understanding of the UHII concept and the compromise on the UHII scopes among the stakeholders, both in GI-pillar and UHM-pillar of UHII.
4.3. Structured UHII system requirements analysis

4.3.2.1 Institutional requirements for the GI pillar

The below stated issues have to be addressed in the multi-institutional policies and agreements, that should be published and made available for everybody (e.g. via internet site) - the UHII users, data providers and all the other parties involved in UHII development. It also refers the general UHII development issues; the pillar of GI UHII components covers as well the domain-specific pillar of UH data, what means that the GI institutional requirements apply as well for all the issues related to the risk and hazard data.

- The broad of co-operation is necessary, covering the spatial data producers (GI-specific actors) and the UH data producers, the cluster initiative model was proposed during the discussions, where a group of potential, equally important UHII contributors is created from the representatives of different organisational levels, and the multi-institutional sub-clusters are created for execution of different tasks. This proposal has to be tested against the organisational hierarchical rules and inter-organisational policies and alternative UHII initiative body structure should be discussed. The potential leadership of the UHII has been recorded during the discussions, based on the willingness to co-operate and the expression of clear goals of UHII by the independent actors; the Geomatics Division representative (CoW), and the representative of SG were willing to create the GI exchange pillar leadership, though their actions should be still tested against the UHM specific goals of UHII. The UHM specific part should be coordinated by the representatives of Disaster Management, Emergency Services and Urbanisation & Planning Divisions of CoW, but it has to refer to the other divisions as necessary thematic advisors.

- The role of each stakeholder has to be clear and agreed in advance with regards to setting up the separate elements of UHII (legal, financial, technical, data, human resources) and integrating them,

- The financial arrangements for setting up UHII elements should be agreed with regards to both - the capacity of an UHII stakeholder and possibly the level of utilisation/benefit or the level of current demand. The study could be executed therefore to investigate the financial extent of benefit from UHII.

- The role of each stakeholder in UHII design and implementation process should be clarified and legally agreed in terms of setting up the separate elements of UHII and integrating them. There should be especially a clear agreement on the data foundation of the UHII i.e. the copyrights and terms of data use and sharing shell be specified in detail.

- Assuming that initially UHII will be designed for the benefit of clearly defined group of users, without an open right to explore the data for the other parties than discussed external and target stakeholders, the issue of protection of data from the use outside agreed environment is a very important issue. As well even within this environment the terms of use and legal penalties for misuse should be defined and executed. The user groups of UHII should be therefore clearly specified, with the data access rights protection, and the data use characteristics (read and write options for particular data and metadatasets, changes of data models, etc.) should be defined.

- the provision of spatial digital and analogue data by the two main GI actors in this study, the CoW and Survey General, should be in detail determined, especially in terms of production of the secondary digital data from their primary analogue forms. The legal responsibility for the cadastral products lies on the SG, in case the digitizing process is outsourced and the digital data are to become open, the auditing of quality of the digitizing process and the quality test of the final product be performed to assure high accuracy and reliability of a digital product. The liability clause should be attached to any of the datasets. The share of tasks for the provision of spatial data in analogue and digital forms, and depending on the scale and thematic context, should be officially agreed between SG and the CoW. It is proposed that the institutional focus
in the GI pillar is on the SG and the base and framework data production (basic topo maps) in mid- and small scale, whereas for the large scale and updates of the maps of dynamically developing urban areas shell stay in focus of the CoW due to its relatively larger capacity to produce and maintain these datasets (even by institutional mandate).

- The security of data transfer, with specification of the transfer means and the procedures of data exchange and sharing should be addressed. It is especially important since all investigated stakeholders indicated the internet and/or intranet as the main preferred data transfer environment, whereas the fieldwork observations were that the main procedure for data sharing was hand-to-hand information delivery, and mostly in an informal background. Under-utilisation of the technology and lack of legal and non-bureaucratic procedures for fast data exchange have to be handled.

- The metadata for all the datasets that will constitute UHII element have to provided prior to the data themselves. In the multi-institutional context, where the data discovery and exploration tools have to be provided to make the UHII users aware of the data existence, the metadata is the crucial issue. There should be a metadata standard chosen and followed by all UHII stakeholders, in order to provide cohered and integrated metadata environment. This standardisation of metadata should follow at least the minimum metadata standard as indicated by ISO (see www.iso.org/iso/en/ISOOnline.frontpage). Still, the main problem is the lack of awareness of metadata importance among some of the stakeholders and the lack of full acceptance to undertake the effort of metadata collection. There should be an evident pressure to contribute to the metadata creation and maintenance, the provision of metadata should be a condition to access UHII on the full rights. The education on metadata issues such as metadata use, structure and maintenance should be executed. Since there is no awareness of metadata importance, and the acceptance is low, the concept has to be implemented in a user-friendly way, to support easy use and production of metadata, not to discourage the users. The requirement for creation and maintenance of metadata with a user-guiding interface. The detailed functional requirements for metadata are given in the latter sections.

- The issue of data pricing and free share and exchange should be a target of a detail investigation, to prepare an agreement on the pricing policy within UHII vs. free share and exchange policy. The types of data designated for free share and the types of use of data allowing for such free exchange should be specified.

- The issue of stimulation for an open spatial data market should be given more attention, since it is the conflict issue among the stakeholders. The target UHM and GI actor, the CoW, is not in favour of allowing the access to digital data to the private users, even to the individual land surveyors, who have to digitize the plans updated by the municipality, to be able to use them in GIS environment. More open access to the digital spatial data is believed by some data users to be an incentive for economic stimulation in Windhoek, and an unused potential of the CoW.

- It is necessary to remember about the requirements for GI management and SDI development arising from the national initiative for establishing spatial information infrastructure. Such institution as the inter-ministerial NSDI Committee should be consulted and the national spatial data policy should be referred to when establishing UHII.

4.3.2.2 Institutional requirements for the UH data pillar

- The creation of risk maps and analysis of hazards should be done with compliance to the regional and national directives and standards, if these exist, so that the further development of similar initiatives did not result in an incompatible, heterogenous data environment. The standardised procedures for urban hazard classification should be developed and the data requirements for risk assessment should be regionally authorised and standardised. REMU could
become a consultative body with regards to this issue due to its mandate, but due to the lack of knowledge in the local requirements the other solution should be considered - the local development of standards with the support of regional authority and further transfer of these standards onto the regional ground was proposed by the stakeholders.

- More investigation should be made for requirements of the thematic and functional scope of the information infrastructure to link it to the regional and national focus areas (wild-land and suburban fringe fire, drought crisis and its water provision, food security, etc) to be able to use UHII potential in responding locally to the regional emergencies, the co-operation with REMU and National Disaster Management Unit is required to achieve this. As well the institutional link should be maintained to provide the financial support for strengthening local preparedness status.

- The datasets related in any aspect to UHM and owned by private parties should be identified and the private sector actors should be encouraged to contribute to the UHII initiative by knowledge sharing and spatial data exchange.

- The deep investigation of inter-municipal data resources should be conducted, to identify level of involvement of specific divisions in UHII and to create the profile of UHII user groups from within the CoW.

- The information system for dissemination and visualisation of urban hazard data should receive the organisational structure, it should be maintained mainly by the Disaster Management Division and Emergency Services Division from the CoW and the RA of the Ministry of Works, transportation and Communication, but since these three do not assure professional data management frame, it is also crucial to establish the GI management core of the system maintained by the other party (e.g Geomatics Division or an external actor, to provide equality of access and user & maintenance rights between the CoW and the RA)

- There should be a multi-institutional agreement on the types of data classification and for both the disaster-specific terminology and data management glossary, to avoid the conflicts between the CoW and the Ministry arising from the semantic differences. Also all the requirements applying to the GI concept should be transferred to the UHM-specific level to assure fluent cooperation in the UH data management domain.

### 4.3.3 Other issues regarding standardisation

The necessary internal and multi-institutional spatial data standardisation policies should be developed as indicated in the SWOT analysis; the attention should however be paid to the two types of policies required for harmonised functioning of UHII:

1. Standardisation of data formats or open standardisation for data maintenance software, to assure interoperability of data provided by different stakeholders; this refers to the first pillar of UHII - the GI pillar, concerned with the management of spatial data constituting the UHII

2. The UHM pillar of UHII requires standardisation of all procedures leading to the production of spatial hazard/risk data and emergency response scenarios. The concepts of hazard, risk and their extents have to be clearly defined, classification of urban hazards should be accepted regionally together with their form of representation on the maps, be it of digital or of analogue format. The main standardisation guidelines should as well be prepared for the risk assessment data model and its relation to the risk maps. The digital spatial urban hazard data/maps should as well have standardised options of update, and as learned on Dutch experiences, the visualisation component is not enough to support UHM process the map analysis and query should be enabled.
4.3.4 Metadata requirements

Metadata are crucial especially in case when a lot of stakeholders and processes are involved, and when different stakeholders are not aware of their data resources, as it is in an organisational environment in Windhoek. Yet, there is no awareness of the importance of metadata and the education on its concepts and potentials should be executed, as recommended above. There are more requirements related to the technical and functional side of metadata as opposed to the institutional context:

- Metadata should enable discovery of data and localisation of the data owner
- Metadata should allow to assess the relevancy of data for the user’s purpose, indicating the semantic clarification of the type of data, format (analogue or digital), standardisation of data if any was followed;
- It should give an idea of the fitness for use indicating the age, accuracy, reliability, supplier (reputation context), lineage (original source and modifications) and spatial context as georeferencing information, and spatial extent, etc;
- The terms of access to the data, in case the access is not direct, should be described
- There should be the mechanism to control the metadata quality, mainly the completeness and reliability - the completeness depends on the standard for metadata record chosen, but the minimum metadata content should be dictated according to the multi-institutional need to understand one-another's datasets. The attention should be given to two aspects of metadata - spatial data history and quality (GI context) vs. spatial data classification for thematic use (UHM context).

4.3.5 UHII Quality requirements

4.3.5.1 Data quality

The quality of data cannot be treated as accuracy only, it should be described as well by such terms as reliability, completeness, timeliness ("up-to-date-ness"), integrity and consistence of subsets, and lineage consistency. For the needs of UHII the requirements were analysed in terms of data timelessness (the age of required data), completeness (incl. availability of all necessary data classes to perform the analysis in decision-making) and consistency (here understood as possibility to logically link data subsets, without creating an error). The issue of positional accuracy is important from the point of view of the users, especially when talking about the support for emergency response planning and risk mapping, where the external risks are assessed according to the spatial relationships between hazardous and vulnerable objects. The thematic accuracy refers to proper connection between the spatial objects (e.g. parcel) and their thematic description (e.g. land cover assigned to the land cannot be the one of the water body). In terms of accuracy, the important quality question arises when discussing the digitization of the analogue maps and plans, a common process in the CoW and in the SG. This process introduces errors of digitizing (inaccuracy in following the analogue lines, overlapping boundary lines, crossed limits of objects, etc) depending on the type of digitizing method applied. The systematic mistakes have to be identified and eliminated and the accuracy of the final product should be tested against the original matrix. Digitizing products of different scales may introduce different errors, and it is important to always not the scale of the original product, not to misuse the digital copy for the applications requiring larger scale product.

The positionally accurate map may still not be reliable, if e.g. the textual information indicated on it is misplaced and assigned to wrong spatial objects. Such mistakes in assigning the thematic description wrongly to the objects in the geo-databases have to be carefully analysed. Misinformation on the hazardous object can be a cause of the big losses (including life loss) in case of an accident. There usually is a link between a map source and a socially assessed reliability of a map, here the metadata on the source and lineage would play a role of a reliability indicator.

The completeness of the data in terms of complete representation of all the data or data model classes
on the map and in terms of providing all necessary descriptions and tabular extensions of the map, has to be as well tested before incorporating the maps into UHII. If the dataset is not complete, it should be indicated in the metadata.

The timelines of the data indicates the moment of its capture and representation in either analogue or digital form, important to notice is that these 2 do not necessarily happen in the same moment, the data can be captured long before it is finally represented on the map, or inserted into the database. In case there is such a difference it should be indicated in the metadata.

The consistency and integrity of the datasets or subsets of one set indicate possibility of overlapping different layers of data allowing for spatial analysis without errors introduced by inconsistent object boundaries or locations. It plays an important role for accurate risk assessment analysis.

To assure data quality, the process of quality management should be introduced, the quality check should be done before the incorporation of the datasets into the information infrastructure.

4.3.5.2 Metadata quality

The above mentioned quality aspects apply to the metadata as well, they should be complete according to the chosen standard, reliable, accurate and up-to-date. The process of metadata update should follow the processes of data processing, the metadata lineage should be maintained in a way to make it description complete.

4.3.6 UHII management requirements

Such issues as updating data resources and reuse of the old resources, metadatabase creation and update, security of datasets and network for assuring safe data exchange operations, creation of different UHII user groups with different user rights, integration of new data sources (databases) into the infrastructure, financing the UHII data resources and network maintenance, flexible functional UHII boundary (extension of thematic applications and of administrative level of use), and consequently flexible, but robust architecture of UHII belong to the UHII management requirements. Most of these were addressed in the text above in detail, only the ICT requirements with ICT management issues will be presented below.

It is important to analyse the critical factors of success of UHII performance in the long term context, to assure its sustainability, as well the need to address the feasibility of detailed UHII management solutions is acknowledged, but these do not remain any more in the focus of this research.

4.3.7 UHII ICT requirements

The main principle is to reuse the existing data and software/hardware and network resources in order to diminish the costs of UHII and to make its implementation feasible. The attempt is to use the facilities of the CoW as the core and reliable networking environment, and to link it with the Survey General network (as it has been in the mind of the staff of SG and the CoW long time ago) and to provide the online access to the data to the Ministry of Works, transportation and Communication.

The following issues have to be resolved in order to be able to implement the UHII:

- The analogue data necessary for support of UHM (topographic maps, aerial photos, cadastre information, land use plans, building infrastructure, updated utility maps, plans of evacuation facilities, flood lines, fire vulnerability zoning, etc.) have to be made available in digital forms, or at least the digital metadata has to be produced for the analogue sets, in order to enable data discovery through UHII.

- The Central spatial and non spatial database in Geomatics division has to become interoperable with the other databases in the CoW and with the databases of the data providers (Oracle8 for GeoMedia in case of he Road Authority and the Survey General), either through the external open data environment (translation of data through ASCII, or enabled data transfer with the use of XML and GML). The AutoCAD and MunSys are used for digitization and visualisation.
of spatial data in the CoW, these systems do not provide however the flexible change of data models and implementation of the risk mapping module would be non-feasible with the use of MunSys only - it has a fixed database, defined for small number of features, allowing for fixed location queries, and the spatial analysis is not possible in this environment; the change of the spatial digital data visualisation and analysis tools is a necessity. The MapGuide GIS environment, as another tool used for visualisation and querying of municipal spatial data, with the online module accessible via internet, would have to be updated in the structure for the metadata content, if possible. Here, the use of the spatial database is limited, no topology is available and only visual analysis can be performed, which constrains the use of UH data, but allows for potential dissemination of UH maps through the internet. Existing independent municipal information systems have to be modified to support metadata storing and extraction, and to provide fluent exchange of attribute information.

- The robustness of- and capacity of data transfer through the CoW LAN/ Municipal Area Network has to be tested, and the influence of possible BIS implementation on the interoperability of datasets has to be checked, since it creates potentials for easier implementation of UHII elements such as UHEMIS.

- Data is secured in the CoW for the updating and re-structuring - only the IT Services Division has official access to the municipal data; all the changes must be requested through them, what can be the constraint for UHII, since the capacity of IT Service Division is small, and additional tasks could be conflicting with existing CoW work. There is a need then to establish, possibly under the UHEMIS, as much automated data management as possible, with the authorisation of different user groups and with a data security guard being assigned form the stakeholders to control the data management process. As well the municipal network is secured from the infiltration of unwanted external users, and the security of it has been tested, unlike in the case of SG and the Ministry of works (stated for November 2002). It as well provides the backup service, necessary for UHII functions.

- The information environment tool to solve semantic, syntactic and schematic data structure differences is required, the BIS is assumed to solve at least partly these problems, although the semantic issue has to be resolved first by agreements on the standard data classes used.

- The UHII interface built by UHEMIS system should be user-friendly, since there is not too much experience among average stakeholders representatives in terms of the digital spatial data use and analysis, neither there is experience on the data management itself. The guidance role and clarity of interface is a crucial issue; there should be clear functional modules of this interface developed.

- The specifications of necessary hardware include the switches, hubs and cables for extending the network connection, the use of radio internet connection seems to be a good alternative as indicated in discussions, the BlueTooth technology is not feasible due to its costs. New PC units would have to be provided to the Disaster Management Division and Emergency Services Division, as well to the Road Authority. Survey General currently has the technical capacity ready to use.

- The integrity of operational systems has to be assured.

- The security of continuity and capacity of internet connection is a limiting factor of UHII.

- Standardised data transfer protocols have to be discussed for use in UHII, the potential of the use of XML and GML for data transfer and storage should be investigated in detail.
4.4 UHII model

The model of the UHII infrastructure is derived according to the analysed spatial data management problems in As-Is situation, lessons learned from the preliminary study and critical recommendations from the analysed reference cases. The concept of UHII, is based on the creation of an application-specific data sharing and exchange network under the umbrella of the global-domain spatial data infrastructure. The goal is to facilitate the access to- and use of- spatial data in Windhoek to support Integrated Urban Hazard Management by the provision of guide-model for organisational structure, and model of spatial data exchange and sharing through the urban hazard information system (Urban Hazard and Emergency Management Information System - UHEMIS).

It is assumed that UHII is being developed with the relation to the Namibian National Spatial Data Infrastructure and that it complies to its standards.
Chapter 4. From the lessons learned to system modelling - the Critical Approach to Urban Hazard Information Infrastructure for Windhoek

Figure 4.4: The concept of UHII architecture as supported on UHEMIS core
4.4. UHII model
Chapter 5

UHII implementation strategy in practice: UHEMIS as the core of UHII - functional issues

In the previous chapter the analysis of requirements was done for development of Urban Hazard Information Infrastructure, the results indicated the need of development of a tangible element of this infrastructure that would support integrated Urban Hazard Management. This has been identified as a System, in the meaning of a logical support for execution of given tasks, with the use of spatial and non-spatial information. This chapter presents the process of analysing UHEMIS requirements and interpreting them, The conceptual models are being drawn and the guidelines for UHEMIS development under the UHII umbrella are presented, for the organisational, functional and technological context.

5.1 UHEMIS scope, boundary and organisational structure

The boundary of the system is here described by the set of its functional (processes, activities), organisational(stakeholders), and physical (hardware, network, physical location) structures, through which the system interacts (i.e. in this case supplying the information and acquiring data) with external environment.

Therefore, there were three subsequent elements defining the system boundary:

1. Stakeholders’ interest and their functional requirement
2. Process requirement for supply in data and information
3. Stakeholders’ physical resources and capacity for setting up UHEMIS

After investigating the demands for UHII the assumption was made that UHEMIS, as a strong element of UHII, will be related closely to the Urban Hazard Management processes, and that it will serve as support to integrate UHM and spatial planning and development control, and that it will contain spatial component being therefore a GIS-related system. Having said that as a starting point, the analysis of stakeholders demand for UHEMIS and foreseen potential benefit from the system was done (see: Chapter 3, tables 3.1 and 3.2) to validate the assumption. 7 out of 22 stakeholders indicated, during the workshop discussion and in the interviews, that their demand for access to GIS environment under UHII is high or very high. These stakeholders however were driven by different forces and soon it appeared that there exist different, sometimes even opposite expectations as for UHEMIS functionalities. Therefore further detailed research had to be conducted to clearly define UHEMIS specifications.
5.1. UHEMIS scope, boundary and organisational structure

5.1.1 UHEMIS functional context model

The division of stakeholders could have been observed into these, who are interested in the application-specific approach to UHEMIS and those, who are interested in the global-domain scope of UHII initiative, related to fostering spatial data exchange and sharing. In total UHEMIS is supposed to serve as the information system for handling urban hazard data in their spatial and non-spatial form, linking the processes of UHM and Spatial Planning and Development Control. The two Functional aspects of UHEMIS were underlined as two functional pillars when conceptualising UHEMIS: the Spatial Data Management Pillar and UH Data Analysis and Visualisation Pillar.

5.1.1.1 UHEMIS and its Data Analysis module

The first pillar manifested itself in the strong demand for GIS-base for decision support in UHM. This strong request for the UHEMIS to support the analysis and visualisation of hazard and risk data came from 4 of 7 stakeholders, who indicated the need to access GIS environment, namely Disaster Management Div. (CoW), Emergency Services Div. (CoW), Road Authority (MinWTrCom), and Planning & Urbanisation Div. (CoW). They required UHEMIS as well to be able to allow for identification of problem zones and points in Windhoek, characterised by high urban man-made risk, and to be able to compare it with existing spatial plans and road development plans. This might be executed via GIS-based data visualisation and analysis tool. GIS support could lead to undertaking the counter-measures through the spatial planning and spatial development control processes, which is referred to in this work as a part of Integrated UHM.

Critical re-evaluation of such UHEMIS functions had to be done in order to avoid the creation of another municipal GIS incompatible with the other spatial and non-spatial information systems of CoW, unsustainable and non-useable in long term. The technology-push approach observed in the discussions, although very enthusiastic, could have led to very ineffective solutions in system development, narrow in applications and non accessible to the wider range of stakeholders. This would conflict with the objectives of UHII, for which UHEMIS should serve in the first place. The Critical Systems Approach allowed to re-prioritise the Spatial Data Analysis Module against other UHEMIS functions, and to guide towards long-term solutions compliant with UHII goals.

5.1.1.2 UHEMIS and its Spatial Data Management module

Considering poor spatial data management conditions in the environment of the target and external stakeholders, UHEMIS was meant to act as a starting point for the development of the UHII itself. As well in the latter attempts it may play the role of the link between National and local Spatial Data Infrastructure, moreover, by its specifications it is already connecting the global and application-specific domains for decision support. This implies very specific approach for interpreting critically the requirements analysis, in which the need for two different functional subsystems is observed. In order to fulfil the objectives of UHII, there must be a mechanism in UHEMIS for managing spatial data, as learned from lessons in the reference cases: for recording their availability, formats, quality etc., in the form of metadata, for providing access to these metadata, for updating, down- and up-loading both metadata and core datasets or for obtaining information on where these data are available. UHEMIS is here hoped to initiate development of UHII and foster data exchange and sharing by provision of facilities for spatial data exploration and exchange.

5.1.2 Boundary of the system and organisational structure

The two identified information subsystems of UHEMIS have different functional boundaries and therefore different organisational units shall be responsible for maintenance of these functions. The objective was to match the functions of the system with the functions of organisational units, and the following boundaries were defined:
Chapter 5. UHII implementation strategy in practice: UHEMIS as the core of UHII - functional issues

1. UHEMIS Spatial Data Service Centre: Geomatics and Survey General (although it is an external actor for the application-specific pillar of UHEMIS) - spatial data management and metadata management, data exchange, digitisation, quality assessment, etc.

2. UHEMIS Risk Data Analysis and Emergency Planning Centre: UHEMIS collaborative body - Multi-organisational "Integrated Hazard Management Unit", composed of target stakeholders (CoW Disaster Management Division, CoW Emergency Services Division, Ministry of Works, Transportation & Communication - Road Authority) and a representative of Spatial Planning and Development Control units (Planning and Urbanisation Division).

The grayed-out boxes indicate external UHEMIS actors supplying the data to UHII and the same to UHEMIS. The role of SG is significant due to special arrangements between the CoW and SG on the sharing and digitisation of SG data by the COW.

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**Figure 5.1: Conceptual UHEMIS boundary in the organisational and functional context of UHII**

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5.2 Detailed user-centered requirements analysis outcomes for UHEMIS

The detailed requirements for the information system UHEMIS were analysed and interpreted from the questionnaire based survey and interviews. Since the spatial data management was a relatively new concept for the interviewed stakeholders, the guidance through the investigation was necessary. The ability of users to express their requirements was varying depending on the background: the information management approaches, system development, standardisation or metadata concepts were not always accepted and required explanation. The issues of database management, analysis of user views, and identification of some specific requirements were making the fieldwork part of the research challenging. Despite of the problems a lot of valuable information was collected to support the research on UHII development.

5.2.1 UHEMIS role as a decision support tool

In the context of the decision support provided by UHII, the UHEMIS functions could have been proposed to the potential users in the framework of the below universal model of spatial data infrastructure support for decision making (discussed already in Chapter 2). The provision of access to data through UHEMIS and data analysis possibilities are pictured in the below model.

![Diagram showing the relations between UHII elements and UHEMIS decision support for accessing data & technologies](image-url)

Figure 5.2: Relations between UHII elements and UHEMIS decision support for accessing data & technologies, UHEMIS specific view
5.2.1.1 Integrated Urban Hazard Management Process requirements

The first structured investigation of the disaster management processes and urban hazard management processes in Windhoek has failed to provide proper functional analysis model, due to the fact that there was no systemic approach to the problem. The situation could have been described only in a soft way, the attempts to structure the analysis failed and the answer was relatively easy - there was yet NO Integrated Approach to Urban Hazard Management. In other words, there was no link between Spatial Planning / Development Control and the hazard management activities. It holds for both requested and analysed application domains - fire hazard risk assessment and groundwater contamination risk assessment (on the base of the provided vulnerability studies). The Critical approach had to be applied again, to change the organisational status quo in relation to the urban hazard management process and its data requirements. Here the main reference for the process analysis was the preliminary study, providing the materials on standardised procedures of risk assessment in the Netherlands. It provided the fundamental information on necessary data required in fire hazard management and urban risk assessment (for details see: Schadescenarioboek released by the Dutch Ministry of Internal Affairs (MinBZK, 1992)). The most important concern made in this point of the research was the relevance of the development of the GIS information system for the support of the process that does not yet exist in the form allowing for accurate extraction of the requirements. Since it was not an attempt of this research to re-engineer the Integrated Urban Hazard Management Process in a business approach, but to provide guidelines for strategic and policy approach to development of UHII in general (considering some for of an information system as a core of the UHII), therefore the focus in this moment has been shifted from the application-domain of UHII and UHEMIS, to the pillar supporting delivery of spatial data for the processes contributing to the future Integrated UHM. Critically it has been assessed that the main bottleneck for the development of the UHM process at the very moment was the lack of data or the lack of knowledge on their availability. The lack of data flows from the Spatial Planning / Development Control processes to the Division of Disaster Management (and not to the process yet) was the main gap, as expressed by the target stakeholders. This complex and non-systemic situation we can observe on the figure below. Some of the information flows are lacking, some, even if forced by the SDW software to match, are in reality blocked (data is produced but not used, due to the lack of information on the availability), etc. The most important observation in this stage of research was that the preparation of base, framework, and risk specific by different stakeholders and their exchange constitute the prerequisite to thinking on design and development of data analysis module for UHEMIS.
Figure 5.3: As-Is Top-Level Functional Analysis for the CoW UHM and SDC processes, note improper system boundaries definition
The Critical Approach was applied in order to change the opinion in CoW in terms of possible divisional responsibilities for the integrated UHM process. The actors had to be made aware of the UHM information requirements and their implications. In order to analyse the possibility of changing the current status of the Integrated UHM process and its contributing processes, the legal power among the stakeholders was analysed. 5 out of 6 target stakeholder representatives are playing an important role in decision-making and creation of organisational policies, what is promising for undertaking the initiative of UHM process re-engineering, and steering collaborative data exploration and sharing for creating UHEMIS framework. All necessary domains are covered by the will of policy- and decision-making: disaster management, emergency management, spatial data management, transport management and spatial development with development control. The same holds for detailed activities possible to be executed within integrated UHM - risk assessment, emergency planning and land use planning.

5.2.1.2 Fire hazard management and ground water protection information requirements

**Required data types and their availability:** The first, general level of data requirements for fire hazard management can be seen on the context level diagram of the CoW functional analysis for integrated UHII. The information on these requirements was analysed through the questionnaires and interviews, but the main important observation was that due to the lack of clearly defined processes, there is as well the lack of awareness on what data are really necessary to support the hazard management. The Critical Approach was applied for making the respective divisions aware of the necessity of making their specific data available for Disaster Management Division, Emergency Services Division, and Planning & Urbanisation Division so that they could set up the risk assessment procedures. The necessary data identified as crucial for spatial risk analysis under UHEMIS were the same as in the context of UHII (for data specifications see 4.3.1.2).

![Figure 5.4: As-Is System Context Diagram for the CoW UHM and SDC data supply - external data providers](image-url)
5.2. Detailed user-centered requirements analysis outcomes for UHEMIS

Figure 5.5: Improved context diagram for Cow Integrated Spatial Development Control and Urban Hazard Management, after applying Critical System Approach
5.2.2 UHEMIS as spatial data manager of UHII

As indicated in the above sections the management of spatial data through UHEMIS was requested by the users. Moreover, by the Critical Approach, data management facilities have been assessed as the priority over spatial data analysis functions in UHEMIS, at least in the meaning of phasing of UHEMIS implementation - steps addressing total spatial data management were of priority over the steps related to GIS risk analysis.

5.2.2.1 Use and assessment of used data for future UHEMIS support

In order to see what shell be the functions of UHEMIS data management module the assessment of current status of data management was made. It has been investigated that over 65% of data mentioned in the survey is used in digital format, although the results can be considers representative for the city of Windhoek only. The data for almost half of the cases were assessed as of good quality and reliability, in the other half most of the data were not possible to be assessed. Moreover, even in cases of so-called “good quality” the respondents were expressing only their subjective opinions, there was no test on the data quality mentioned. The age of data mostly was not known and if known then it varied from recent and up-to-date (municipal data on urban infrastructure) to 10 years (population maps). In most of the cases the municipality was mentioned as its own, sustainable data provider, with the medium of provision as MapGuide, indicating that the digital dataset was produced by Geomatics Division.

5.2.2.2 Access to data

The easy visualisation modules of MapGuide are utilised in the City of Windhoek, due to the good LAN settings and good setup of municipal spatial visualisation systems, but still almost 40% of current data access attempts is executed via direct contacts. When asking about the preferred access to the spatial and non-spatial data either for UHM support or for any other process, almost 100% responses indicated that internet/intranet access is in absolute favour. This as well has an implication on the spatial data analysis module of UHEMIS, which as well is preferred to operate as an on-line data analysis system, i.e. in the form of web-GIS. The difference between current municipal GIS solution and UHEMIS would have to be provision of basic data analysis functions, not only data visualisation, e.g. selection queries on the areas based on different criteria, distance measurements, simplified network analysis, etc.

Among the problems in accessing required data there were no top problems significantly prioritized above the others, in fact every option indicated in the questionnaire was almost the same problematic. The lack of standards in data exchange, lack of info on existing data, and lack of cooperation among vendors seemed to be mentioned the most often, but right after them the bureaucracy and the lack of data themselves are as well mentioned. In such situation implementation of data analysis module of UHEMIS would be very difficult, because of no proper data support for the system itself. Once again the spatial data management module of UHEMIS is proven to have the priority over the new GIS component.

5.2.2.3 Metadata management

The issue of metadata constituted a very problematic area of discussion in the CoW, since its importance has neither been recognised by the staff dealing with data management nor by the domain-specific actors. The reason might be the assumption made by all users of MapGuide that the data accessible through it are by default reliable and do not have to carry metainformation with them. In case of need for metadata, the Geomatics division was addressed as the “metaknowledge base” of the municipality. The situation looked relatively better in the SG, where the concepts were recognized, but from the recognition to implementation there still was a long way to go. This issue would not be a problem if not a very high rate of staff change in the CoW, and the threat that the knowledge on the datasets will one day leave with the data manager. This as well would be very dangerous in case of
5.2. Detailed user-centered requirements analysis outcomes for UHEMIS

multi-institutional data exchange, if the metadata was not recorded, since it might very easily lead to the loss of data reliability and quality (e.g. if the lineage is not registered and the quality of data processing is not known). In the light of UHII introduction, UHEMIS should evidently impose the metainformation management on its users via the interface, in order to assure data reliability.

The metadata in UHEMIS should follow one of the globally accepted standardisation schemas. It is assumed that currently on-going initiative for National Spatial Data Infrastructure development in Namibia will soon release the guidelines for metadata formats, it would be therefore wise to consider compliance of UHEMIS with the NSDI choice. Since this research is not supported by the information on the standard chosen, the possible solution is presented with the FGDC (Federal Geographic Data Committee) metadata structure concept. The FGDC standard requires seven main components of the metadata to be present in the metadatabase:

1. Identification Information (data content, spatial domain)
2. Data Quality Information (quality and suitability for use)
3. Spatial Data Organisation (model/mechanism for representation of spatial information in the dataset)
4. Spatial Reference (Geo-coordinates frame used)
5. Entity and Attributes (attribute definitions, domain, unit of measure)
6. Distribution Information (data distributor information)
7. Metadata Reference (information on the current status of metadata and of the creator of a current metadataset)

5.2.3 UHEMIS operational IT requirements

The use of IT infrastructure was analysed and indicated high utilisation of network facilities in the CoW. Although the data coming from other institutions may be not considered significant, but due to the lack of validation of these data it is assumed that they are sufficiently correct; their indication is that in case of SG (with Deeds office and Topographic Mapping Directorate), and RA there is lower IT capacity and a lot lower relative level of utilisation, due to the lack of IT knowledge among staff.

The patterns of horizontal communication between departments and vertical communication between different administrative level were not analysed, although they might have important meaning for indicating informal information flows. In the CoW the e-mail communication is used as frequent as mobile and land-line phone communication. Still, the access to data manifests itself by personal contacts, using either the hard copy, floppy, CD or ZIP media, the online data transfer was indicated twice only. on the other hand the bias of the answer can be spotted when asking on the information exchange methods; these indicate a lot more share of internet and intranet. It can be be biased, if it regarded the transfer of data between CoW and home place - for extra work. The required UHEMIS IT resources, however are in place - there were around 500 computers in the municipality, and on average departments had 30 computers. Most of these computers are said nowadays to be sufficient for installing GIS components. The speed of transfer of data over intranet and internet was assessed as sufficient for data visualisation, but no data could have been obtained for online data analysis. During the fieldwork the observation was made that the operating system was Microsoft NT, and the software components used were mainly MsOffice, AutoCAD, MapGuide and Internet Explorer. Apart from IT department there is no awareness on the components of municipal information systems. The interview with the current head of Information Services indicated serious problems in achieving interoperability among 333 different subsystems. This was considered as a main obstacle towards implementation of another GIS component as it would be the spatial data analysis module of UHEMIS. Achieving the interoperable, open data environment is one of the goals of the CoW, and UHEMIS is hoped to contribute to the actions towards it.
After the discussion with the Information Services Division it was recommended either to base UHEMIS on planned Business Information System, meant to introduce interoperable environment for municipal datasets or to independently decide on the concept of UHEMIS with XML and GML representation for data models and the same for extensible or geographic markup language transfer options for non-spatial and spatial data respectively. The idea was suitable for structuring the management of spatial and non-spatial data, and for introducing the metadata management. The advantage was possibility of introducing the XML/GML as an intermediary environment for exchanging different data formats - in other words, for accessing different datasets in their own formats, converting them and subsequently using XML/GML to transfer the data in the previously defined ("tagged") data structure. The concept shell be expanded in the further research on logical and physical UHEMIS development, but such design is not included in the main focus areas of this work. The model of UHEMIS data management module was presented below as a final concept, agreed after analysis of UHII and UHEMIS requirements with the Critical Approach.

5.2.4 UHEMIS prototype concept model

After validation of the SWOT analysis and user requirements analysis, the UHEMIS concepts were adapted to the real-life, critical requirement for making existing CoW and other information system interoperable. UHEMIS should become a core of UHII, acting not as a GIS-based decision support tool, but as a Spatial Information Management Service Centre, that allows for metadata management, creation of new web-based GIS services, and stimulates production of value added digital spatial information. UHEMIS vision now answers the OpenGIS concept needs via planned application of XML/GML data and metadata exchange solutions, being an interoperable base for Web Mapping Services. In such way the interoperability for existing CoW information systems can be achieved through UHEMIS, and the link with information systems used by actors other then the CoW can be established within UHII. The important issue is as well the parallel adaptation of UHEMIS model with the creation of Integrated UHM processes, as recommended during this research, although this issue is independent form the IT solution presented above, but it affects the data dictionary of and XML and GML data models.

![Figure 5.6: Concept Model of UHEMIS as a (Meta)Information Management Service Centre for Urban Hazard Information Infrastructure](image)

Figure 5.6: Concept Model of UHEMIS as a (Meta)Information Management Service Centre for Urban Hazard Information Infrastructure
5.2. Detailed user-centered requirements analysis outcomes for UHEMIS

Figure 5.7: Schematic example of a simplified Top-level functional analysis diagram for integrated UHM and SDC processes with the use of UHEMIS
Chapter 6

Discussion, Conclusions and Recommendations

6.1 Research methodology - discussion

6.1.0.1 SDI development problems in developed and developing countries and - pears and apples?

There was a very strong doubt from the beginning of the research on the way in which the experiences of SDI establishment from the developed countries could help the developing countries to avoid the mistakes such as technology-pushed approach to information system development (implying the end of the project soon after its leaders are gone, due to the e.g. lack of skills among the staff to maintain the system), or multiple, heterogenous initiatives of similar spatial data management goals resulting in the lack of integrity of produced similar datasets, etc. The example can be the set of initially non-coordinated projects for risk mapping in the Netherlands, where it costed a lot of time and effort to standardise regionally the risk mapping process. The attempt made in this research to learn from negative experiences of the others rather than positive (best practise) cases was chosen not to apply the best practises from one situation background to the completely different background, causing the failure. Still there are a lot of positive recommendations, evidently worth discussing in different organisational settings, so the argument for negative reference only would not work here for this research. Therefore it was attempted to analyse the organisational criteria for (a)choice of methods to apply for system development in different organisational settings and for (b)decision on the system boundaries and on choice of strategic methods for information infrastructure implementation. The attempts failed however, due to the fact that there was a lack of access to verifiable method for assessing the link between the nature of organisations and the SUCCESS of SDI development. In the general sense it was not clear what types of organisational criteria should be used and how when deciding on the alternative actions of SDI implementation.

6.1.0.2 Lessons learned - how to really benefit from them?

The objective of the use of the reference cases as the tier of Critical System Approach was to avoid the bias of the results of requirements analysis, leading to the development of an unsustainable and irrelevant (in terms of compliance with organisational setup, technological and legal situation) Information Infrastructure. Since the final objective is to prepare a quality model of an infrastructure an one of its functional elements (UHEMIS), one has to remember what is understood by the System Quality. In general the quality of the information systems and information infrastructures in wider scope is the accuracy of representation of the user requirements. The Critical Approach applied here denies the value of some of the requirements changing them and modifying the final design of UHII and UHEMIS. Hence, one can argue that we miss the final objective of the quality model design.
What stands for this methodology is the lack of feasibility or relevancy of solutions required by the users. By the feasibility one should understand possibility of implementation of the requirements in an organisational, legal and technical situation changed according to the gap analysis. Since not all the gaps can be directly repaired, some of the solutions will have to wait for implementation until the optimal situation is achieved (the time of strategy implementing the requirement has to be postponed). Also irrelevancy of the requirement refers to such views of the UHEMIS that conflict with the objectives of the UHII, i.e. the idea of UHEMIS primarily as a visual GIS support in decision making had to be adapted to the concept of the data exchange and sharing by the shift of focus from the GIS visualisation and analysis part to the data management module. This was done to avoid population of another stand-alone GIS incompatible with the environment of municipal information systems.

The "un-feasible" requirements are identified based on the lessons learned form the preliminary study and the set of reference cases. They are modified and the final UHII and UHEMIS model can be designed. Hence, the System Quality definition here has to be extended and the accordance with user requirements is not the only criterion to assess it.

6.2 Conclusions

6.2.1 Research objectives and questions

In the flow of this research some of the objectives and questions had to be modified, in order to assure relevancy of the research for the organisational situation of analysed cases. The main obstacle was the feasibility of the research objectives, that initially were set according to the requirements of investigated organisations, in order to support with this research their development. Final modifications of the research focus had to be done during and after the analysis and interpretation of fieldwork data, due to the methodological approach taken.

6.2.1.1 Investigation of a demand and potentials for development of Urban Hazard Information Infrastructure (UHII) in Windhoek, Namibia

The first main objective of this research aimed to exploration of an organisational environment of Windhoek and to analysing the problems and demands leading to the potential development of Urban Hazard Information Infrastructure (UHII). The analysis conducted proved the necessity to solve the problems of hazard data management, and the concept of UHII fitted in the interests of stakeholders. There were however many aspect of UHII development, each of them in different priorities of stakeholders, so the final idea of UHII design and development strategies depended very much on the point of view taken. Here the point of view of the City of Windhoek was taken due to the indications made during the stakeholders analysis.

The UHII can be considered by one not the only solution for data management problems in a dynamic but relatively weak organisational environment of Windhoek spatial data producers and users. There might have been a lot of assumptions taken to lead to the UHII model. This research proved useful to look carefully at the organisational structural and social background, through the detailed analysis of demands, interests and capacities of organisations, to define the boundary of the information infrastructure. It is however difficult to assess to what extent the consensus between different stakeholders’s demands could have been or was achieved. The results state that there is an immense potential for UHII development in Windhoek, but to reach the stage of UHII implementation a lot of conflicting or wrongly defined requirements must be analysed and answered in an appropriate way.
6.2.1.2 Identification of bottlenecks in urban hazard data management in different organisational environments of case studies and their implications for decision-support by UHII in the framework of integrated UHM

The second main objective of this research aimed to analysis of the relationship between the bottlenecks in urban hazard management process and its implication for data management problems. This objective was achieved by soft, structured and critical analysis of urban data management problems, described during the user-centred requirements analysis for UHII development. The relation between bottlenecks in data management and hazard management processes were observed both for the case of Windhoek (Namibia) and Enschede (the Netherlands). In the latter case, the preliminary analysis indicated necessity of integrating different urban management processes such as Spatial Planning, Development Control and Hazard Management.

6.2.1.3 Development of a combined soft-structured methodology for analysing demands and requirements for development of UHII in Windhoek, with the reference to the lessons learned from the case studies;

It was observed that the combination of soft and structured system analysis methods gave a very accurate overview of the UHII and UHEMIS requirements. The open discussion during the workshop indicated different requirements of involved institutions for building the common data management infrastructure. Potential leaders of common UHII were identified in the CoW and other institutions. The SWOT analysis indicated potential benefits of the CoW from introduction of UHII via inter-departmental UHEMIS initiative. The substantial effort for pre-formulating data exchange and sharing conditions has already been made by the Geomatics Division of the CoW. This division, together with the Disaster Management Unit (DMU), will be in charge of the implementation of UHEMIS within existing GIS infrastructure. This will be the starting point of UHII development. The Business Intelligence System to be introduced for data management in all departments of the CoW is meant to support technological aspect of UHII introduction by providing the interoperability for 33 divisional and centralised information systems currently (under)used. The feasibility of UHEMIS implementation depends on the availability of technological solutions for integrating different GIS and DBMS softwares and on the social integration of departments within CoW. Similarly the end-users’ willingness to master new spatial data management tools is necessary for UHEMIS development. The success of UHII depends strongly on the legalisation of inter-institutional cooperation. Common data standards and information infrastructure cannot be maintained without the clear definition of organisational mandates. The financial aspects of UHII implementation remain not discussed, since they depend on the final inter-institutional agreements. A choice of the type of UHII DBMS’es has been left open in the long term; the initial solution is to grant the CoW absolute priority over the control on UHII database. The possible implementation of UHEMIS prototype was planned as test of organisational capacity to use and maintain UHII in the future.

6.2.1.4 Guiding through policies and strategies for UHII development.

The strategic analysis based on the outcomes of the SWOT, for multi-institutional environment of UHII introduction in Windhoek, allow for guiding through the UHII development process with regards to the requirements specified by the stakeholders. Still, the application of Critical Systems Approach had an influence on the final shape of the requirements used for UHII modelling. Few corrections made were supposed to link the UHII development initiative with the national level SDI initiative in Namibia, and as well were supposed to stimulate the development of integrated Urban Hazard Management by fostering data exchange between different urban management processes. The crucial points in the strategic approach shell refer to the change of process flows in the CoW and in the related flows of data between stakeholders. As well there exist approach to link the development of national SDI, local SDI and UHII, what is very important for integration of the different framework and base datasets over 3 administrative levels and over horizontal application domains.
6.3. Recommendations

6.3.1 Process of Integrated Urban Hazard Management and its Data Management

The re-engineering of the UHM process has to be performed in order to assure its integration with other urban management processes. Achieving the Integrated Urban Hazard Management in Windhoek should be a process addressing primarily the change of status of disaster management and the change of awareness of its importance in Spatial Planning and Spatial Development Control. The mission of relevant divisions should address integrated UHM and within a vision statement the issue of collaborative efforts in planning and managing urban environment should be mentioned. The execution of integrated UHM should involve common collaboration on change or new ways of shaping the urban structure.

The proper management of data for integrated UHM is a pre-requisite for the process to be executed. The collaboration between different departments and respective divisions must include creation of a common agreement on sharing responsibilities in UHII and UHEMIS implementation and utilisation. The detailed inventory and status of spatial data used in Spatial Planning, Development Control, and the ones necessary for Urban Hazard Management, should be conducted in more detail to be able to create proper data model for UHEMIS.

6.3.2 Implementation of UHII in Windhoek

The financial, technical, educational, political and organisational constraints for expansion of existing information technology and data management solutions should be identified in detail in more extensive research. Without the institutional acceptance of the initiative and an increase in awareness on multi-disciplinary aspects of the urban hazard reduction process, the implementation of the UHII
and the UHEMIS will not be feasible. To make it successful in the long term, the strong framework for building data exchange and quality control process has to be established.

The guidelines for acquisition of existing data to the databases and dissemination of these in the tabular and spatial forms should be made with regards to the changed technological and organisational environment. The data shall be made transparent for the users’ and producers’ environment, it should be easy to discover them and assess their fitness for use. The main role would therefore play the metadata engine of UHII, placed, as the model indicates, in the UHEMIS core. The widely accepted or open standards shall be applied for this data and metadata management.

It is recommended that organisations create collaborative body for UHII implementation, composed of political forces of local government and SG and executive forces of all stakeholders. This body shall be given the results of investigation on the spatial data management problems and their economic and social implications.

Implementation of UHII under the umbrella of national and for stimulation of local SDI creates the change to open spatial data market. It is recommended, especially for the CoW as for a public institution treating spatial data as a public good, to analyse the opportunities and benefits from opening the digital spatial data to the market.

The alternative strategic and policy approaches shall be studied together with the uncertainties of UHII implementation process in order to be able to re-adapt the implementation to changing organisational conditions.

6.3.3 Development, implementation and use of UHEMIS

The preliminary process analysis of The City of Windhoek (together with the results of SWOT) has been used to support identification of best available UHEMIS implementability area, which is the inter-divisional unit including DMU, Geomatics, Sustainable Development and Urban Policy, Fire and Emergency Services Divisions. These will be supported by respective divisions and institutions that provide detailed technical, environmental and population data, necessary for urban hazard assessment.

The role of UHEMIS is foreseen as a Spatial Data Service Centre, having characteristics of a small scale clearinghouse and a centre for creation of a value added datasets on request. This requires specific conditions for UHEMIS utilisation - more of the requirements analysis should be conducted to test what are expected forms of value added datasets to obtain through UHEMIS (e.g. online dynamic mapping or static map products). This is important as well for the management of metadata, since the value added datasets can have specific, user customised structure. The problem of metadata management for dynamic mapping is however an advance stage of potential UHEMIS usage, and it shall not be a technology-push that leads to its implementation, but detailed analysis of what really is required in the hazard data market. In any case UHEMIS in its final form shall have a function of automated metadata capture.

With regards to the GIS based part of UHEMIS, as required by the some of stakeholders - the technical suitability of GIS approach should be tested. Also the standardisation of spatial data models used in GIS environment should be assured, e.g. in order to match the base and framework data models from SG, especially in case of further co-operation in digitization of cadastral data by the CoW for SG. Final UHEMIS therefore provide possibility to assess data quality and integrity of these digitized datasets.

Strategic planning should be applied for UHEMIS as much as it was operated for UHII; the tangible goals and indicators shall be chosen to assess UHEMIS implementation status and success of the project.

The UHEMIS interface shall be a subject of more detailed analysis, to assure user-friendly aproach, and guidance through different UHEMIS functional modules.
6.3.4  Open spatial data market opportunity

The possibility to involve the market-pull approach to UHII development should be tested, with relation to the parallel implementation of UHII and local SDI. The opportunity to foster the spatial data market has been used in the developed countries such as Germany and the Netherlands, and so far it has been successful. The question should be raised on how to learn from their experiences in the countries like Namibia.

6.3.5  Other recommendations

6.3.5.1  Legal aspects of UHII functioning

The implementation of UHII will impose changes in legal and institutional approach to data management, the analysis of this impact is required in order to be able to manage UHII further after implementation. Mutual adaptations of the UHII settings and legal rules are foreseen to appear.
Appendix A

Criteria for the choice of methodologies

The following were considered relevant as the criteria for choosing the methodologies of UHII introduction in Windhoek, based on this list the criteria were grouped and generalised to relate to criteria mentioned implicitly in the literature on information systems development:

1. Characteristics of an institutional background
   - multi-institutional initiative vs. single-institution project
   - system approach to the multi-institutional environment - mutual influences and dependencies in spatial data production and use
   - division of responsibilities in the spatial data production (state, regional and local focus, thematic priorities)
   - dynamics of the development in and among the organisations in question
   - cooperation vs. competition, alliances vs. conflicts
   - common focus areas
   - willingness to create common agreements in the focus areas
   - mutual financial support and its possibilities
   - legal dependance among organisations
   - knowledge exchange traditions

2. Stability/strength of an environment of the target institution (strong vs. weak):
   - Structure of organisation - distribution of responsibilities and tasks inside and between departments, shape of decision making processes, fluency of production of data and policies, hierarchic structure with its control and monitoring procedures, economic status and external/internal dependence of the organisation, functional vs. social structural characteristics, etc.
   - staff turnover cycle (long vs. short)
   - training and promotion opportunities within the organisation
   - knowledge base and experience of the workers
   - level of organisational development
   - awareness of the need for- and possible execution of cohered organisational (business) strategies
• willingness of organisational members to change the old structures and learn from the changes
• willingness to shift to the business orientation to answer the needs of spatial data users (private investors, surveyors, other governmental organisations, citizens)
• bureaucracy vs. transparency of procedures and equal empowerment of organisational units
• competition vs. cooperation approaches among departments
• communication patterns in the organisation (vertical-hierarchic and horizontal-inter-divisional communication channels) and the communication language (is common semantics maintained?)
• financial independence of a target organisation and involvement in projects financed by international organisations
• dependance on outsourced information provision, etc.

3. Ability to express and accept demands for hazard/spatial data exchange and sharing
• awareness of the raising demands for facilitated data exchange among spatial data producers
• awareness of spatial data user demands and potential business benefits (flexibility to achieve customer orientation)
• awareness of intra-organisational benefits from data sharing among the departments
• cultural attitude towards data ownership and willingness to share

4. Awareness of the existing spatial data management issues/problems:
• metadata management
• agreements on standards and their implementation
• technical issues: availability of technical infrastructure, availability of common software platform for assuring data integrity (Database Management System) and interoperability (Data Service/exchange Environment transparent for different data formats)
• legal issues including copyrights, data ownership and responsibility for data quality
• data quality management (reliability, completeness, accuracy, timeliness, etc.)
• creation of multi-institutional policies and agreements on common data management

5. Awareness of the existing problems in executing integrated hazard management
• treating hazard management as a multidisciplinary domain involving different urban management activities
• connecting urban hazard management with spatial planning for hazard mitigation and better preparedness - cooperation between fire brigades and local spatial planning units
• existence of mutually cohered disaster management plans for local and regional administrative levels
• awareness of existing hazards and characteristics of potentially vulnerable communities (location, population numbers, population groups, specific characteristics important for emergency response, etc.)
• problems with developing communication channels (technical and social) within the organisation to shape the emergency preparedness status and to support integration of disaster prevention with other urban management processes (spatial planning, water management, etc.)
• developing legal measures enforcing emergency preparedness in large commercial companies
• the necessity of multi-institutional policies for sharing tasks and responsibilities in different phases of disaster management cycle, etc.

6. character of the problem situation (after (Daellenbach, 2001)):

• clarity of problem definition (clear problem variables, quantifiable?), objectives of decision makers and known alternatives
• possibility of structuring the problem and offering the solution
• knowledge of decision constraints
• availability of data for problem solution
• awareness of the relationships between problem variables
• level of problem dependence on external systems and dependence on human aspects
• relevance of human acceptance of the problem solution and change in the environment enforced by the system implementation
• influence of problems arising between stakeholders on the problem situation and system development process
• empowerment of decision makers to enforce system implementation
Appendix B

SWOT analysis

B.1 External and internal scanning factors analysis

ISFA and ESFA: Both internal and external strategic factors can be placed into categories of opportunities and threats. The Internal Strategic Factor Analysis and the External Strategic Factor Analysis methods follow the same steps. These methods help managers to analyze how well they are responding to specific factors, because the factors are weighted by importance to the firm. The final score can be used to compare one firm to others in the industry. The steps are as follows.

1. List opportunities and threats (5 to 10 each) in column 1.
2. Weight each factor from 1.0 (most important) to 0.0 (least important) in column 2 based on that factor’s probable impact on the company’s strategic position. The total of the weights must sum to 1.00.
3. Rate each factor from 5 (outstanding) to 1 (poor) in column 3 based on the company’s response to that factor.
4. Multiply each factor’s weight times its rating to obtain each factor’s weighted score in Column 4.
5. Use column 5 (comments) for rationale used for each factor.
6. Add the weighted scores to obtain the total weighted score for the company in column 4. This tells how well the company is responding to the strategic factors in its external environments.


B.2 Extensive SWOT for UHII introduction in the CoW
### B.2. Extensive SWOT for UHII introduction in the CoW

<table>
<thead>
<tr>
<th>Strength (int)</th>
<th>Weakness (int)</th>
<th>Opportunity (ext)</th>
<th>Threat (ext)</th>
</tr>
</thead>
<tbody>
<tr>
<td>good information resources, data is always kept somewhere</td>
<td>data is not easily accessible, difficult to trace if it is not in the system, some departments do not have the system introduced to disseminate data yet</td>
<td>UHII gives new input for sustainable planning - risk maps and other information on hazards and vulnerabilities</td>
<td>competitive environment for risk analysis information (insurance companies can assess better for their customers)</td>
</tr>
<tr>
<td>use of data is facilitated by their availability in the municipal info system</td>
<td>still, data is under-utilised or duplicated in parallel Progress systems – e.g. utilities &amp; finance; due to above weakness</td>
<td>new product to sell in the market (risk map)</td>
<td>insurance companies do it in detail for their customers, who are not interested in general risk map</td>
</tr>
<tr>
<td>deep knowledge and awareness of local social and political settings, knowing the ways to compromise co-operation with input calculation</td>
<td>dependence on the approval decisions of Senior Management and City Council, that do not have the knowledge on projects proposed for development</td>
<td>reduction of potential disaster costs and facilitated, more transparent monitoring of development activities (if UHII functions on frequent update basis)</td>
<td>difficulties in creating co-operation base for development of a multi-institutional user setting, without which there are no opportunities for multi-criteria risk assessment</td>
</tr>
<tr>
<td>willingness to co-operate inter-departmentally and with other organisations</td>
<td>lack of staff to take care primarily of the problem of strategic data management, lack of resources for that, though the need has been expressed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>there is a knowledge base in the municipality, a lot of practical experience.</td>
<td>staff shortage, the new staff coming does not have any experience with data management</td>
<td>There is a need for reliable, desired output of e.g. large scale topographic mapping not provided by S.G.</td>
<td>experienced staff emigrates for better money and better living standards</td>
</tr>
<tr>
<td>development of for policies data sharing, exchange and dissemination is being initiated, there is a leader of co-operation and data exchange</td>
<td>no policies of data exchange and dissemination, blocking the information flows</td>
<td>inter-organisational co-operation on SDI development can succeed in shortening the data approval &amp; exchange processes</td>
<td>Survey General (Deeds, Cadastre) does not see the direct benefits from contributing to establishment of SDI, no co-operation leader is there yet, due to the lack of problem awareness and due to the staff shortage (as well municipality of Windhoek is not in the priorities of SG)</td>
</tr>
<tr>
<td>Multi-disciplinary approach and experience of Windhoek DMU, supported by other departments (data contribution, analysis methodologies)</td>
<td>lack of sufficient understanding on multi-disciplinary aspect of DM in other departments</td>
<td>Khomas Region (REMU) has very narrow DM understanding (drought and food support) and lacks basic experience on other DM issues, lacks data either. Existing municipal resources will have to be used for regional purpose sooner or later.</td>
<td>threat that Regional Emergency Management Unit – Khomas reg. will set up incompatible, separate regional system without co-operation, there is no leader of co-operation from their side). It would limit UHII development.</td>
</tr>
</tbody>
</table>
Appendix B. SWOT analysis

<table>
<thead>
<tr>
<th>Strength (int)</th>
<th>Weakness (int)</th>
<th>Opportunity (ext)</th>
<th>Threat (ext)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipality itself is preparing to reorganise the Information Systems structure to answer the needs of different departments (Business Intelligence System analysis and implementation), the detailed User Requirements Analysis will constitute the basis for improved systems.</td>
<td>Municipality on the local level has succeeded to organise some other actions regarding cross-administrative level and thus it might be considered by others as a good leadership organisation</td>
<td>Ministry of Transport is as well interested in traffic risk analysis on the national, regional and local level, it might be a basis for mutual agreement on data exchange and common system development</td>
<td>Ministry of Transport can develop similar, competitive but incompatible risk assessment and management information system and it might not be easy to share the data</td>
</tr>
<tr>
<td>Municipality has a basis (data and technological infrastructure) for further development of IS and SDI, as well as UHII, it will most probably be referred to when REMU and SG try to develop their systems.</td>
<td></td>
<td></td>
<td>Khomas region (REMU), Windhoek Municipality, Survey General and Ministry of Transport do not have common agreements on data exchange and risk assessment procedures. They do not have yet established co-operation for UHII development. Lack of co-operation might lead to scattered information resources, different conclusions in Risk Analysis and may constrain the development of UHII</td>
</tr>
<tr>
<td>there are possibilities of introducing low-cost local, (departmental) GIS solutions only if their outputs can be imported to the central system. It has been accepted that several divisions can co-operate in creating common extended GIS for data management.</td>
<td>each department might want to have different local solutions, as it appears already, some of the departments already have local MSAccess databases from which data is not distributed to the rest of departments</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
B.2. Extensive SWOT for UHII introduction in the CoW
Appendix C

Survey questionnaires
Questionnaire for fire hazard management information needs

The following questionnaire has a shape of **multiple option choice**, each question has a set of answers, from which you should **checkmark one or more** describing situation in your work.

In some sections you will be asked additionally to **type extra information** to give missing option or to specify details (e.g. source/age of used data).

### 1 Respondent Application Background

#### 1.1 What administrative level do you work on?

<table>
<thead>
<tr>
<th>Checkmark option</th>
<th>Local</th>
<th>Regional</th>
<th>National</th>
<th>Cross-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>In NONE specify other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 1.2 What phase do you work in?

| Checkmark option | Assessment & valuation of damage | Re-development of damaged objects / areas | Other (specify) | Other (specify) | Other (specify) |

#### 1.3 What aspects of fire management do you work with?

<table>
<thead>
<tr>
<th>Checkmark all chosen options</th>
<th>See Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision-making</td>
<td>(E.g. Policy making, Issuing development permits, running evacuation)</td>
</tr>
<tr>
<td>Education</td>
<td>(E.g. Training alerts, use of fire and flammables; fire physics)</td>
</tr>
<tr>
<td>Spatial planning</td>
<td>(E.g. Land use planning and control, planning safe urban spaces)</td>
</tr>
<tr>
<td>Development control</td>
<td>(E.g. investment control, registering dangerous objects, issuing usage permits)</td>
</tr>
<tr>
<td>Spatial risk assessment, use of risk models</td>
<td>(E.g. calculating of theoretical fire spread, assessing extent of danger)</td>
</tr>
<tr>
<td>Life / health risk assessment</td>
<td>(E.g. casualties estimation)</td>
</tr>
<tr>
<td>Risk mapping; access mapping</td>
<td>(E.g. Risk area boundaries, zones of fast access from fire brigades etc.)</td>
</tr>
<tr>
<td>Statistical data analysis</td>
<td>(E.g. population data, casualties statistics, fire statistics, time of access to fire etc.)</td>
</tr>
<tr>
<td>Emergency planning</td>
<td>(E.g. preparation of emergency scenarios, plans of access routs)</td>
</tr>
<tr>
<td>Resources planning</td>
<td>(E.g. scenarios of supply for water, extinguishers, crew, equipment)</td>
</tr>
<tr>
<td>Emergency response</td>
<td>(E.g. Rescue actions – fire suppression, fire control, evacuation)</td>
</tr>
<tr>
<td>Rapid modelling of fire spread</td>
<td>(E.g. calculation of gas cloud spread during the emergency using weather data)</td>
</tr>
<tr>
<td>Medical care provision</td>
<td>(E.g. being a part of ambulance crew, other medical crew etc.)</td>
</tr>
<tr>
<td>Loss estimation</td>
<td>(E.g. investigation of damage, loss value assessment)</td>
</tr>
<tr>
<td>Loss compensation</td>
<td>(E.g. insurance compensation)</td>
</tr>
<tr>
<td>Commodities provision</td>
<td>(E.g. provision of food, water, clothing, accommodation etc. for victims of disaster)</td>
</tr>
<tr>
<td>Others [specify]</td>
<td></td>
</tr>
<tr>
<td>Others [specify]</td>
<td></td>
</tr>
<tr>
<td>Others [specify]</td>
<td></td>
</tr>
</tbody>
</table>
## 2.1 Use of spatial & thematic data

<table>
<thead>
<tr>
<th>Checkmark all used data</th>
<th>Who is a provider? (E.g.: Municipality departments, Ministries of, Mapping agency etc.)</th>
<th>Underline used formats (D=digital, A=analogue)</th>
<th>Map Scale</th>
<th>Data Age (yrs)</th>
<th>Quality (Poor - p, sufficient, good - g)</th>
<th>Reliability (Poor - p, sufficient, good - g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Topography maps</td>
<td></td>
<td>D / A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Administrative boundaries</td>
<td></td>
<td>D / A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Cadastral maps</td>
<td></td>
<td>D / A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Population maps</td>
<td></td>
<td>D / A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Occupation / population stats</td>
<td></td>
<td>D / A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Land use plans / zoning plans</td>
<td></td>
<td>D / A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Building use data / maps</td>
<td></td>
<td>D / A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Building structure / construction</td>
<td></td>
<td>D / A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Data on hospital capacity and equipment</td>
<td></td>
<td>D / A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Road network</td>
<td></td>
<td>D / A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Utilities (gas, water, electricity, telecomm.) data / maps</td>
<td></td>
<td>D / A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Water sources (lakes, rivers, pipelines, hydrants)</td>
<td></td>
<td>D / A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Weather data (wind, humidity, rainfall) or maps</td>
<td></td>
<td>D / A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Vegetation data / maps</td>
<td></td>
<td>D / A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Elevation models / terrain height maps</td>
<td></td>
<td>D / A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Aerial photography / Satellite images</td>
<td></td>
<td>D / A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Other data [specify]</td>
<td></td>
<td>D / A</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>□ Other data [specify]</td>
<td></td>
<td>D / A</td>
<td></td>
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</tr>
</tbody>
</table>

Please share your comments and reactions on the above issues:

___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
### 3.1 How do you access/receive different types of data you use?

*Put checkmarks in the table, or specify other way of access / other used data.*

<table>
<thead>
<tr>
<th>You may select many options</th>
<th>Via mail</th>
<th>Direct contacts</th>
<th>Internet / intranet transfer</th>
<th>Other ways (how?)</th>
<th>I don’t know how to access these data</th>
<th>Data is not yet available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topographic, height and administrative maps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land use plans, cadastral information</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Building use &amp; construction data</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilities maps &amp; roads network</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Water and vegetation maps</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Weather data</td>
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<td></td>
<td></td>
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<tr>
<td>Aerial photos and satellite images</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Medical infrastructure, med. statistics data</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Other data you use</td>
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<td>Other data you use</td>
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<tr>
<td>Other data you use</td>
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</tr>
</tbody>
</table>

### 3.2 How would you prefer to access/receive these data?

*Checkmark one option for each type of data.*

<table>
<thead>
<tr>
<th>Through mail</th>
<th>Direct contacts</th>
<th>Internet / intranet transfer</th>
<th>Other ways (how?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topographic, height and administrative maps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land use plans, cadastral information</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building use &amp; construction data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilities maps &amp; roads network</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water and vegetation maps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weather data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aerial photos and satellite images</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical infrastructure, med. statistics data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other data you use</td>
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<tr>
<td>Other data you use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other data you use</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.3 How would you prefer to access/receive the data for:

**Fire risk mapping?**

- By mail
- Direct contact
- Intranet in your work
- Mobile /radio communication
- On CD-rom
- Through internet
- In another way (specify)

**Emergency planning?**

- By mail
- Direct contact
- Intranet in your work
- Mobile /radio communication
- On CD-rom
- Through internet
- In another way (specify)

**Emergency response action?**

- By mail
- Direct contact
- Intranet in your work
- Mobile /radio communication
- On CD-rom
- Through internet
- In another way (specify)
### 3.4 What are the main problems in accessing & exchanging data in your work?

*Give ranking (from 1-“most significant problem” to 5-“it does not affect data access & exchange at all”)*

<table>
<thead>
<tr>
<th>Problem</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>High prices of datasets</td>
<td></td>
</tr>
<tr>
<td>Long processes / bureaucracy</td>
<td></td>
</tr>
<tr>
<td>Lack of technologies</td>
<td></td>
</tr>
<tr>
<td>Lack of data itself</td>
<td></td>
</tr>
<tr>
<td>Lack of standards in data exchange</td>
<td></td>
</tr>
<tr>
<td>Lack of information on existing data</td>
<td></td>
</tr>
<tr>
<td>Poor telecommunication among vendors</td>
<td></td>
</tr>
<tr>
<td>Other (specify)</td>
<td></td>
</tr>
</tbody>
</table>

### 3.5 Where would you primarily look for information on how to access the data you need?

*Give ranking (from 1-“most preferred source of information” to 5-“I don’t use it to search for data”)*

<table>
<thead>
<tr>
<th>Source</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministries, national departments</td>
<td></td>
</tr>
<tr>
<td>Local governments, Municipalities</td>
<td></td>
</tr>
<tr>
<td>National Mapping Agencies</td>
<td></td>
</tr>
<tr>
<td>Cadastre Agencies</td>
<td></td>
</tr>
<tr>
<td>Consulting agencies, prv. companies</td>
<td></td>
</tr>
<tr>
<td>Scientific Institutions</td>
<td></td>
</tr>
<tr>
<td>Insurance companies, banks</td>
<td></td>
</tr>
<tr>
<td>Private contacts</td>
<td></td>
</tr>
<tr>
<td>Data Clearinghouses through internet</td>
<td></td>
</tr>
<tr>
<td>Other (specify)</td>
<td></td>
</tr>
</tbody>
</table>

### 4 Use of communication technologies & information infrastructure

#### 4.1 Which of the following technologies do you use in your work?

- Geographic Information Systems (GIS)
- Other digital mapping systems (E.g. CAD based)
- Decision Support Expert Systems (Guided, automated decision-making)
- Database Managements Systems (E.g. Microsoft Access, Dbse, Informix, Oracle, Sybase etc.)
- Digital Image Analysis (E.g. DTM models creation, georeferencing)
- GPS (Global Positioning Systems)
- Radio communication
- Mobile telecommunication
- Mobile GIS Systems
- Other automated systems for fieldwork support
- Land Surveying (E.g. field measurements and observations)
- Other (specify)
- Other (specify)
### 4.2 Which of the following do you have the access to in your work?

*Question regards potential access, you do not have to use the facilities personally to answer positively*

- Stand-alone Computer
- Local Computer Network *(indicate briefly no. of computers)__________* *(Without Internet connection)*
- Wide Computer Network *(indicate briefly no. of computers)__________* *(Incl. Internet connection)*
- On-line data transfer management facilities *(E.g. ftp servers etc.)*
- Modern internet connection *(up to 56 kb/s transfer capacity)*
- Cable internet connection *(indicate transfer capacity)_____________*
- ISDN connection *(indicate transfer capacity)_____________*
- E-mail facilities
- Portable computers [indicate if include GIS software installed] Y/N _____
- Portable GIS devices *(GIS palmtops, GIS supported notebooks)*
- GPS devices
- Atmospheric conditions measurement tools
- Stationary telephone
- Fax
- Other technologies & devices *(specify)__________________________________________*

You are not sure about the access possibilities to above-mentioned *(to which)__________________________________________*

### 4.3 Do you use the following information infrastructure elements?

- Spatial Data Clearinghouses *(for metadata / data providers tracing / data download) (underline)*
- Thematic Data Clearinghouses *(for metadata / data providers tracing / data download) (underline)*
- Web based interactive data management tools *(E.g. on-line datasets updating or map making)* *(underline)*
- Central Database Management Systems *(E.g. MS Access, Oracle, Sybase, Informix)*
- Distributed Database Management Systems *(E.g. Oracle, MS Server)*
- Other *(specify)__________________________________________________________________________*

### 4.4 How do you share/exchange your information?

*Checkmark all options that you use*

- Through computer network - intranet
- Through computer network - internet
- Through radio-communication network
- Through telephone / fax
- Through personal contacts
- Using hard copies
- Using digital copies
- Using another media *(specify)__________________________________________________________________*
- Using other way of data sharing *(Specify)_________________________________________________________*
4.5 What software platforms do you use in your work?

- DOS
- Unix / LINUX
- Microsoft Windows 3.1 / 95 / 98 / Millennium
- Microsoft Windows NT / 2000 / XP
- Microsoft Office
- Internet Explorer
- Netscape Explorer / Opera
- Other software platforms / GIS softwares (specify)

1.  
2.  
3.  

Please share your comments and reactions on the above issues:

___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________


Questionnaire for fire hazard management process flows

The following questionnaire has a shape of multiple option choice, combined with open questions. Each question has a set of answers, from which you should checkmark one or more describing situation in your work, and an open answer for you to indicate details or specify the missing option.

## 1 Legal Aspects of fire hazard management

### 1.1 What are the policies & legal acts regulating the following:

<table>
<thead>
<tr>
<th>Category</th>
<th>Acts' Names</th>
<th>Issuing Organs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division of responsibilities in fire management process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire prevention and emergency response (guidelines)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institutional co-operation &amp; standardisation in risk &amp; emergency management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharing and exchange of data for fire management (incl. data standardisation policies)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classification of fire risk sources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land use &amp; Building use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building structure &amp; installations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land valuation / mortgage estimation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment of disaster damage &amp; damage compensation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 1.2 Who is primarily responsible for the following in Windhoek area?

#### Urban fire risk assessment

- Municipal Fire Brigades
- Municipal Emerg. Unit
- Regional Fire Brigades
- Provincial Disaster Unit
- National authorities
- Insurance companies
- Other authorities [specify]

#### Emergency actions

- Municipal Fire Brigades
- Municipal Emerg. Unit
- Regional Fire Brigades
- Provincial Disaster Unit
- National authorities
- Insurance companies
- Other authorities [specify]

#### Damage assessment

- Municipal Fire Brigades
- Municipal Emerg. Unit
- Regional Fire Brigades
- Provincial Disaster Unit
- National authorities
- Insurance companies
- Other authorities [specify]
2 Processes in fire hazard management

2.1 Which of the following activities are done for fire management?

Checkmark activities executed in reality

- Control of spatial development applications
  (E.g. check of conformity of investment applications with LU plans, use permits)
- Control of potentially dangerous objects
  (E.g. Inspections on volume and type of stored / produced materials, fines & fees)
- Adjusting spatial planning and economic urban policies according to risk assessment
  (E.g. Land use planning and control, planning safe urban spaces)
- Fire safety education in office spaces / schools / public areas
  (E.g. seasonal fire alert training)
- Subsidising fire management
  (E.g. financing part of equipment by government, purchase of data)
- Seasonal actions for fire safety awareness spreading (involving citizens)
  (E.g. picnics organised by fire brigades, demonstrations of emergency action)
- Distributing brochures on what to do in emergency
  (E.g. in schools, offices, places of mass recreation)
- Reallocation & control of water resources
  (E.g. extra reservoirs in industrial areas, limiting water use in dry periods)
- Preparation of emergency scenarios / manuals
  (E.g. for pre-defined objects or for types of accidents)
- Registering and statistical analysis of fire incidents
  (E.g. collecting statistics on damage caused by fire and on fire accident frequency)
- Preparation of risk maps
  (E.g. identification of potentially dangerous objects, risk zones, vulnerable objects)
- Above-regional co-operation in fire management
  (E.g. Exchange of data & equipment, supply of crew support in case of disaster)
- Standardisation of procedures and data used
  (E.g. Uniform regional emergency scenarios for the same type of accidents)
- Others [specify]
- Others [specify]
- Others [specify]

3 Technology Support for fire hazard management

3.1 Which of the following facilities / equipment for passing information are used during emergency?

Checkmark available / used facilities

- Mobile communication between crew & emergency control centre
  (E.g. passing data on water sources and dangerous objects in vicinity of accident)
- Automated emergency control system
  (E.g. Fire alarm systems alerting automatically Emergency Unit)
- Radio-communication infrastructure for crews and supply units
  (E.g. passing data on water demand and additional crew needs)
- Communication facilities for water tank airplanes
  (E.g. radio communication for passing information on detected fires)
- GPS navigation
  (E.g. for accessing the fire source)
- Web based communication
  (E.g. download of data from web spatial data clearinghouses)
- Others [specify]
- Others [specify]
- Others [specify]
### 3.2 Are digital data / models / GIS / GPS used:

<table>
<thead>
<tr>
<th>Checkmark options using GIS / databases</th>
<th>See Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>In emergency control centre</td>
<td>(E.g. to locate fire accident, identify hydrants and objects in vicinity, plan routes)</td>
</tr>
<tr>
<td>Inside crew cars</td>
<td>(E.g. to plan access routs, model fire spread, to identify objects in vicinity)</td>
</tr>
<tr>
<td>For disaster monitoring during emergency</td>
<td>(E.g. to model fire spread using current weather data)</td>
</tr>
<tr>
<td>In risk modelling for land valuation, insurance</td>
<td>(E.g. to identify zones of high fire / explosion risk)</td>
</tr>
<tr>
<td>In damage assessment</td>
<td>(E.g. to analyse aerial photos for extent of damage)</td>
</tr>
<tr>
<td>Others [specify]</td>
<td></td>
</tr>
<tr>
<td>Others [specify]</td>
<td></td>
</tr>
<tr>
<td>Others [specify]</td>
<td></td>
</tr>
</tbody>
</table>

### 3.3 How do you plan logistics for rescue actions?:

<table>
<thead>
<tr>
<th>Checkmark options using GIS / databases</th>
<th>See Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>In emergency control centre</td>
<td>(E.g. to locate fire accident, identify hydrants and objects in vicinity, plan routes)</td>
</tr>
<tr>
<td>Inside crew cars</td>
<td>(E.g. to plan access routs, model fire spread, to identify objects in vicinity)</td>
</tr>
</tbody>
</table>

### 4 Methodologies in fire hazard management

#### 4.1 Who and when investigates the risk of fire / explosions?

<table>
<thead>
<tr>
<th>Checkmark in the matrix</th>
<th>Before issuing development permits</th>
<th>In case of increased risk</th>
<th>During emergency</th>
<th>Soon after emergency</th>
<th>Late after major accidents</th>
<th>In damage and redevelopment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units of Ministry of Internal Affairs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regional Crisis / Emergency Departments</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Local (Municipal) Emergency Departments</td>
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<td></td>
</tr>
<tr>
<td>Local Fire Brigades</td>
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<td></td>
</tr>
<tr>
<td>Units of Ministry of Health &amp; Social Services</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Units of Ministry of Environment &amp; Tourism</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Development Control Agencies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Municipal Development Control Units</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insurance companies / banks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others [specify]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 4.2 What methods are used for risk assessment?

<table>
<thead>
<tr>
<th>Checkmark used elements</th>
<th>See Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematical models of fire spread</td>
<td>(E.g. Models based on urban texture shape, construction &amp; wind speed input)</td>
</tr>
</tbody>
</table>
### 4.3 What are the criteria used for risk assessment?

<table>
<thead>
<tr>
<th>Checkmark used elements</th>
<th>See Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of fuel / type of object in flames</td>
<td>Type of objects in vicinity</td>
</tr>
<tr>
<td>Volume of fuel / size of object in flames</td>
<td>Number of vulnerable objects in vicinity</td>
</tr>
<tr>
<td>Number of people in vicinity of object</td>
<td>Distance from the water sources</td>
</tr>
<tr>
<td>Number of elderly / disabled people in vicinity</td>
<td>Time of access from fire brigades</td>
</tr>
<tr>
<td>Number of children in vicinity of object</td>
<td>Time of access from health emergency units</td>
</tr>
<tr>
<td>Number of sleeping people in vicinity</td>
<td>The potential financial cost of damage</td>
</tr>
<tr>
<td>Capacity of water reservoirs</td>
<td>Capacity of available health rescue teams</td>
</tr>
<tr>
<td>Capacity of available fire brigade crews</td>
<td>Capacity of health units to treat the casualties (hospitals)</td>
</tr>
<tr>
<td>Availability of emergency equipment (extinguishers, cars)</td>
<td>Availability of medical equipment</td>
</tr>
<tr>
<td>Others [specify]</td>
<td></td>
</tr>
<tr>
<td>Others [specify]</td>
<td></td>
</tr>
<tr>
<td>Others [specify]</td>
<td></td>
</tr>
</tbody>
</table>

### 4.4 What are the criteria used for estimation of loss?

<table>
<thead>
<tr>
<th>Checkmark used elements</th>
<th>See Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of land affected by accident</td>
<td>Estimated time of re-development</td>
</tr>
<tr>
<td>Direct cost of damaged infrastructure</td>
<td>Estimated cost of re-development</td>
</tr>
<tr>
<td>Cost of emergency action</td>
<td>Importance of affected objects (E.g. damage of governmental offices, transport nodes etc.)</td>
</tr>
<tr>
<td>Cost of lost opportunities (E.g. large losses caused by impossibility of operating in affected companies)</td>
<td>Cost of provision of commodities for victims (E.g. provision of shelter, food, clothes, medicines, transport)</td>
</tr>
<tr>
<td>Others [specify]</td>
<td></td>
</tr>
<tr>
<td>Others [specify]</td>
<td></td>
</tr>
<tr>
<td>Others [specify]</td>
<td></td>
</tr>
</tbody>
</table>
# Questionnaire for user-centred requirements of UFEMIS

The following questionnaire has a shape of multiple option choice, each question has a set of answers, from which you should checkmark one or more describing situation in your work. In some sections you will be asked additionally to type extra information to give missing option or to specify details (e.g. proposed UFEMIS functions).

## 1. UFEMIS project evaluation

### 1.1 Do you find UFEMIS project relevant for your work?  
**Yes / No**

*If YES, specify what would you apply UFEMIS for?*

- Education
- Risk identification and analysis
- Spatial data analysis / thematic data analysis
- Others [specify] __________________________________________________________________________________
- Others [specify] __________________________________________________________________________________

*If NO, specify reasons: ________________________________________________________________

### 1.2 How do you assess potential UFEMIS functionalities for support of your work?

<table>
<thead>
<tr>
<th>Checkmark ONE OPTION for each function in the matrix</th>
<th>Relevance of Use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Necessary</td>
</tr>
<tr>
<td>“Data address book” – contact information about UFEMIS input data sources / providers</td>
<td></td>
</tr>
<tr>
<td>Provision of metadata (e.g. on data quality, age, formats and standards)</td>
<td></td>
</tr>
<tr>
<td>Mapping point risk objects</td>
<td></td>
</tr>
<tr>
<td>Mapping point vulnerable objects</td>
<td></td>
</tr>
<tr>
<td>Mapping potential extent of fire effects</td>
<td></td>
</tr>
<tr>
<td>Calculating total risk for the area unit</td>
<td></td>
</tr>
<tr>
<td>Classification of vulnerable objects depending on number of people endangered</td>
<td></td>
</tr>
<tr>
<td>Classification of vulnerable objects depending on value of endangered property</td>
<td></td>
</tr>
<tr>
<td>Search functions for fire accidents register</td>
<td></td>
</tr>
<tr>
<td>Access routes &amp; times (to fire, to hospitals)</td>
<td></td>
</tr>
<tr>
<td>Dynamic calculation of risk in emergency</td>
<td></td>
</tr>
<tr>
<td>Mapping evacuation zones</td>
<td></td>
</tr>
</tbody>
</table>

*Specify other functions you would include in UFEMIS*  

1. _____________________________________________________________________________________
2. _____________________________________________________________________________________
3. _____________________________________________________________________________________

---

[UFEMIS survey C] [Page 1]
1.3 What would you like to have as deliverables of UFEMIS?

Checkmark all chosen options, underline required data formats

<table>
<thead>
<tr>
<th>Option</th>
<th>Format</th>
<th>Data Formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maps indicating risk values for area units</td>
<td>A / D</td>
<td>A / D</td>
</tr>
<tr>
<td>Maps indicating risk sources, vulnerable objects and location of emergency units</td>
<td>A / D</td>
<td>A / D</td>
</tr>
<tr>
<td>Maps indicating areas vulnerable due bad accessibility for fire brigades and ambulance</td>
<td>A / D</td>
<td>A / D</td>
</tr>
<tr>
<td>Maps indicating effect of new development on risk values</td>
<td>A / D</td>
<td>A / D</td>
</tr>
<tr>
<td>Simulation of accident spread (dynamic maps)</td>
<td>A / D</td>
<td>A / D</td>
</tr>
<tr>
<td>Maps of access routing alternatives in emergency</td>
<td>A / D</td>
<td>A / D</td>
</tr>
<tr>
<td>Maps of evacuation zones</td>
<td>A / D</td>
<td>A / D</td>
</tr>
<tr>
<td>Others [specify]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2 Data organization and storage

2.1 How would you like to visualise/browse risk data?

Checkmark all preferred options, and give ranking 1-most preferred, 3-least

<table>
<thead>
<tr>
<th>Option</th>
<th>Rank</th>
<th>Data Formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>By type of fire source</td>
<td></td>
<td></td>
</tr>
<tr>
<td>By type of vulnerable objects affected</td>
<td></td>
<td></td>
</tr>
<tr>
<td>By number of people affected</td>
<td></td>
<td></td>
</tr>
<tr>
<td>By distances/extents of fire/explosion effect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others [specify]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.2 How would you like to access the input data with UFEMIS?

Checkmark all chosen options in matrix

<table>
<thead>
<tr>
<th>Option</th>
<th>Locally from UFEMIS database</th>
<th>Internet download when necessary</th>
<th>Download from other municipal systems</th>
<th>Contact providers via UFEMIS “Address book”</th>
<th>Others (specify)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data on land use, building use and use permits</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building infrastructure and construction data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building ownership and maintenance data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Address / code / location data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of people occupying buildings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data on adjacent groups of risk objects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. UFEMIS User Interface requirements

3.1 How would you like to explore UFEMIS data?

Checkmark all preferred options, and give ranking 1-most preferred, 3-least

<table>
<thead>
<tr>
<th>Rank</th>
<th>1-3</th>
<th>Rank</th>
<th>1-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using text menu-driven interface (guided by menus)</td>
<td>___</td>
<td>Clicking on interactive maps to display more data</td>
<td>___</td>
</tr>
<tr>
<td>Using graphics and icons (guided by pictures)</td>
<td>___</td>
<td>Browsing the database and displaying chosen maps</td>
<td>___</td>
</tr>
<tr>
<td>Using window-based screen display (menus, maps and database attributes in different windows)</td>
<td>___</td>
<td>Using interactive menus and graphics (not window-based) to guide through the data analysis process</td>
<td>___</td>
</tr>
<tr>
<td>Others [specify]</td>
<td>____________</td>
<td>Others [specify]</td>
<td>____________</td>
</tr>
</tbody>
</table>

3.2 What type of screen display would you like to use?

Checkmark all preferred options, and give ranking 1-most preferred, 3-least

<table>
<thead>
<tr>
<th>Rank</th>
<th>1-3</th>
<th>Rank</th>
<th>1-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text menu bars &amp; maps</td>
<td>___</td>
<td>Text menu bars &amp; tables (map display on-click)</td>
<td>___</td>
</tr>
<tr>
<td>Graphic / icon toolbars &amp; maps</td>
<td>___</td>
<td>Graphic / icon toolbars &amp; tables (map display on-click)</td>
<td>___</td>
</tr>
<tr>
<td>Other display [specify]</td>
<td>____________</td>
<td></td>
<td>____________</td>
</tr>
</tbody>
</table>

4. UFEMIS performance requirements

4.1 How often would you use/apply in UFEMIS the following:

Checkmark ONE OPTION in the matrix for each use type

<table>
<thead>
<tr>
<th>Frequency of Use</th>
<th>Every day at work</th>
<th>Few times a week</th>
<th>Once a month</th>
<th>Once in a while</th>
<th>I would not use it with UFEMIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Data address book” – contact information about UFEMIS input data sources / providers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Module for online data download</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metadata base (history and source of data)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maps of point risk sources / vulnerable objects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maps of potential extent of fire effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maps of evacuation zones</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Maps of access routes & times (to fire brigades, to hospitals)
Calculating total risk for the area unit
Analysis of risk maps depending on different factors (# of people endangered, value of loss)
Generating reports on fire accidents
Dynamic calculation of risk values (in emergency, based on additional data)

Relate to “others” from section 1.2
Other 1.
Other 2.
Other 3.

4.2 What would you use UFEMIS as:

Checkmark options

- Data storage
- Maps visualisation
- Generating reports
- Sharing data with other systems

Others [specify]

4.3 How often would you like to update input data for UFEMIS?

Checkmark ONE OPTION in the matrix for data group

Continuously Weekly Monthly Once in a while With other frequency

Data for prevention & risk assessment
Data for fast risk assessment (in emergency)
Module for online data download
Data for damage assessment & valuation
Metadata base (history and source of data)
“Address book” (providers contact information)

5 UFEMIS implementation / application requirements

5.1 What are the limitations for applying UFEMIS in your working environment?

- Lack of sufficient local IT infrastructure (i.e. computers / network in Municipality / Emergency Unit)
- Lack of interest in applying UFEMIS
- Lack of resources to set up communication infrastructure
- Lack of standards /policies for structured risk assessment
- Lack of resources for GIS / data management training
- Lack of standards /guidelines for emergency response
- Lack of cross-sector cooperation to set up common input information base for UFEMIS
- Lack of standards for data exchange and sharing, what limits fluency of up-to-date data provision for UFEMIS
- Others [specify]
- Others [specify]

Please share your comments and reactions on the above issues:

___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
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