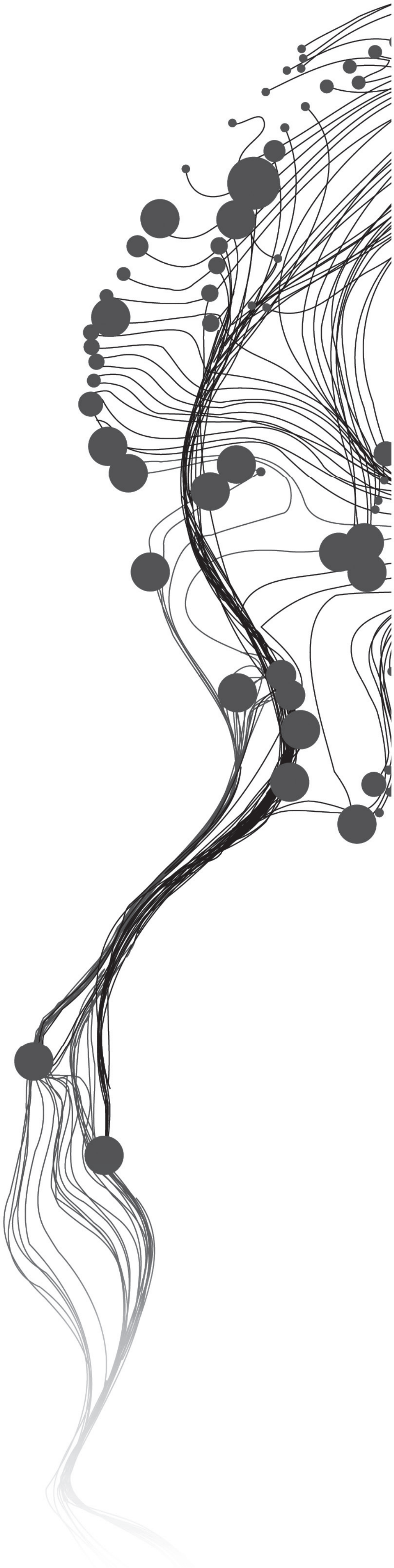
ANALYZING THE USE OF PUBLICLY AVAILABLE DATA FOR MULTI-RISK ASSESSMENT IN KUNDUZ (AFGHANISTAN)

SAMIULLAH SOFIZADA
February, 2013

SUPERVISORS:
Dr. C.J. Cees van Westen
Drs. N.C. Nanette Kingma



ANALYZING THE USE OF PUBLICLY AVAILABLE DATA FOR MULTI-RISK ASSESSMENT IN KUNDUZ (AFGHANISTAN)

SAMIULLAH SOFIZADA
Enschede, The Netherlands, February, 2013

Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation.
Specialization: Applied Earth Sciences
(Natural Hazard & Disaster Risk Management)

SUPERVISORS:
Dr. C.J. Cees van Westen
Drs. N.C. Nanette Kingma

THESIS ASSESSMENT BOARD:
Prof. Dr. V.G. (Victor) Jetten (Chair)
Dr. L.P.H. (Rens) van Beek (External Examiner, Utrecht University)

ABSTRACT

In this research the availability of spatial input data for multi-hazard risk assessment for the war-affected country of Afghanistan, with severe problems related to security, responsibility for spatial data collection and management, and data sharing was analyzed. The aim of this research is to evaluate how in a war-affected country (Afghanistan) with large security problems spatial data is collected, maintained, and shared by national organizations, how international organizations collect and share geospatial data through internet, and how the available data can be utilized for making a provincial scale multi-hazard risk assessment. The research evaluates first which spatial data on Afghanistan is accessible through internet, and a large amount of data was obtained. The next step was to analyze the quality of data, and to evaluate to which extend this data could be used for multi-hazard risk assessment. Several data layers were made new as the quality of the existing data was too low. For instance a settlement map was made by digitizing from a high resolution image. The basic data layers were converted into the same projection and georeference and two sets of data layers were made: one for analyzing the hazards, and the others for the elements-at-risk. For the flood hazard assessment a PC-Raster script was used, and the resulting map was compared with another flood hazard map made through a similar method, which turned out to be better. A landslide susceptibility map was made using spatial multi-criteria evaluation, using criteria for triggering factors, and causal factors. The earthquake hazard map was already available from a study carried out by USGS. The next step in the analysis was the exposure analysis, which was carried out for the 3 types of hazards, and for 3 types of elements-at-risk: people, agricultural lands and roads. The results show that flooding is the most serious problem in Kunduz province as nearly half of the agricultural land and 32 percent of the population.

This study shows that it is possible to make a basic and qualitative multi-hazard risk assessment based on publicly available data. In the near future more of this type of analysis will be carried out in Afghanistan as a basis for risk reduction planning. More efforts are needed to come to a National Spatial Data Infrastructure, as the risk assessment requires a large amount of data, coming from different sources.

Keywords Multi-risk assessment, Vulnerability, Natural hazard, Earthquake, Landslide, Flood

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to the contribution made by various individuals to complete this research. Without their encouragement, help and valuable advice this work would not have been possible. However it is not easy to mention all them and to mention few doesn't mean to disparage the role of others.

My deep appreciation goes to my both supervisor Dr. C.J. Cees van Westen and Ms. Drs. N.C Nanette Kingma for their support, patience and invaluable assistance during proposal writing and during the whole period of my research. They work hard to guide me step by step to placidly teach me the new knowledge, and to make sure that I am still on the right track.

I especially thanks to Dr. Emlyn Hagen, USGS, WHO and all other organization who made a nice collaboration with the datasets and made this research possible. Also I would like to express my gratitude to the Erasmus Mundus Scholarship program for sponsoring me to pursue my education in University of Twente. I am very grateful from my employer Kabul University for providing me a chance to continue my studies and spatial thanks goes to all of my colleagues at Geo Science faculty, department of geography for supporting me during my studies.

I also thank those persons who in their own special way, enriched me offering their friendship, solidarity, knowledge, and never ending support during my study and research period.

Special gratitude goes to my parents, for their support and for being there for me during my difficult time and for encouraging me bring it to successful completion.

Samiullah Sofizada
Enschede, the Netherlands
February 2013

M.Sc thesis

ANALYSING THE USE OF PUBLICALY AVAILABLE DATA FOR MULTI-RISK ASSESSMENT IN KUNDUZ (AFGHANISTAN)

By:

SAMIULLAH SOFIZADA

Has been approved in Faculty of Geo Information Science and Earth Observation (ITC)

On February 2013

By thesis assessment board:

1st Supervisor

Dr. C.J. Cees van Westen

2nd Supervisor

Drs. N.C. Nanette Kingma

Chair

Prof. Dr. V.G. (Victor) Jetten

External Examiner

Dr. L.P.H. (Rens) van Beek

Certified by:

Dean of of Geo Information Science and Earth Observation (ITC)

Prof. Dr. Ir. A. (Tom) Veldkamp

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ANNEXES

ABBREVIATIONS

USGS	United States Geological Survey
NGA	National Geospatial-Intelligence Agency
UNGIWG	United Nations Geospatial Information Working Group
USAID	United States Agency for International Development
AIMS	Afghanistan Information Management Services
UNFPA	United Nations Population Fund
UNAMA	United Nations Assistance Mission in Afghanistan
UNHCR	United Nations High Commissioner for Refugees
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
FAO	Food and Agriculture Organization of the United Nations
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
FEWSN	Famine Early Warning Systems Network
UNHCR	United Nations High Commissioner for Refugees
NATO	North Atlantic Treaty Organization
ISAF	International Security Assistance Force
I-NGO	International Non-Governmental Organization
NGO	Non-Governmental Organization
HKH	Hindu Kush Himalaya
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
GDEM	Global Digital Elevation Model
SMCE	Spatial Multi Criteria Evaluation
GIS	Geographic Information System
WHO	World Health Organization
ADB	Asian Development Bank
CIESIN	Center for International Earth Science Information Network
CAPRA	Central American Probabilistic Risk Assessment
CSO	Central Statistics Organization, Afghanistan
AGHO	Afghan Geodesy and Cartography Head Office
AIMS	Afghanistan Information Management Service
ANDMA	Afghanistan Natural Disaster Management Authority
ASDI	Afghanistan Spatial Data Infrastructure
USSR	Union of Soviet Socialist Republics
DMIS	Disaster Management Information System
OASIS	Operational and Situational Information System
USDMA	United States Defence Mapping Agency
DFO	Dartmouth Flood Observatory
PGA	Peak Ground Acceleration
ASDI	Afghanistan Spatial Data Infrastructure
SDI	Spatial Data Infrastructure
NSDI	National Spatial Data Infrastructure
AGS	Afghanistan Geological Survey

1. INTRODUCTION

1.1. Background

Natural hazards driven by geological and hydrological processes affect many countries in the world because of their geographical setting. In addition to the risk posed by natural hazards, many of the countries in the world are exposed to the risk of war and civil conflict. Due to these aspects the vulnerability of the people in these countries exposed to natural hazards is substantially increased. In countries that are having major security problems because of war or civil conflict there are hardly efforts on disaster risk reduction, and there are many ways in which violent conflicts complicate, confuse, and obstruct the efforts of planners, engineers, and others to assist people in protecting themselves, their livelihoods, and their built environments from natural hazards. Also sometimes natural hazard events make the work of aid organizations even more difficult in the areas which are affected by war or civil conflicts (Wisner, 2009). For example due to civil war or war on drugs more than a million people have been affected and are internally displaced in the country of Colombia. Often the migration of these poor and unemployed people is directed to the dangerous areas where mostly they stay in self built houses in unsuitable locations, such as flood plains or steep ravines, which poses a big problem to emergency management planners. In the past decades even though some important innovations in landslide and earthquake mitigation and preparedness have materialized in Colombia, the total number of people displaced by conflict or violence threatens to overcome the hard work that was put into action (Wisner et al., 2004).

In the past decades the capacity to prevent the damage and losses from different types of natural hazards was often deflected by violent conflict and its result. After the tsunami that seriously affected Sri Lanka and ten other countries, the government of Sri Lanka and the Tamil Tigers couldn't conclude on an agreement for relief and recovery support (Enia, 2012). Therefore, for the benefit of both sides a discussion is needed to strengthen the link among disaster research and peace research, as we can find similar and overlapping histories between the two (Goodhand et al., 2005).

The reasoning first is that countries affected by war or civil conflicts are often more prone to natural disasters, because they do not put enough effort in disaster risk reduction activities, and the society is occupied with more urgent problems related to the conflict. Civil conflicts often cause large changes in the pattern of human occupation, because of refugees, and temporary settlements, which may often be located in dangerous areas. Also the vulnerability of displaced persons is much larger, as the structures in which they live are more vulnerable, and their coping capacity is much more reduced. They are depending on other organizations, such as NGO's. Access to the conflict affected areas is limited and dangerous, and therefore investigations related to hazard and risk related activities are difficult to carry out.

During the last decades the impact of natural disasters has resulted in a high number of lives lost and livelihoods destroyed, especially in countries which have weak governments and are affected by civil conflicts. Some examples are the recent disasters such as the earthquake in Haiti (2010), the drought in the Horn of Africa (2006), landslides in Yemen (2005) and the earthquakes in Pakistan (2005) and Iran (2003) (Hagen and Lu, 2011) which have tested the capacities of national and international agencies to provide quick and useful assistance. All these disasters resulted in major mortality, injuries and disability among the affected population, and in the last decades the fatalities and economic losses due to natural catastrophic events have increased (El Morjani et al., 2007). Although countries hosting refugees are generally spread across the world, countries with a weak economy host a large number of refugees. Many people leave their

country because of civil war, conflict and failed states such as Afghan immigrants in Pakistan, Iraqi immigrants in Syria and Somalian immigrants in Yemen. Almost 50 percent of UNHCR's aid load counts for Afghanistan, Somalia and Iraq, while almost 60 percent of internally displaced people come from countries like the Democratic Republic of Congo, Colombia, Sudan and Somalia (IFRCRC, 2012).
In recent years the huge challenge for the humanitarian actors is the escalating numbers of forced migrants. This enormous humanitarian problem requires preparedness, better instruments for protection, assessing vulnerability and building resilience, better instruments for protection, society commitment and capacity building and advance approaches for delivering assistance. (See figure 1-1)
More than 70 million people are forced migrants: one in every 100 persons of the world's citizens are displaced by civil war, political disruption, conflicts, and disasters, also by the negative impacts of climate change. Unfortunately the number of affected people is increasing each year.
The global problem of refugees and other people who have crossed international borders cost at least US$8 billion per year for the international community. This high figure is mainly the costs of human forced migration – increased vulnerability of women and children, lost homelands, damaged livelihoods, disempowered communities and devastation of shared values of humanity, which all need urgent and important action. Also other important factors like rapid urbanization, population growth, inequality and increasing poverty, global climate change, hazardous contaminated sites, new technological hazards, combine to emphasize vulnerability and increase desire for forced displacement to occur (IFRCRC, 2012).

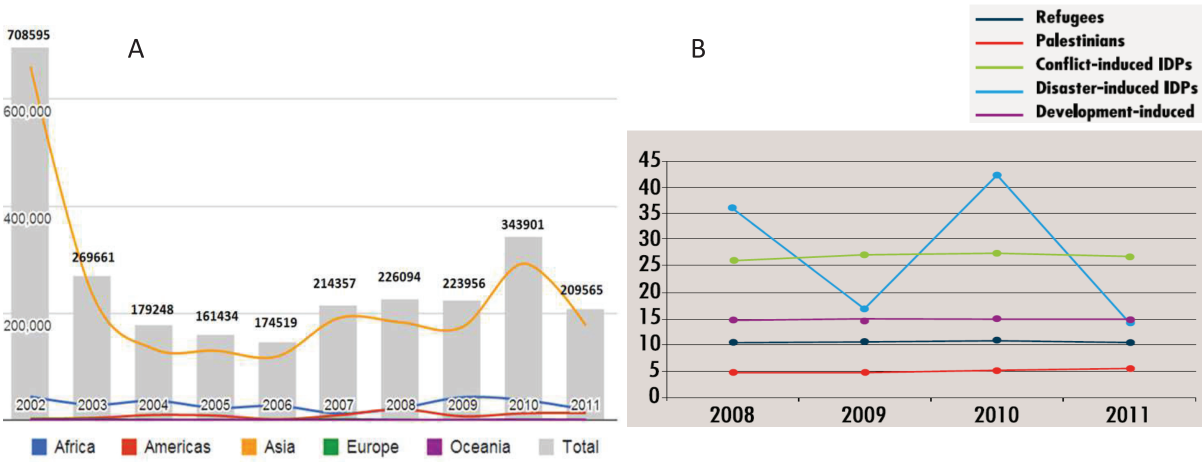


Figure 1.1; A) Total number of affected population by disasters from 2002-2011 B) Population shifts from 2008–2010 in millions of people. Source: World Disasters Report 2012 (www.ifrcmedia.org)

1.2. Problem statement

The area of study in this research is located in Afghanistan, a country with rough terrain and dominated by rugged mountain ranges. More than 3 decades of war in Afghanistan has affected all of the governmental organizations, including the key organizations that are supposed to be involved in collecting the Geospatial data in the country. At present time lack of spatial data is one of the major problems in order to come to hazard and risk assessment. Some of the data that exist in the country is vastly fragmented. At present no base data is available for the country and at the same time most of the data is very sensitive in terms of security issues. Another problem is the very low level of collaboration between the various organizations. In most cases the data cannot be shared by the government or other involved organizations, which make it very hard to access to data. There is no spatial data infrastructure for disaster risk management in place, and the use of spatial data is often restricted to organizations with a military mandate, supported by international organizations (e.g. NATO)

Involvement of other countries involved in spatial data collection and management is playing an important role in the country, but there is no motivation with regard to the sharing of data. (I)-NGOs working in Afghanistan in different sectors need spatial data for different purposes, and the spatial data is shared through internet enabling NGOs to make maps.

So, taking into account the mentioned problems it is important to evaluate how in such a problematic situation in a country with large security problems spatial data has been collected by international organizations, how this is shared through internet, and how this data can be utilized for making a provincial scale multi-hazard risk assessment. In short the main problems regard to (spatial) data in Afghanistan are as follows:

- The government does not put enough effort in disaster risk reduction activities, because the society is occupied with more urgent problems related to the conflict.
- The government organizations that would normally be involved in disaster reduction activities; do not have the resources to do so, because most resources are used in the civil conflict.
- Civil conflicts caused large changes in pattern of population occupation, because of refugees, and temporary settlements, which are often located in dangerous areas, such as floodplains or steep ravines. Also the vulnerability of displaced persons is much larger, as the structures in which they live are more vulnerable, and their coping capacity is much more reduced. They are depending on other organizations, such as NGO's.
- Access to the conflict affected areas is limited and dangerous, and therefore investigations related to hazard and risk related activities are limited.
- Organizations that have the mandate (in peace time) to collect and manage data related to hazards, exposure and vulnerability do not function properly. Because they do not have enough resources in terms of funding and manpower, they do not involve actively in collecting (spatial) data and they do not want to share (spatial) data as they are afraid data might come in the wrong hands.
- The collection and management of (spatial) data related to hazards, exposure and vulnerability is often taken over by others such as International NGO's, UN Organizations or international armed forces involved in the conflict. In this case ISAF and NATO, which are not willing to share the data. They are mainly focused on the safety of their own personnel
- The collection and management of (spatial) data related to hazards, exposure and vulnerability is also taken over by International NGO's or UN Organizations. They often take over parts of the work related to humanitarian activities, including disaster management. They generally focus very much on the disaster response or on disaster response planning, and are less involved in hazard and risk assessment. The data they collect are more general as it is generally collected using archived data or using Remote Sensing with only limited access to field data.
- Sharing the data on hazards, elements-at-risk and vulnerability by these (I)NGO's and International Organizations is mostly done through internet, more or less bypassing the official organizations. The data is either shared through dedicated data warehouses, or web portals of the respective international organizations, which require password access and are not publicly available. However, also a substantial amount of data is freely available on Internet.

According to the location of Afghanistan in the Hindukush Himalaya region (HKH) and it's rugged topography, yearly the country is experiencing different types of natural hazard events, like earthquakes, landslides, floods/flash-floods, snow avalanches, sand storms and drought (Ebi et al., 2007). See the past events show that the damage to human lives, property and environment is dramatically high.

Unfortunately because of population growth, poor governance and planning, and urbanization the vulnerability is increasing day-by-day.
Among the mentioned hazards, earthquakes, floods and drought are causing the most destructive losses to human life and assets. (See figure 1-2). Due to the decades of war, the infrastructure is very fragile and vulnerable to the impact of these hazard events. The financial strength is not enough to recover from the loss each year. So it is important to build up an assessment strategy against Multi- hazards. So for this perspective, the current MSc research is important in order to evaluate and analyze natural disasters risk in Afghanistan.

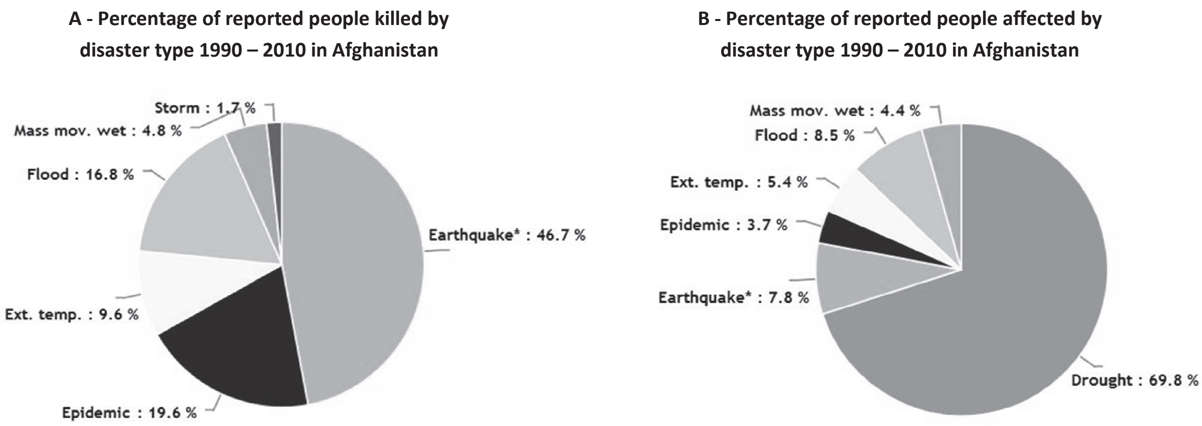


Figure 1.2; Percentage of people killed (A) and affected (B) by disaster type in Afghanistan
Source: "EM-DAT: The OFDA/CRED International Disaster Database

1.3. Aim and Objectives

1.3.1. Aim

The aim of this research is to evaluate how in a war-affected country (Afghanistan) with large security problems spatial data is collected, maintained, and shared by national organizations, how international organizations collect and share geospatial data through internet, and how the available data can be utilized for making a provincial scale multi-hazard risk assessment.

1.3.2. Sub-objectives

1. To evaluate which spatial data on Afghanistan is accessible through internet, to analyze the quality of data, and to which extend this data could be used for multi-hazard risk assessment.
2. To use this data in order to carry out a multi-hazard risk assessment at provincial scale using a (semi) qualitative method.
3. To define the areas with high vulnerabilities in relation to natural hazards like landslide, flood and earthquake and generate a holistic risk map.
4. To formulate requirements on how spatial data should be collected and maintained in order to improve the hazard and risk assessment in Afghanistan.

1.3.3. Research questions

- Which international organizations are involved in collecting and managing spatial data in Afghanistan, and how do they share this data? Is this data available through internet?
- What is the availability of spatial data in Afghanistan?

- How is the accessibility to spatial data on Afghanistan?
- What is the quality of this data?
- What level of details we can acquire from such data?
- How much of these data can be potentially used as input for Multi-risk assessment?
- Which of essential data are missing, and it is possible to use proxies?
- Where are the most vulnerable areas to different natural hazards?
- How to prioritize the study area with respect to the various types of hazards and their expected losses?
- What are the requirements for collecting and maintaining the spatial data in order to improve the hazard risk assessment in Afghanistan?

1.4. Methodology

The research was carried out as a desk study, without the possibility to actually visiting Afghanistan. During this research a multi-risk assessment was done for Kunduz province. The research was divided into four stages:

- The first stage was the establishment of a hazards database. The hazards that are included in the research, as mentioned before, are earthquakes, landslides and floods. The data base is based on published papers, the international agencies that offer free web-based data, and some data was requested from specific agencies that worked in Afghanistan through the war period. The data is integrated into a separate database for each hazard. Then the recorded events were analyzed in order to verify their reliability. For example, in case of earthquakes the aftershocks and the foreshocks were removed from the data in order to keep the main events. Landslides and flash flood areas were mapped from high resolution images.
- The second stage is the collection of the baseline data. Baseline maps include high resolution imagery, DEMs, geology, geomorphology, landuse and precipitation data. The baseline database was established based on the availability of the data from internet. The DEM was established using the ASTER GDEM with a spatial resolution of 30 m. The other maps were digitized from the published work, if they were not available digitally.
- The third stage of the research was the generation of the elements-at-risk maps. This research focused on the vulnerable people and settlements which include the buildings, agricultural land, and the road network that can cause the obstruction in the supply of vital materials like food, fuel and medicine in case of hazards. The settlements map was made by image interpretation from a high resolution images, through screen digitizing.
- The fourth stage was the analysis of the various hazard types and the overlay of the hazards maps with the elements-at-risk maps in order to quantify the exposures. The hazard map for landslides was made using a Spatial Multi Criteria Evaluation (SMCE) approach. The flood hazard map was made using a simple dynamic model in PC RASTER, which was later replaced by a more detailed flood map made with a similar approach in a larger research study. Earthquake hazard data were used from existing sources.
- The fifth stage includes the producing of the vulnerability and risk maps that are produced also using a multi-criteria analysis of the three hazard maps and the elements-at-risk in the ILWIS software. The results are displayed per pixel or by administrative units.
- An overview of methodology is presented in figure 1-3

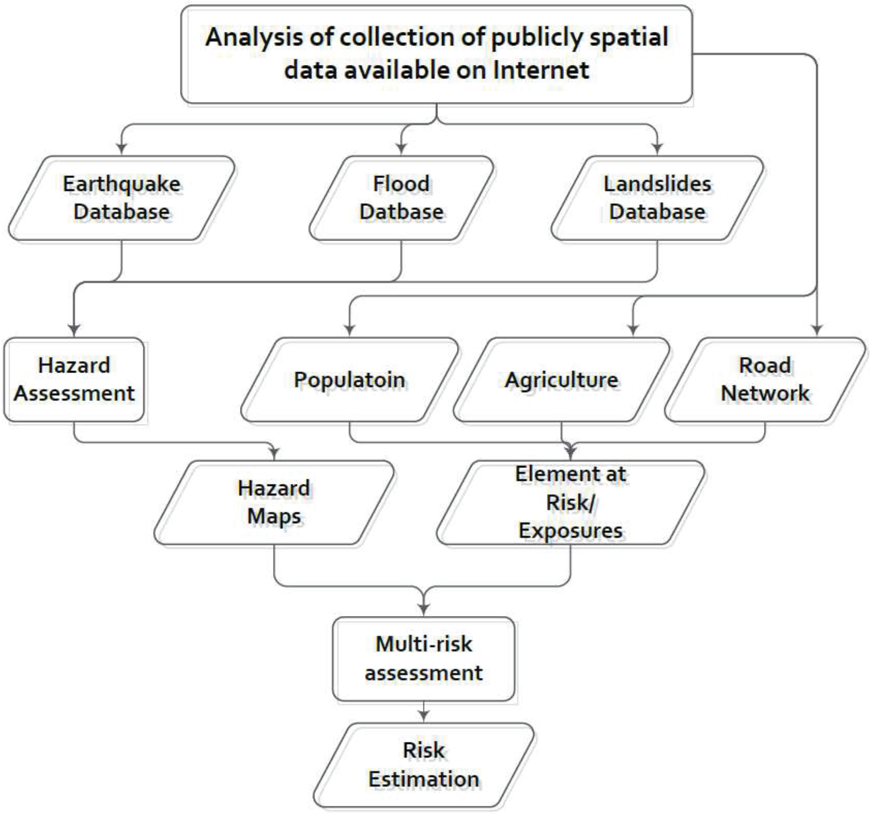


Figure 1.3: Flowchart of the methodology used in this research

1.5. Structure of the thesis

This research is mainly focused on four activities. The first one is collecting spatial data and creating a database for risk assessment in Kunduz province. The second is the hazard analysis for three types of hazards (earthquake, landslide and flood). The third part is the exposure analysis of population, infrastructures, roads and agriculture areas. The fourth part is the vulnerability assessment using Spatial Multi Criteria Evaluation (SMCE) for elements-at-risk which is analyzed from the physical point of view in Kunduz province (see figure 1-4).

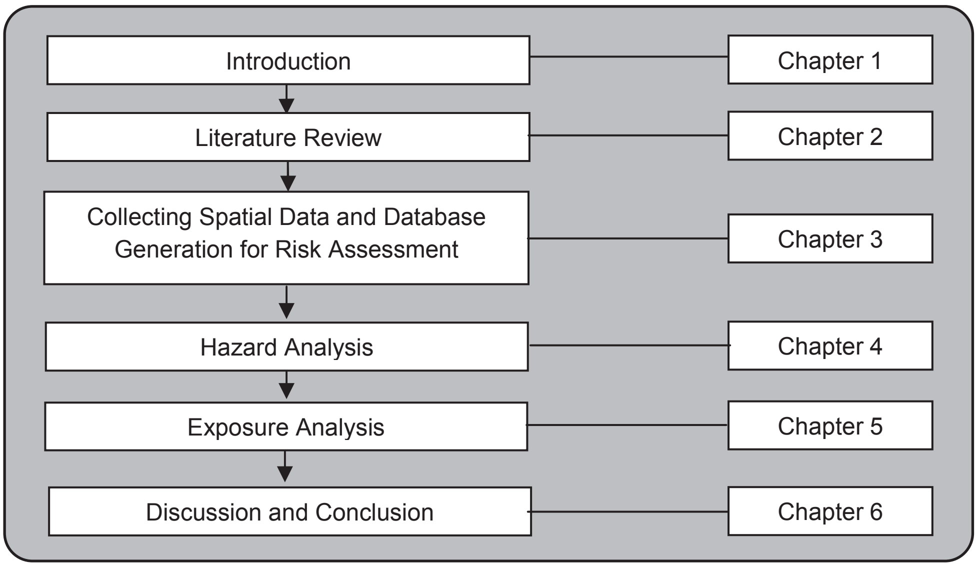


Figure1.4; Thesis structure

2. LITERATURE REVIEW

2.1. Multi-hazard risk assessment

Innovative approaches for risk assessment and risk management are required for the reduction of the effects of different catastrophic events and their direct or indirect impact, , which allow the comparison of risk that accounts for all the possible risk interactions (Marzocchi et al., 2012). Many areas of the world are prone to several natural hazards and useful risk reduction is possible if all relevant threats are considered and analyzed. In contrast to single hazard analysis, the assessment of several hazards poses a range of additional challenges due to the specific characteristics of different hazards. This refers to the assessment of the level of hazard and also to the vulnerability toward distinct processes, and to the arising risk level (Kappes et al., 2012).

Risk assessments for natural hazards have usually been carried out separately for the various pertinent hazards in the considered regions or cities, without attempting to combine these studies into one holistic risk assessment (Grünthal et al., 2006). Multi-risk evaluation is a new field, until now developed only to some extent by professionals with different backgrounds (statistics, engineering, toxicology, seismology etc.). Among the limited works on this field, we quote the UNDRO study (UNDRO, 1977), the KATANOS report (BZ, 1995), Granger (Granger et al., 1999), Van Westen (van Westen et al., 2002), Ferrier and Haque (Ferrier and Haque, 2003), Blong (Blong, 2003), Grunthal (Grünthal et al., 2006), Kappes (Kappes et al., 2010), and Schmidt et al. (Schmidt et al., 2011). However, the specific problem of possible interactions among different threats and/or cascade effects has been approached qualitatively only by Kappes (2010). This is, a synoptical view that enables planners and decision-makers to make adequate decisions on risk reduction and loss prevention programs (Marzocchi et al., 2012).

It is clear that the availability of different hazard and risk related spatial data is a very important requirement in order to make multi-hazard risk assessments. Natural and technological disasters in the past have shown that such incidences significantly affect local and regional development (Greiving et al., 2006). The methodological approaches in risk assessment studies range from very coarse indices to elaborate assessments. An example of a coarse index approach is the methodology of Ferrier and Haque (Ferrier and Haque, 2003). Based on readily available data and expert knowledge about the hazards and their possible effects on the municipality, this method yields a ranking of the different risks in a community and provides guidance to both mitigation and preparedness priorities. Another coarse index was proposed by Munich Re (2003) and also uses available data and expert opinion (Grünthal et al., 2006).

Multi-hazard risk assessment using GIS can be carried out on different geographical scales, and for different purposes. Multi-hazard risk assessment at the national level covers a vast area of information and resources. It is important to carry out Multi-hazard risk assessment on a national scale in order to provide awareness raising about the problems of hazards and risks, to improve national planning, functioning of national disaster risk reduction policies and to allow for the development of disaster preparedness plans and insurance policies. National scale risk assessment forms the basis for disaster risk management policy development, and should be a first step in order to prioritize the areas that are most at risk (van Westen).

Hazard assessments which are carried out for the whole earth at a gobale scale are often focused on global problems like climate change, or are intended to display the distribution of specific hazards ata global scale. Risk assessment at the mentioned scale is proposed mostly to generate risk indices for different countries, for making a prioritizations of support by international organizations, for example WHO, UNDP, FAO, ADB ,Word Bank etc. and link them to indices correlated to socio economic development (Cardona, 2005). The input data have spatial resolutions in the range of 1-5 km, and a scale which is less than 1:10 million. The Columbia University, the Development Economics Research Group (DECRG) and

Hazard management unit of World Bank completed a global scale multi hazard risk analysis, which is mainly concentrated on recognizing key hot spot around the globe that are having the high risk due to natural disasters (Dilley et al., 2005). Series of global risk and hazard maps resulted from the mentioned project that can be downloaded from the CIESIN website (CIESIN, 2005).

For the continents or regions that are including many countries, hazard applications either focus on how to analyze the several triggering mechanisms which is covering large areas of thousands of square kilometres, such as earthquake, drought and tropical cyclones. They are also taking into account the hazards that cross the national boundaries. For example flood hazard in large catchments or policies related to the natural hazards at international level. Using the standardization methodology the hazard maps are generated, and are mainly aimed at post disaster damage assessment and both early warning and at risk assessment (De Roo et al., 2007). The areas are evaluated in different size, also it important to mention that some countries like USA, China or India are larger than a continent like Europe, which counted in one administrative setup. Spatial resolutions may differ from 90 meters to one kilometre which depends on the application, and the scale of the maps is between 1:100,000 and 1:5 million (van Westen).

Hazard and risk assessment carried out at national scale is covering an area from 10 to more than hundred thousand square kilometres, depending on the country size. Hazard assessment applied at national scale is intended for disaster preparedness, insurance, for the purpose of national planning, implementation of risk reduction policies, and early warning systems. Zooming to a larger scale like the provincial level make the applications in planning more concrete. For example hazard and risk assessment become an element of Environmental Impact Assessment for developments of infrastructure and regional development plans. Hazard and risk assessment carried out at municipal level is carried out for the design of risk reduction measures and as a base for landuse zoning. Hazard and risk assessment at a community level, carried out with involvement of local authorities and local communities, is used for the design of concrete risk reduction measures and as a clear means for obtaining commitment for disaster risk reduction programs (van Westen).

Risk assessment and the quantification of risk are core parts of the risk management. However, an integrated multi-risk assessment in still a major challenge and only few studies have addressed multi-risk assessment in some countries (Schmidt et al., 2011). Reducing the potential for large scale loss of lives, numbers of casualties, and extensive displacement of populations that can result from natural disasters is a difficult challenge for the governments, communities and individuals that need to respond. Though it is really hard, if it is impossible, to predict the occurrence of most natural hazards; it is possible to take action before emergency events happen to plan for their occurrence when possible and to mitigate their potential effects. Multi-hazard approaches are not only valuable to get an overview on the overall risk but have also a high significance for planning effective countermeasures (Bell and Glade, 2004). The increased vulnerability of many areas, especially in developing countries is a major reason of concern. Therefore emphasis should be given to the reduction of vulnerability, which requires an analysis of potential losses in order to make recommendations for prevention, preparedness and response (van Westen et al., 2002).

2.2. Disaster Risk Management

The framework for risk management and the various components is given in figure 2-1 based on Van Westen et al (2005, 2008). The risk assessment forms an important component, and consists of the technical part of risk analysis and the decision making part of risk evaluation. For different situations specific risk is calculated related to the return period of the triggering events, hazard intensity, hazard type, and type of elements-at-risk, also integration in regard to risk, hazard and vulnerability can be done in different ways qualitative or quantitative. It is possible to make the risk for the different units such as administrative units like road sections, settlements, census tracts, municipalities, provinces and individual slopes. Methods for qualitative risk assessment are used when the individual risk factors cannot be quantified and are generally derived by incorporating hazard and vulnerability indexes, applying the Spatial Multi Criteria Evaluation.

It is very important to evaluate the risk for various sectors of society, such as education, transportation, agriculture, health, tourism, natural environment, housing and mining, because the hazard will seriously impact on various types of element at risk. Related Stakeholders can be organizations, authorities, businesses and individuals should be engaged in risk management. (van Westen).

Disaster Risk Management in conflict areas is generally very complicated for reasons explained in section 1.2

One of the important issues is related to the scale and the fact that populations are often exposed to conflicts and civil war as well as to natural hazards. Although natural hazards like earthquakes, famine, and epidemics, affect many people, the overprinting effect of other like conflict, civil war, hunger and endemic disease, are making that disaster risk management is basically being reduced to disaster management, which literally means trying to manage the effects of disasters one after the other (Norris, 2003). All complications due to conflict and civil war can widely be seen in different phases of the disaster management cycle. The efforts of prevention, preparedness and integrated mitigation are made difficult by past, present and probable future conflicts. For example early warning may be difficult or impossible in a situation of civil war or conflict (Galtung, 1969). For example, the city of Goma which is located in the eastern part of the Republic of Congo with a population of 500,000 had no public warning for the destructive volcanic eruption in 2002. The city was under the control of rebel soldiers and there was no municipal government. It is known that in the situation of conflict or civil war the capacity of response may also be reduced (Wisner, 2009).

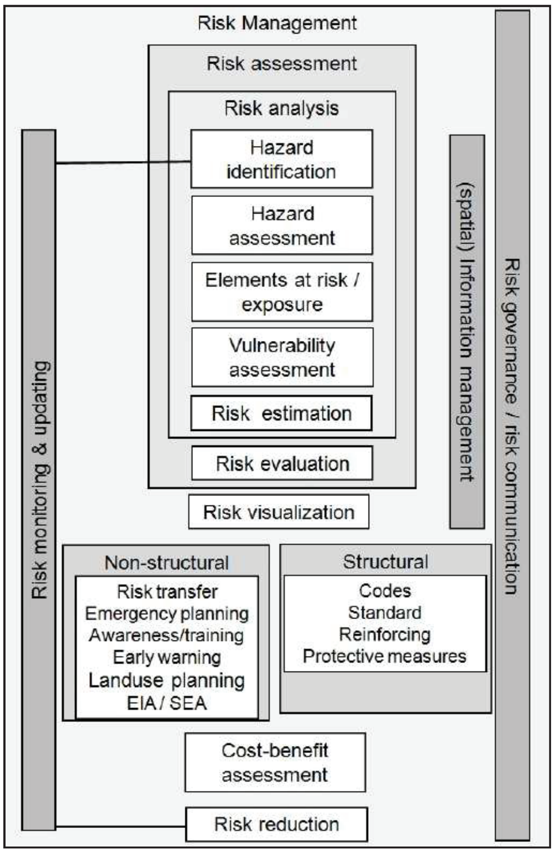


Figure 2.1; Risk management framework (van Westen)

Another example is the case of Central American countries like Guatemala, Panama, El Salvador and Nicaragua that all have societies which went through violent conflicts in the past. For El Salvador, few of the elements of the 1992 peace agreement had been implemented when in 1998 the region was hit by the famous Mitch hurricane, and the extreme level of damage was also contributed to controversial issues regarding reform of police, land occupancy, economic development and social safety (Wisner et al., 2004). The government of El Salvador was not able to make effective use of international assistance for multi hazard mitigation due to institutional weaknesses. For the same condition in Nicaragua half a million of poor rural people went for seeking work across the border to Costa Rica (Canton, 2006). These immigrated people mostly live in places that are directly or indirectly exposed to landslides, flooding and disease(Wisner, 2009).

2.3. Spatial data infrastructure

Hazard and risk assessment needs a large amount of data which is coming from various sources. It is very important to have a strategy mainly on how to prepare and make the data available for risk management.

When referring to the risk management process, there are many actors (stakeholders, users). An actor represents the type of role played by an entity (person/organization) in a specific process. An actor thought of as a role does not necessarily represent a specific physical entity but merely a particular facet that is relevant to the specific process under consideration. These actors could be broadly classified into two types:

- Risk information consumers (RC): refers to governmental and non-governmental institutions (national, regional, local) as well as to communities and individuals, who may require "information on risk" as an input to carry out their specific tasks.
- Risk information providers (RP): governmental and non-governmental institutions (national, regional, local), who are requested to provide the required data inputs to carry through the decision making process concerning risk assessment (the technical aspects); this includes providers of basic data as well as providers of information on risk.

Because the data which is required comes from different organizations it is significant to check and understand the different aspects of data represented in the metadata, and to be able to evaluate the quality of the data. Also specific datasets can be used for different purpose and various projects. The same datasets can be used for risk assessment as well as for resource management. For the exchange of spatial information on risk organizations and a spatial data infrastructure are needed, that allow to share basic GIS data between the end user organizations and different technical organizations involved in risk assessment and hazard studies. A spatial data infrastructure is a basic framework with resources, policies and configurations to make it available for the decision makers while they seriously need it (van Westen). Clearinghouses are websites especially for data exchange. One example of it is the European ORCHESTRA project (ORCHESTRA, 2009)The ORCHESTRA project was an EU FP6 project (http://www.eu-orchestra.org/) with the aim to design and implement the specifications for a service-oriented spatial data infrastructure for improved interoperability among risk management authorities in Europe, which will enable the handling of more effective disaster risk reduction strategies and emergency management operations. The ORCHESTRA Architecture is open and based on standards. They defined three types of users:

- System users such as IT architects, system developers and integrators that conceive and develop risk management applications would be enabled to share and integrate data that can be transformed into relevant information. By facilitating the integration of their current technological solutions this group would be able to provide improved services to their end users.
- Providers of data and application services that are used for risk management will benefit from thematic information services that can be applied in many different risk scenarios. Information services represent a new channel to be exploited by this group. These information services should be more profitable, since they can be directed to more customer segments than mere data services.
- End-users such as members of public, agencies or private companies that use the thematic applications (built according to the ORCHESTRA specifications and using the ORCHESTRA services) benefit from more efficient interoperable services that easily integrate with the current technological reality. To coherently handle both spatial and non-spatial data and to assure the exchange of information among different actors at different levels from local to national is a major efficiency and effectiveness benefit

A more recent example is the GeoNode, which was developed in the CAPRA project framework of World Bank (CAPRA, 2009) as an open source platform for risk assessment that makes it possible to create, distribute and collaborate with geospatial data (GeoNode, 2010). Some example of initiative that mainly focus on spatial data for disaster relief are HEWSweb 2010, Alernet 2010, GDACS 2010 and Reliefweb 2010 (van Westen).

2.4. Spatial data quality

The data which are derived from different sources from the internet, and which are used in a Geographical Information System (GIS) application, might potentially have large differences in quality. In order to be able to use it in the multi-hazard risk assessment, it is highly important to obtain an impression of the data quality, and if possible, measure it quantitatively, as we would like the data to be consistent and credible. Data quality and metadata have a key role in determining if the collected data for the research would be of use (Mhere Bwana, 1998). (See figure 2-2).

Metadata is distinct as "data about data" and also other related definitions (COULONDRE et al., 1998) have been given such as, the data which describes the documenting specific data, data related to the datasets and usage aspects of it, or data or information in regard to the quality, condition, content, and other aspect of data. In the perspective of the mentioned definitions, in the documentation the role of metadata is essential. For choosing the most suitable datasets the mentioned information must give the right and decision element to the user(Klas and Sheth, 1994). It is difficult to evaluate the data content in case of having a large amount of data. Metadata in that case gives explanation elements of necessary information about the dataset (COULONDRE et al., 1998). An example of metadata for the Landcover map of Afghanistan which obtained and later on used in analysis is shown in annex 1. It contains the following types of information: Time_Period_of_Content, Bounding_Coordinates, Keywords, Access_Constraints, Use constraints, Contact information, Data Quality information, spatial data organization information, Spatial reference information, thematic information, metadata reference information. If metadata is available the data quality might be directly assessed. However, much of the data which was obtained from internet unfortunately doesn't contain metadata describing the data quality. Data quality has a number of components that need to be analyzed separately:

- **Completeness:**

Completeness is part of the data quality information which explains the level to which all of the anticipated features, their attribute and their correlation have been encoded into a data set by taking into account the product specification of data set. It indicates whether the data is covering the entire study area or only part of it (Mhere Bwana, 1998). Among the collected data for this research a good example of completeness is the difference between two geological maps of Afghanistan. The first one was the Afghanistan German Geology map which is not covering the entire country; specifically the northern part of Afghanistan that Kunduz province is also located. The second one is the Afghanistan Geology Map by the USGS which is covering the entire country completely with right information.

- **Logical consistency**

This element describes the level to which all the data is brought together in accordance to the structure of the dataset or to understand based on the dataset creation specification the level which the correct encoding of features aspect into dataset. Logical consistency describes the reliability of interaction encoded in the data formation of digital spatial data (Mhere Bwana, 1998).

- **Positional accuracy**

One of the important elements of data quality is positional accuracy which describes the accuracy related to the position of features in accordance to data set specification (Mhere Bwana, 1998). For example the settlements map used in this research contained points that did not correspond to the actual location of the settlements.

- **Lineage**

Describes the data set history as much as known to clearly understand the life cycle of the data set, and covers the information from acquisition and collection through origin to its present form (Mhere Bwana, 1998). Due to many years of war and civil conflict in Afghanistan, most of the data is not updated. For example the Afghanistan administrative division second degree (province level) shapefile which can be download as part of the free data from internet, is not updated and does not have the right information, because after 2004 Afghanistan is having 34 province but the mentioned data is showing 32 provinces. Another example is related to the population statistics for Kunduz province. Several data sources reported quite a difference in the population per district in Kunduz, probably related to different time periods.

- **Thematic accuracy**

This explains the identification of thematic information, attributes and entities according to their specific assigned values, and description of applied tests, or a short assessment of the reliability which is specifically assigned to features in relation to the actual values(Mhere Bwana, 1998). For example the data for precipitation in Afghanistan obtained from the WHO had incomplete attribute information and the actual information shown was misleading.

In order to get the right and accurate result, all the data which were collected for the generation of the database used for the analysis, were also analyzed with respect to their data quality elements. The results are reported in the next chapter.

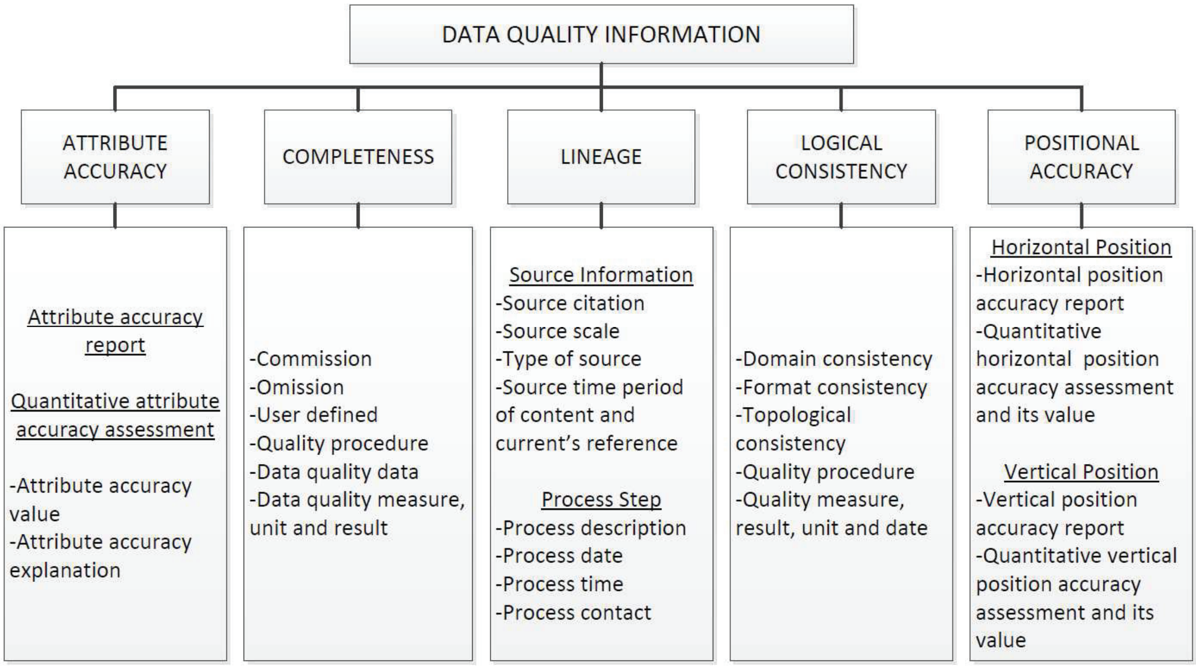


Figure 2.2; show data quality elements and their components.
Source: Mhere Bwana (IFA PM report GIP-ITC 1998)

2.5. Study area

Afghanistan is a landlocked mountainous country located south of Uzbekistan, Tajikistan and Turkmenistan, to the northwest of Pakistan, and east of Iran. The narrow Wakhan corridor extends from north-eastern Afghanistan to meet with China (Crone, 2007). The country is bounded by the geographical coordinates of latitudes 29° N and 39° N, and longitudes 60° E and 75° E, and lies on the border between the Middle East and South West Asia with having plains in the north and southwest (Library of Congress – Federal Research Division, 2008). (See figure 2-3)

The country with a total area of 652,230 square kilometres (251,830 sq mi) is dominated by rough mountain ranges, which run from the northeast to the southwest. The mountains ranges occupy all, except for the north central and south western regions, which are dominated by plains (Ambraseys and Bilham, 2003). Nearly half the country has an elevation of 2,000 meters or more. The country's highest point which belongs to the north-eastern Hindu Kush is the peak of Noshakh, at 7,492 meters (24,580 feet) above sea level. These are high, young mountains characterized by narrow valleys and rugged peaks. The Hindukush Mountains, one of the world's largest mountain ranges, crosses Afghanistan from the Northeast to the Southwest, extending about 1200 km and having a width of 50 to 400 km. The eastern part of this massif system is difficult to access. (Crone, 2007). (See annex-2 for Hypsometry map of Afghanistan)

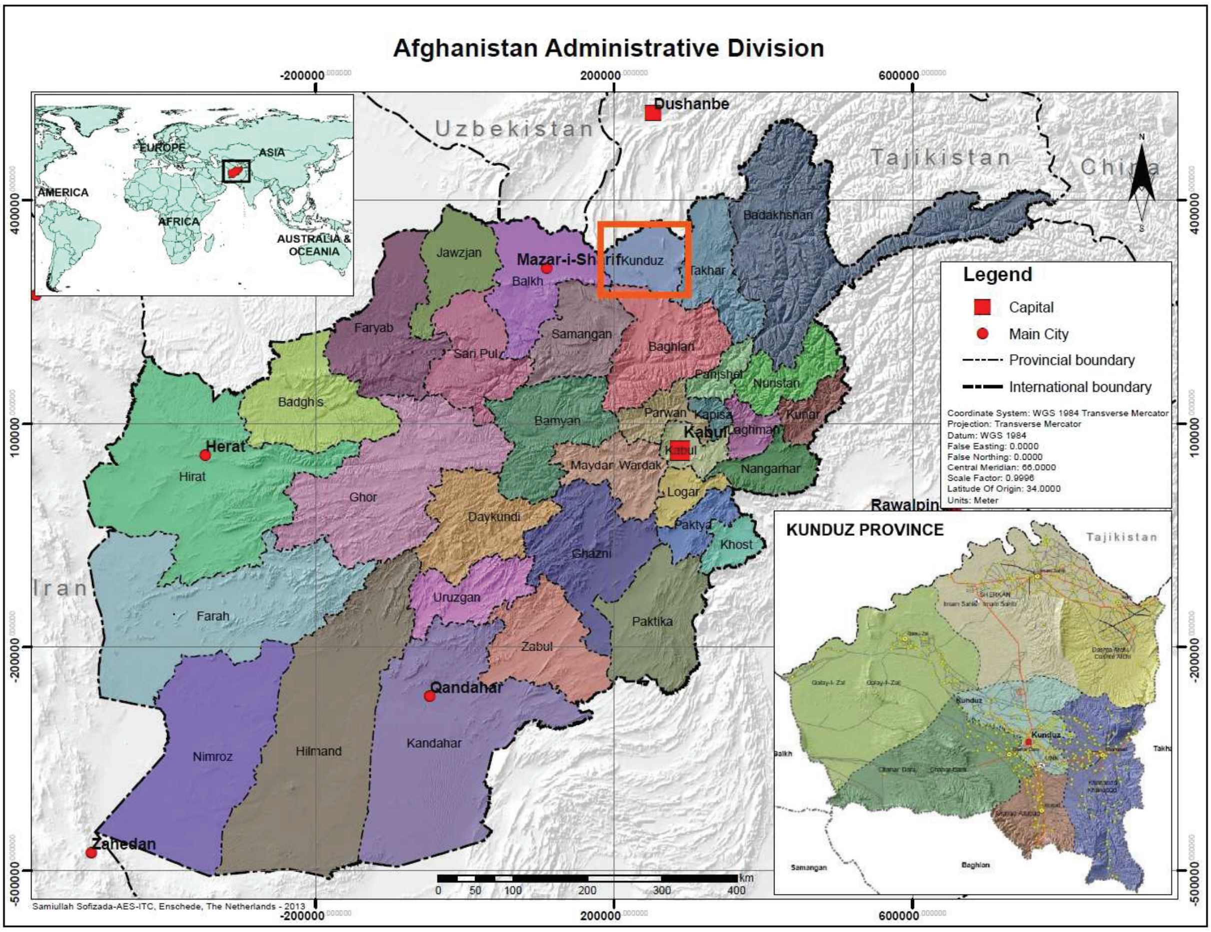


Figure 2.3; Map of Afghanistan

The north-eastern Hindu Kush Mountain range, in Badakhshan Province of Afghanistan, is located in a geologically active area where earthquakes may occur frequently (Ambraseys and Bilham, 2003). They can be deadly and destructive sometimes, causing landslides in some parts or avalanches in winter. A very strong earthquake occurred in 1998, killing about 6,000 people in Badakhshan. This was followed by another Hindu Kush earthquake in 2002, which over 150 people of various regional countries were killed and over 1,000 injured. More recently, a devastating earthquake in the Baghlan Province (March, 2002) claimed over 1200 lives. The earthquake damaged houses and caused landslides which blocked many roads in the epicentral area. Just 150 km northeast of the same region, in Rostaq, a magnitude 5.9 earthquake struck on February, 1998. The consequences of this earthquake were very dramatic with at least 2,323 people were killed, 818 people injured and 8,094 houses were destroyed in the Rostaq area. More than 4000 lives were lost and many homes destroyed in the May 1998 earthquake (Magnitude 6.6) in Badakhshan and Takhar province (Crone, 2007). The earthquake in 2010 left 11 Afghans dead, more than 70 people injured and destroyed 2,000 houses. Another common hazard is flooding which originated from the seasonal rain and mountainous snow melting. The sources of most rivers lie in the mountains and are fed by snow melt and seasonal rain. The flow is thus highest in spring and early summer. During other seasons some of the rivers may become scarce or disappear entirely at river plain. The seasonal character of rivers and streams make the areas through which they flow highly vulnerable to floods, mostly flash floods and landslides (Hagen and Teufert, 2009). In order to analyze these hazards and associated risk in Afghanistan one of the main problems is the lack of necessary data. No research has been done before in regard to the Multi-risk assessment in the country. Only few researches applied some risk assessment for individual hazards like earthquake by USGS (Boyd et al., 2007), but in the most cases chance to access the data is very low.

Disasters cause widespread damage and disruption in Afghanistan with a high frequency of natural calamities such as flood, landslide, earthquakes, avalanches, and sandstorms. Secondary or social impacts of the creeping disaster of drought take a sustained toll in large parts of the country (Dilley, 2005). Extreme winter cold is another phenomenon having a large scale impact due to very low coping capacities. Besides these, disastrous events also result from adverse human actions.

The prolonged war has not only left the nation with direct casualties, but it has also destroyed the coping capacity of the government as well as the communities (Hagen and Teufert, 2009). Wars, conflict and the narcotics trade have been the most researched aspect of Afghanistan in both the contemporary and historical sense. The search for peace in Afghanistan from a buffer state to a failed state (Rubin, 1996) and reform and uprising in Afghanistan, king Amanullah khan 1919-1929 failure to modernize a tribal society(Poullada, 1973) are just two examples that show that conflicts area deeply entwined within Afghanistan history. Some scholars have also highlighted the rich and diverse cultural setting of the nation, and the religious and social development (HAGEN, 2010).

Afghanistan's climate is generally arid to semiarid with hot summers and cold winter, mainly having very harsh winters in the central highlands, the glaciated northeast (around Nuristan) and the Wakhan Corridor, where the average temperature in January is below −15 °C (5 °F), and hot summers in the low-lying areas of the Sistan Basin of the southwest, the Jalalabad basin in the east, and the Turkestan plains along the Amu River in the north, where temperatures average over 35 °C (95 °F) in July.

Despite having several rivers and basins, large parts of the country are dry. The Sistan Basin is one of the driest regions in the world (Vekerdy et al., 2006). Beside the usual rainfalls, the country experience heavy snow during winter in the Pamir and Hindu Kush Mountains, and due to increase in temperature the melting snow in the spring come into streams, the rivers, and lakes. Nevertheless, two thirds of Afghanistan water flows into neighbouring countries, such as Turkmenistan, Iran, and Pakistan.

Afghanistan is recurrently hit by natural disasters causing losses to people, livelihoods and high damage to property. In recent decades, this has led to massive problems of food insecurity and population exodus from the worst hit areas. From 1970 to 1998, 57 large scale disasters has recorded in the country, about 19630 number of persons killed (estimated) and 3361178 persons affected persons (estimated) (Boyd et al., 2007). With more than three decades of civil war and conflict, the vulnerability of the people has been increased (Crone, 2007).

2.5.1. Focus on Kunduz province

Kunduz is one of the provinces in northern Afghanistan, with an area of 8040 km². The total population is about 935600. The province is divided into seven districts. Kunduz city is the centre of the province, which is highly populated and the city is linked by highway to the Tajikistan border in the north, Kabul to the south and Mazari sharif to the west. Kunduz province is dominated by the Kunduz river valley. The flow direction of the river is from south to north part of Kunduz and joins the Amu Darya (Oxus) river. The river also forms the international border between Afghanistan and Tajikistan. The province has borders with Takhar, Balkh, and Baghlan provinces (Wikipedia, 2012). (See figure 2-4).

The canals that are diverted from the river provide the chance of irrigation to the cultivated areas. There is also open rangeland and rain fed fields. Approximately three quarter of the total area is flat land and about 13% of the topography is mountainous terrain (WFP, 2012). (See table 2-1)

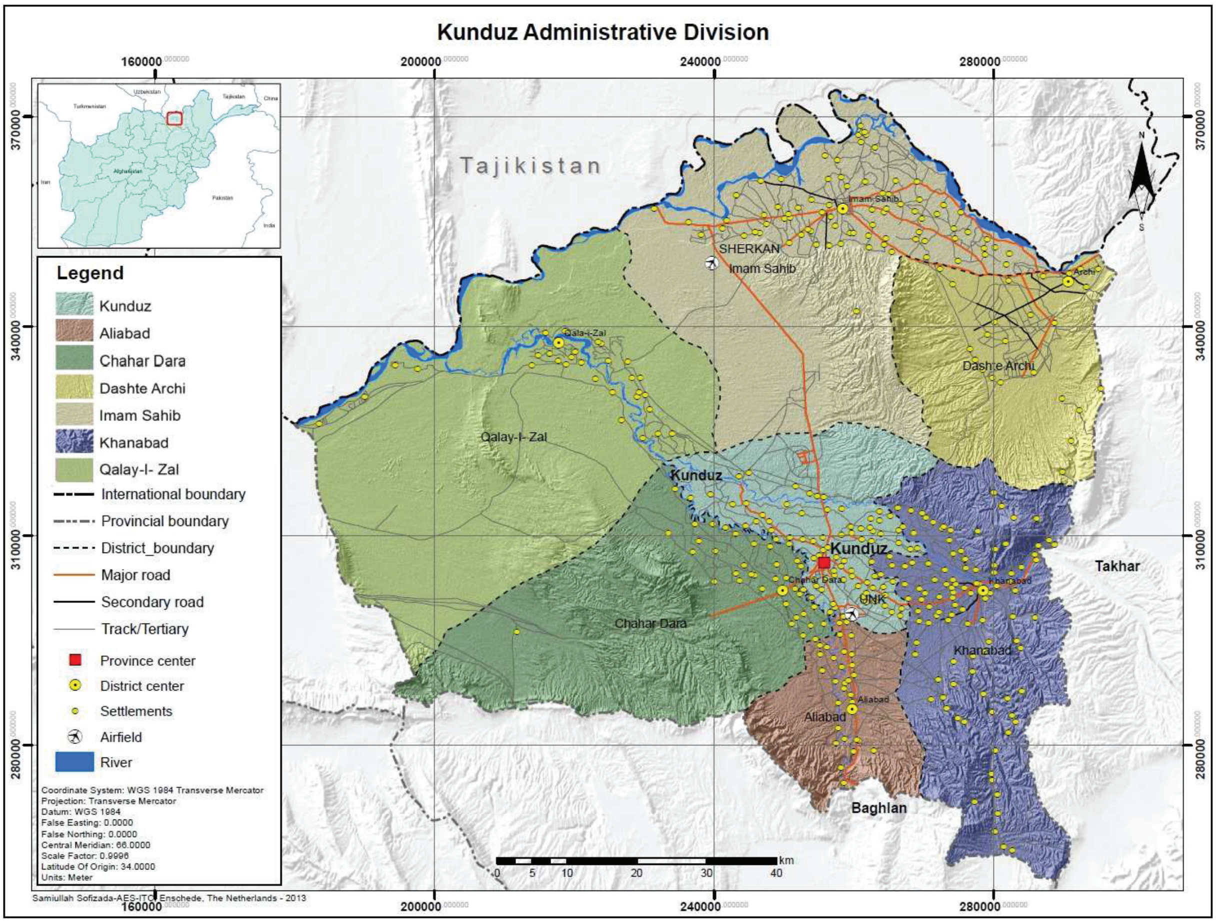


Figure 2.4; Kunduz Administrative division map

Topography type				
Flat	Semi Flat	Semi Mountainous	Mountainous	TOTAL
78.8%	7.8%	8.2%	5.2%	100.0%

Table 2.1; Topography type of Kunduz province
Source: CSO/UNFPA socio economic and Demographic Profile

From the total population of Kunduz, 75.35% lives in the rural area and 24.64% in urban areas. About 50.89% of the population is male and other 49.11% is female. The main ethnic groups living in Kunduz are Pashtun and Tajik, remaining are Turkmen, Uzbek, Hazara and other (WFP, 2012). Kunduz is among the provinces which have part of the population of Kuchi (Nomads). The numbers of Kuchi are diverse in different season of the year, 3.8% of overall Kuchi population or 88208 individuals stay during the winter in Kunduz. Aliabad, Qala-i-Zal, Archi, Chahar Dara and Imam Saheb districts (WFP, 2012). (See Table 2-2 for total population of Kunduz)

District	Nr. Males	Nr. Females	Total population
Ali Abad	22800	22300	45100
Char Darah	35700	34500	70200
Dasht-i-Archi	41100	39800	80900
Imam Saheb	113000	108800	221800
Khan Abad	77700	75800	153500
Provincial center Kunduz	152100	145700	297800
Qalay-i-Zal	33800	32500	66300
Total	476200	459400	935600

Table 2.2; Kunduz province population by district
Source: Central Statistic Office (CSO) of Afghanistan 2012

Kunduz province is located in the lowlands and in the centre of irrigated area in the north of Afghanistan. The soils of the irrigated area of three Qataghan provinces (Kunduz, Baghlan and Takhar) have exceptional fertility, which is one of the main reasons of the dense population before the destruction by Ghengis khan in the year 1220. The mentioned area never recovered completely, and Murad Beg one of the Uzbegs Amir in Kunduz in the 19th century tried to colonize the fertile green plains by depopulating the mountainous of Badakhshan province (Favre and Kamal, 2004)

Later on in the 20th century the Amir Abdur Rahman Khan king of Afghanistan, in order to occupy the fertile plains in north transmigrated the Pashtuns ethnic group from the south of Hindu Kush, the transmigrated people started some irrigation work in the north, later in when the irrigation canals was built in the Khanabad region up to Poli Khumri in 1930. Two major movements of people resulted because of the very low price of land in the region. The first one was from the south part of Hindu Kush, generally Kandahar and Jalalabad provinces and the second one was from the north. The region in the center of Kunduz province is one of the most intensively cultivated, populated and ethnically complex area of Afghanistan (Favre and Kamal, 2004).

The geology of Kunduz province consists of rocks ranging from the Cretaceous to the recent sediments. The pre Quaternary lithologies consist mainly of lagoonal to marine to continental sediments which have evaporates for example Anhydrite and Gypsum. Also in Kunduz province a high percentage of Quaternary units are present such as continental fluvial deposits and alluvial fan. The formation of Pliocene Bukhara hosts the Celestite deposits in the northern part of Afghanistan. Celestite is an important mineral and the principal source of the element strontium, commonly used in fireworks and in various metal alloys.

The north-eastern part of Afghanistan is geologically active and due to that Kunduz province and other neighbouring provinces are experiencing earthquakes. Also the Geomorphological formation of Kunduz province is in such a way that it is affected by different types of natural hazards like, landslide, flood, drought etc.

3. COLLECTING SPATIAL DATA AND DATABASE GENERATION FOR RISK ASSESSMENT

3.1. Organization in Afghanistan responsible for spatial data collection and maintenance

In order to make a multi-hazard risk assessment a large amount of data is required that should come from organizations that have the mandate to collect and maintain this type of data. Data should be of sufficient quality and should meet the quality criteria that were discussed in the previous chapter. In Afghanistan because of the problematic situation, there is no proper structure established for sharing spatial data and there is no effective coordination among the different responsible organizations (CSO and AGCHO, 2007). Geographic Information Systems (GIS) is generally illustrated as a computerized system have been introduced but there are still a limited number of Afghan staff members from these organisations that have the proper training to use them. What is needed is more than GIS alone, as a tool for the analysis, retrieval, access, compilation and display of geographic and its related data, as mechanism should be in place that allow exchanging accurate information on the different components that are managed by different agencies to maintain and support the multi sector decision making for different levels. To support the institutions and government agencies across the country the development of an Afghan Spatial Data Infrastructure is required for sharing and coordination of fundamental geographic information (Eric et al., 2007).

Beside Schroder (1989), Dr. Emlyn Hagen (2010) and work of some national and international organisations like USGS, WHO, and AIMS, very few contributions in books or journals discuss natural hazards in Afghanistan, and in fact it seems that very little attention is paid to the nation's many natural disasters in academic literature. International organizations like the United Nations and non-governmental organizations have collected some spatial data and have written reports on the effect of natural hazards on people.

The lack of essential information and accurate data is problematic for al type of humanitarian operations in Afghanistan. Owning to their ground presence and experience, the government and non-governmental organizations involved in the reconstruction and development of Afghanistan have a sense of the magnitude of the problems facing the nation, even without accurate statistics and background information, yet this lack of information needs to be resolved. For example it is problematic when UNICEF is trying to assess the quality of orphanages but is unable to even locate the orphanages on a map.

From the invasion of the Soviet Union in Afghanistan (1979-1989) and the start of civil war in the country which continued to the government of Mujahedin, Taliban and the occupation by the United States of America in 2001 till now the country is experiencing more than 3 decades of war. All the key governmental organizations responsible for collecting and maintenance of spatial data are affected, and most of them lost their historically collected data. Generally we can say that an enormous damage has been experienced to the main infrastructures of the country, including the spatial data infrastructure. At the present a number of governmental organizations are officially responsible for collecting and maintenance of spatial data (see Table 3-1). However, it is important to mention that among all governmental organizations responsible for spatial data, the most important organizations that need to coordinate and cooperate closely are AGCHO, CSO and ANDMA. The Afghanistan Information Management Services (AIMS) is a non-governmental organization which also plays an important role in the collecting and maintenance of spatial data in Afghanistan (HAGEN, 2010).

In 2007 an initiative was launched funded by USGS and USAID on the establishment of an Afghanistan Spatial Data Infrastructure (ASDI). AGCHO (the national mapping organization) and the CSO (the national statistical organization) initiated the process and requested support from USGS in this respect. A document was made entitled "Workshop Statement and ASDI Road Forward" (Sorensen et al., 2006). The document describes the major components of the ASDI and an implementation plan that outlines a cooperative initiative among all the involved agencies, organizations, and institutions. The development of a National spatial data Infrastructure has been slow over the past 5 years, and most of the work has been done by the United States Geological Survey, who developed a data portal for Afghanistan (CSO and AGCHO, 2007)

	Governmental Organizations Responsible for Collecting Spatial Data	Type of (spatial) data that the organizations is responsible for
1	Afghan Geodesy and Cartography Head Office (AGCHO)	Geo-spatial data
2	Central Statistics Organization (CSO)	Statistical
3	Afghanistan National Disaster Management Authority (ANDMA)	Natural hazard and Disaster
4	Ministry of Transportation	Transportation
5	Ministry of Telecommunications	Telecommunication
6	Civil Aviation Department	Transportation
7	Ministry of Agriculture	Agriculture
8	Ministry of Defence	Military
9	Agrometeorology Department	Agrometeorological
10	Ministry of Mines & Industries	Mines
11	Ministry of Interior	Population
12	Ministry of Rural Development and Rehabilitation	Rural
13	Ministry of Water & Energy	Hydrometeorology
14	Ministry of Information & Youths	Public
15	Ministry of Higher Education	Education
16	Ministry of House Construction and Irrigation	Buildings, Agriculture
17	Directorate of Municipality	Urban
18	Public Utilities & City Development	Urban
19	Ministry of Economy	Statistic
20	Department of Geology and Mines	Geology
21	Ministry of Justice	Criminal events
22	Ministry of Public Works	Infrastructure
23	Ministry of Health	Public
24	International Chamber of Commerce of Afghanistan	Export, import

Table 3.1; Governmental Organizations Responsible for Collecting Spatial Data in Afghanistan
Source: Afghanistan Spatial Data Infrastructure document (2007)

3.1.1. Role of main government organizations

In Afghanistan the governmental organization mentioned in table 3-1 officially have a significant role in colleting and maintaining spatial data. The first reason is that it is their legal responsibility and duty, the second reasons is related to the government policies which are implemented since the private sectors and non-governmental organizations have a weak role and all management of the information should be prioritize to governmental agencies. Due to limitations in collecting, maintaining and sharing spatial data there is still there is a large problem in accessing the necessary and accurate information. The most important governmental organizations responsible for collecting, maintenance and management of spatial data are AGCHO, CSO and ANDMA. The Afghanistan Information Management Services (AIMS) is a non-governmental organization which also plays a key role in the collecting and maintenance of spatial data in Afghanistan.

- The Afghan Geodesy and Cartography Head Office (AGCHO) is the main agency in the government of Afghanistan which is responsible for all official surveying, mapping and related activities. AGCHO is more focusing on the publication, distribution, and production of political, thematic, topographical, and cadastral, physical and natural resources maps; the national atlas and geodetic affairs, also having the responsibility of directly reporting to the president. AGCHO completed around 30% of the cadastral survey and 26% of the geodetic triangulation of the entire country before the invasion by USSR in 1979. Printing equipment and mapping tools was installed from Netherland, Germany and Switzerland during the mentioned period. After 2001 some efforts were made to modernize the agency with new and update technology. AGCHO has an important role in supply the government ministries and international organizations which in involve in Afghanistan with its services. All of the maps prepared and printed by different organizations inside the country must be legally approved by AGCHO(TCP, 2012). The organization has a basic website and no internet –based GIS products.
- The Afghanistan Information Management Service (AIMS) is a nongovernmental organization established in 1997 first in Peshawar, Pakistan under the United Nations Office for the Coordination of Humanitarian Human Affairs (UNOCHA). To fill the existing gap in case of the information management need of Afghanistan. Later on it became a project of the United Nations Development Program (UNDP) and was relocated to Kabul. AIMS has served as a provider of necessary information management in Afghanistan for the different organizations of Afghanistan government and international donor community and other nongovernmental organizations. The AIMS organization has a basic website and no internet-GIS applications that can be accessed from outside. They claim on their website that they developed a Disaster Management Information System (DMIS) for ANDMA (See below). However, there is no such web-portal available at this moment. According to UNDP a disaster management information system (DMIS) was established and the ANDMA officials and officials from other relevant government organs were trained in two provinces as a pilot project (Kabul and Kunduz).
- Central Statistics Organization (CSO) is an independent administration of Afghanistan government, main purpose is of creating such a body was for the creating a scientific system for statistics, bringing to gather the needed information and the coordination of statistical research and activities in the country. Due to conflict and war in the country CSO seriously affected like other organizations lost it capacity mainly in term of infrastructure and human resources which result a huge data gap for the nation.
- The Afghanistan National Disaster Management Authority (ANDMA) which has the responsibility of management and coordination of all aspect of disasters in case of emergency response has a key role in collecting spatial data in the country, especially the hazard data and related information. However, ANDMA has only a limited budget, and capacity. They indicate also on their website in a banner "Lack of budget is a challenge for ANDMA". With the support of UNDP a Disaster Management Information System was developed and operationalized in two regions (Kunduz and Nangarhar). UNDP also supported computer instructors to build the capacity of ANDMA regional staff in Kunduz and Nangarhar to use computer and keep the DMIS up to date.

The work of the Governmental organization responsible for collecting spatial data is limited due several problems inside the government, such as there is not enough funding that they can do their job in order to run national wide project to reach to the intended goals and objectives, also they cannot purchase the needed up to date software's, tools a and necessary equipments. For most of the organization involved in

collecting spatial data, security problem is one of biggest challenge they face. Most of the very important projects in the country cannot be applied. For example field visits are needed for collecting spatial data but due to security problem the in charge team cannot visit the field.
Skilled staff and trained personals are also very important for collecting the spatial data. In a war affected country like Afghanistan, who last most of its human resources and infrastructure, the lack of experts, skilled and trained staff in the especially in mentioned field is a serious problem and challenge ahead. Most of the developing countries are having the problem of corruption; in this case unfortunately Afghanistan is one of the most corrupted countries in the world. This severe problem is directly affecting all the activities of the government and its related organizations.

3.2. Data sharing within Afghanistan

In general data sharing within Afghanistan is at a very low level. Data sharing also depends on the type of data, and for some types there are better options than for others. There are many reasons such as, most of the organization according to their policy avoid sharing the data. Most of the important data with high accuracy are not accessible or freely available.
Officially data sharing among government organizations is not problematic, inside the government there is a very close collaboration between the organizations. It works by sending an official letter to the other organization and asking the necessary information. At present the involvement of international organization in large scale in Afghanistan has resulted in a very close collaboration in sharing the spatial data between the government organizations and international organization, the reason is that most of these organizations have joint projects with each other, based on international funding. Most of these projects deal with capacity building, reinforcement of the infrastructures and institutions, or deal with humanitarian aids and are related to the United Nations organisations, such as UNDP, UNOCHA etc.
The most problematic part of the sharing of spatial data is between the national organizations and other organizations, such as universities, NGOs, nongovernmental research institutes and organizations. In general there is no interest for sharing spatial data and the collaboration for sharing the spatial data is very low. While contacting these organizations for sharing the data it is very rare to get a response, let alone a positive one. The typical reaction is that the data are confidential, also due to large security problems in the country, and they feel very hesitant as it may be used against them in future. Some of the organizations that deals with spatial data, only sell some of their collected data, for instance through AIMS.
Generally sharing the spatial data by government is in three ways. The first one is the primary information for which registration is compulsory for access to it, downloading from their website or receiving as a hard copy. The second one is the technical data and must be requested officially from the related organization by an official letter of the requesting university, research institute, NGO and etc. The available technical data in case of sharing by government is free for universities, and schools, but other organizations have to pay a certain amount for it, for instance when getting data from AIMS and CSO. The third kind of data is only available for the top government officials.

3.3. International organizations collecting spatial data in Afghanistan

Due to the problems described above in collecting and sharing spatial data by the official government organizations in Afghanistan, international organizations are having an important role in collecting spatial data in Afghanistan. Especially after the year 2001 till now because of the increased involvement of international organizations in the humanitarian and military activities in the country, the process of collecting spatial data by the international organization has completely changed with compare to the years before. At present besides the Afghan government and international organizations like UNDP, security forces (ISAF and NATO) are having a major role in collecting, maintaining, and using spatial data in the country for military purposes. Needless to say that these data are all confidential.

The United States Geological Survey (USGS) has been very active in Afghanistan in the past decade, through many projects. Due to the Open data Policy of the US Government, they also have a good collection of spatial data on their specific website for Afghanistan (http://afghanistan.cr.usgs.gov/), and most of the data for this research was obtained from their websites. The World Health Organisation (WHO) has also a good collection of data for Afghanistan which is also used in this research. These two mentioned organizations are the most relevant in relation to studies on the different type of natural hazards in Afghanistan.

After the occupation of Afghanistan by the United Stated of America a large number of international number of organizations play an important role in collecting spatial data in the country. For instance iMMAP (iMMAP.org) has been a pioneering humanitarian organization in the effective use of information management practices and principles disaster risk management, providing geoinformation support for relief and development projects. They applied their Operational and Situational Information System (OASIS) system also in Afghanistan. In short these international organizations are divided into two groups. Firs group belongs to the security forces (ISAF and NATO) and that is why half of the international organizations are related to the United States and European Union. They collect the spatial data for their specific aims and purposes; the reason is there military involvement and they need the spatial data seriously. Second groups of organizations belongs to the United Nations, their involvement in Afghanistan is for humanitarian aid and cooperation. (See table 3.2)

	International Organizations Collecting Spatial Data in Afghanistan	Web-links
1	United States Geological Survey (USGS)	http://afghanistan.cr.usgs.gov/
2	National Geospatial-Intelligence Agency (NGA)	https://www1.nga.mil/ProductsServices/Pages/PublicProducts.aspx
3	United Nations Geospatial Information Working Group (UNGIWG)	http://www.ungiwg.org/
4	European Union	http://ec.europa.eu/europeaid/index_en.htm
5	United States Agency for International Development (USAID)	http://afghanistan.usaid.gov/en/home
6	Afghanistan Information Management Services (AIMS)	http://www.aims.org.af/
7	CARE International	http://afghanistan.usaid.gov/en/home
8	United Nations Population Fund (UNFPA)	http://afghanistan.unfpa.org/
9	United Nations Assistance Mission in Afghanistan (UNAMA)	http://unama.unmissions.org/default.aspx?/
10	United Nations High Commissioner for Refugees (UNHCR)	http://www.unhcr.org/pages/49e486eb6.html
11	United Nations Development Programme (UNDP)	http://www.undp.org.af
12	World Food Program	http://www.foodsecurityatlas.org/afg/country
13	United Nations Children's Fund (UNICEF)	http://www.unicef.org/infobycountry/afghanistan.html
14	Food and Agriculture Organization of the United Nations (FAO)	http://data.fao.org/map
15	UN OCHA	http://www.unocha.org/where-we-work/afghanistan
16	Humanitarian Response	http://afg.humanitarianresponse.info/mapcentre
17	Civil-Military fusion Centre	https://www.cimicweb.org/cmo/afg/pages/afghanistan_maps.aspx
18	FEWS NET	http://www.fews.net/Pages/country.aspx?gb=af&l=en
19	iMMAP	http://immap.org/index.php?do=maps&cat=10

Table 3.2; International Organizations Collecting Spatial Data in Afghanistan
Partly based on: Afghanistan Spatial Data Infrastructure document (2007)

3.4. Base data collection

In order to assess the hazards and their risk in Kunduz province, many types of data are required. Therefore, an extensive internet search was made and a large amount of spatial data was collected.

The research was carried out as a desk study, without the possibility to actually visiting Afghanistan and all spatial data were therefore collected from the internet, through web portals of national and international organization involved in civilian or military activities in Afghanistan. From the literature review the main organizations were identified that work on the collecting spatial data or natural hazards and risk analysis. The second step was downloading all the possibly relevant spatial data from web base portals, websites of different organizations such as USGS, iMMAP, WHO, CSO and etc.

The third step was to contact the specific organizations and ask for collaboration in sharing the possible spatial data that couldn't be found through the internet. Contacts were also made with individual researchers, who did research on Afghanistan, such as Dr. Emlyn Hagen who did his PhD on Flood Hazard mapping for Afghanistan. Here mainly the contact has been made with USGS, WHO, CSO AIMS, iMMAP, Dartmouth Flood Observatory, AGCHO, and Dr. Emlyn Hagen.

It took quite a long time to get their response. But fortunately from a number of them positive responses were received for collaboration, e.g. from USGS, WHO and Dr. Emlyn Hagen. The other organizations did not response at all. Almost 95% of the collected spatial data in this research come from these three sources, Table 3-3 gives an overview of the collected data. A complete list of all collected data with their source is provided in annex 3. In chapter 6 the data will be reviewed with respect to the quality of the data. In the following sections some of the major types of data will be discussed in more detail. Some of the maps produced in this research as base data for hazard shown in figure3.1

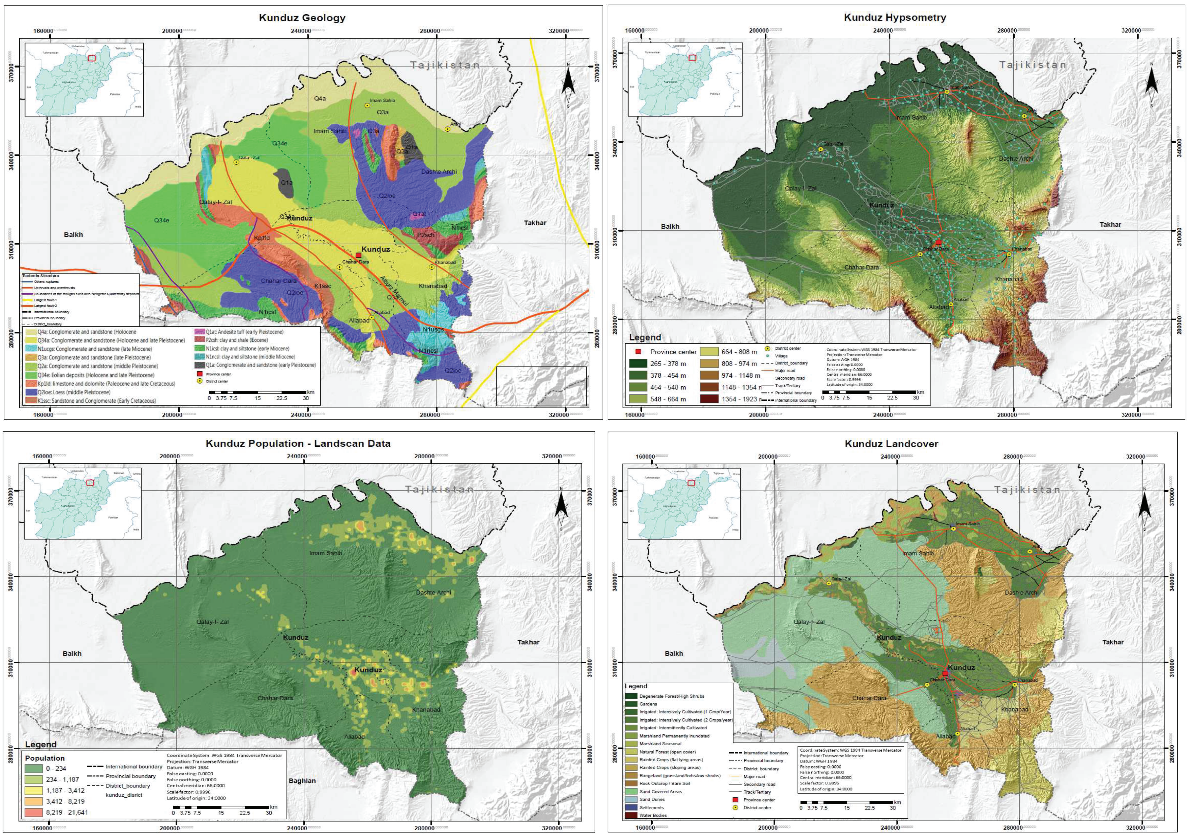


Figure 3.1; Examples of some of the maps produced in this research as based data for the hazard, and exposure analysis. Upper left: geological map, Upper right: elevation map, Lower left: population distribution, Lower Right: land cover map. Larger version of these maps can be found in the annexes.

3.4.1. Digital Elevation Model (DEM)

The DEM which is used in this research is the ASTER (GDEM) that was downloaded from the ASTER (GDEM) website. The resolution of ASTER GDEM is 30 meter, and the relative accuracy is 20 meters (Smith and Pain, 2009). The hypsometry map of Kunduz province is generated using the ASTER GDEM can be seen in annex4. Also all the other topographic layers such as slope, aspect, and curvature were all created by suing ASTER GDEM. The DEM was also an essential input data in the flood hazard assessment, which is described in the next section. See annex 5.

3.4.2. Geology

While collecting the spatial data three different geological maps were obtained for Afghanistan. The first one is a Russian geological map which was completed during soviet time in Afghanistan. The second one is a German geological map and the last one is a geological map prepared by USGS. The three maps were completed different in terms of the mapping units outlined in Kunduz, and their descriptions, as well as in the level of detail. Without having other field knowledge it was difficult to decide which of the three maps was the best.

The German geological map was not only covering the northern part of Afghanistan in which Kunduz province is located. The Russian geological map is covering the entire country but, the map is not complete in term of its contents. It is also rather old. The geological map prepared by USGS is the latest geological map of the country and used in this research. The first two maps were provided as vector file and scanned mosaic images. But the geological prepared by USGS was only available as a pdf file. In order to digitize it, we convert it to image, which was clipped to the Kunduz province and after georeferencing the geological units were digitized using the ILWIS Academic software. The final geological map of Kunduz province is provided in annex 6.

3.4.3. Land Cover

The National land cover map of Afghanistan was prepared by the Afghanistan Information Management Service (AIMS), using satellite image classification. The maps contains details on forest, rain fed crop, marshlands, cultivated, gardens, trees, bare soil /outcrop, sand, and dunes. The National land cover was mapped at a scale of 1:250000, with satellite data from 1992 and the source of the information on land cover types are from FAO. We can conclude that the maps are not up to date. However, when the map was compared with the recent high resolution image, the variation for most of the land cover types, except for the built-up areas, was relatively low. The build-up areas were digitized separately, in the map related to the settlements, and these were later added to the land cover map. Land cover map prepared for Kunduz province is shown in annex 7.

A second landcover map was obtained from WHO. The layer was made from the ESA 2004 – 2006 Globe cover database. The spatial resolution of the data however was 300m and derived from ENVISAT' medium resolution. Due to this very coarse resolution in comparison with the other map, it was not possible to make a change analysis, and this map was eventually not used in the further analysis.

3.4.4. Precipitation

The country has a big gap in the collection of hydro-meteorological data due to the problem of war and conflict for many decades. Meteorological station data for Kunduz could not be found on the internet, except for one station at Kunduz airport, which has data that goes back to 1973 (http://weatherspark.com/history/32753/2012/Kunduz-Afghanistan). However, the data for this station has to be purchased at too high price.

A number of precipitation maps were collected for the study area: one is from WHO which contains the maximum annual total precipitation over 3 three days with a return period of five years. The resolution of the dataset is quite coarse (1km). Also in the metadata it was clearly mentioned that due to lack of historical data of Afghanistan the quality of the dataset is low. Other precipitation data were derived from the atlas of Afghanistan made in 1974 by Geokard-Poland. The map was available in pdf therefore had to be clipped, georeferenced and digitized. This precipitation map for Kunduz was used in the hazard analysis.

3.4.5. High resolution images

The high resolution image used in this research was downloaded from Google Earth with a spatial resolution of 3.5 meter. The image was used for several purposes: mapping of settlements, landslide inventory mapping, mapping of areas susceptibility to flash floods/debris flows, and for validating landcover maps, settlement maps, and geological maps.

There were some problems related to the image: it was not clear from which date the image was. The resolution of the original image was not constant for the entire Kunduz province. The Google Earth uses different images from different sources with varying resolutions, and therefore the quality of the image varied a lot, which had influence on the quality of image interpretation. (See figure 3-2) the Google image is provided in annex 8.

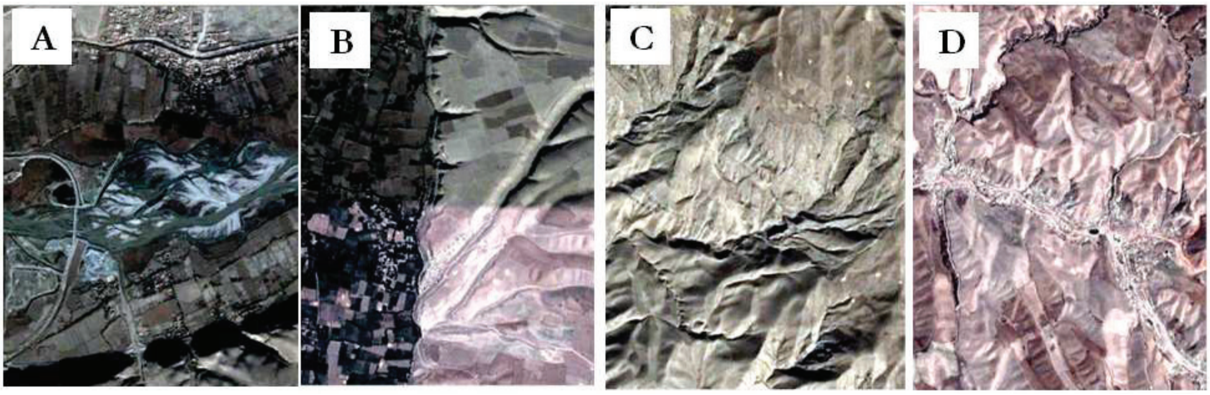


*Figure 3.2; **A**)Part of image with high resolution. **B**) Part if image from two sources. **C**) Part of image suitable for landslide mapping. **D**) Part of image with coarse resolution and not suitable for landslide mapping*

3.4.6. Settlements

Data of settlements was obtained as an ArcGIS shapefile (points) from USGS. The layer is covering the entire country of Afghanistan and was made by AIMS). The settlements were digitized as point by USAID using US defence mapping data at scale of 1:100,000 in 1994. Some of the villages did not have the right geographical location; it might be because of large changes in Afghanistan due to conflict and war, drought or problem between tribes, and many of the villages have been moved or abandoned. In order to update this map for Kunduz province 76 new villages were digitized and added in the attribute table of

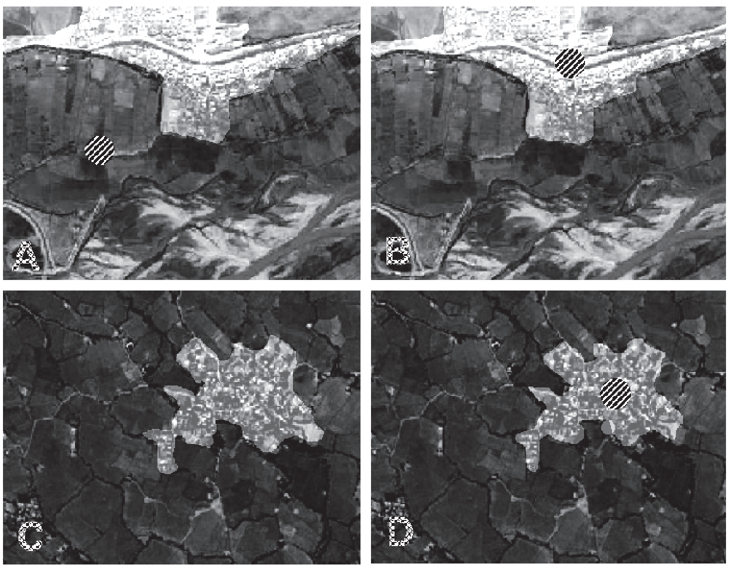


*Figure 3.3; **A**)Settlement point shifted from village, **B)** Settlement point correct to the village, **C**) Settlement without point/new settlement. **D**) New settlement point added to village.*

settlements. Also because of the shifting of settlements point or the possible changes in location of villages most of the settlements points was refined and corrected. (See figure 3-3). The settlements were then mapped as polygons from the high resolution image.

3.4.7. Administrative division

The administrative units of Afghanistan (country, province and district) consist of 34 provinces and were obtained as an ArcGIS shapefile from AIMS. The layer was mapped at a scale of 1:250000. Also the coverage contains polygon topology. This map was made in 1993. First it was digitized by Food and Agriculture Organization (FAO) of United Nations afterward the layer was converted and updated to ESRI shapefile by AIMS. The three type of mentioned boundaries shown on Kunduz base map which is provided in annex 9.

3.5. Hazard data

During this research several types of hazard data were collected for Afghanistan. It is important to mention that all the hazard data which was collected is covering the entire country. We couldn't find specific hazard data for Kunduz province only. A list of collected data is presented in Annex 10. All the represented data in the mentioned table have a good metadata description.

3.6. Element at risk data

3.6.1. Population

Unfortunately, no accurate dataset exist with population information per settlement. This implies that apart from the 30 most populated cities, no accurate population count is available for the approximately 31,000 settlements in Afghanistan. There are population estimates on a provincial and district level. Several population datasets were compared. The first one was the global LandScan dataset with 1 km resolution, which is made using dasyumetric modelling with night-time imagery and other data, by the Oak Ridge National Laboratory, which is funded by the US Department of Energy. In this research the LandScan 2008 population data was not used for the exposure analysis, because of the poor resolution in comparison with the other data. An example of the LandScan 2008 population map of Kunduz is provided in annex 11.

The second population data was a population map for the districts of Kunduz, available as pdf file, and created by UNOCHA. The map is covering the entire Kunduz province and shows the population size per settlement/village in the following 5 classes: very small (103 – 2000), small (2001 – 8000), moderate (8001 – 16000), large (16001 – 32000) and very large (32001 – 72005).

To generate a population map that gives the population per pixel of 30 by 30 meters, the following steps were applied:

- Digitize the segments of all settlements based on image interpretation using the high resolution data from Google Earth , and creating 470 polygons for the settlements
- Adjust the location of the point in the available point map to the correct location the settlements within the polygons
- Use the population data per district and divide this over the settlements based on the type of settlement, and the size proportion. .
- Using the mentioned five population size classes, we calculate the area of population for these five classes, brought the calculated values into the table of districts
- In the table of the districts we had information about the rural and urban population. (from the population classes, very small, small and moderate classes counted as a rural and large, very large classes counted as urban)

- We calculate number of people per pixel for both rural and urban (by dividing the value of very small, small and moderate classes to the rural and also dividing the value of large and very large classes to the urban.
- We joined the calculated values (number people per pixel rural and number of people per pixel urban) into the table of settlements, and calculated the area for the rural and urban settlements
- Finally we could then calculate the population per settlement by dividing the settlement area by the number of people per pixel.

The population data were also used to make an estimation of the number of buildings per settlement. This was done based on reports of average household size for urban and rural population in Afghanistan. Also the main types of buildings were estimated based on general proportion values available for the whole country. The aim was to use this data in the earthquake exposure and risk analysis. However, due to time problems this task could not be completed.

3.6.2. Agriculture

From the available land cover map described earlier, the units related to agriculture were used for the exposure analysis with two types of hazard (flood hazard and landslide susceptibility). The exposure analysis was done in more detail based on which crop is cultivated in Kunduz province. The following land cover unites were used for the agriculture exposure analysis: gardens, irrigated 1 crop/year, irrigated 2 crops/year, irrigated intermittently, rain fed crops in flat land, and rain fed crops in sloping land.

3.6.3. Roads

The data of the road network was obtained as an ArcGIS shapefile from AIMS. The roads network shapefile was digitized from US Defence Mapping Agency (USDMA) at scale 1:100000. The road layer includes three types of roads: main road, secondary road, and tracks or tertiary road. . The roads networks shown on Kunduz base map which is provided in annex 12.

3.7. Missing data for risk assessment

Although a large amount of data was obtained, it is clear from the description above that these data have severe problems with respect to the data quality. In order to be able to carry out a multi-hazard risk assessment in a quantitative manner more data are needed, especially related to data from which frequency of events can be analyzed. For instance daily precipitation data, or records of flood and landslide events. For a war affected country such data gap can be expected, due to the problems described earlier. The most important data which are still missing are:

- Up to date population data for the settlements with attributes that would allow the generation of vulnerability maps, e.g. on gender, ethnic composition, age, schooling, economy etc.
- Daily rainfall data, which could be used to correlate with flood and landslide events in order to estimate return periods.
- A Geomorphological map from which landslides, alluvial fans, terrace levels, and terrace scarps could have been extracted.
- Building footprints with characteristics on building type, building materials, number of floors etc.
- Data on type of buildings (number of floors)
- GDP, and other socio-economic data
- Historical recorded data on landslides/mud flows/rock slides / avalanches/ wildfires /drought
- Drought related data

4. HAZARD ANALYSIS

This chapter will focus on the development of hazard maps for Kunduz province based on the available data which was downloaded from the various websites, and which was presented in the previous chapter. Three types of hazards will be analyzed: flooding, landslides and earthquakes. For other hazard types, such as drought, we were not able to obtain sufficient information.

4.1. Flood hazard

According to the recorded flood events by the government of Afghanistan, Kunduz province is seriously prone to flooding.

During the period of this research a flood susceptibility map was generated for the Kunduz province using PC-Raster. The generation of "the flood susceptibility map is based on an algorithm which has been developed by the Joint Research Center of the European Union for flood hazard and risk mapping at the pan-European scale" (De Roo et al., 2007). A first estimate of the flood hazard is determined from the height above the river. It computes the elevation difference between a specific grid-cell and its closest neighboring grid-cell containing a river, while respecting the catchment tree-structure. In this way a grid cell can never be linked to a river in another (sub)-catchment. An ASTER Global Digital Elevation Model (GDEM) with the resolution (pixel size) of 30m was used for the generating of the flood susceptibility map for Kunduz. (See figure 4.1)

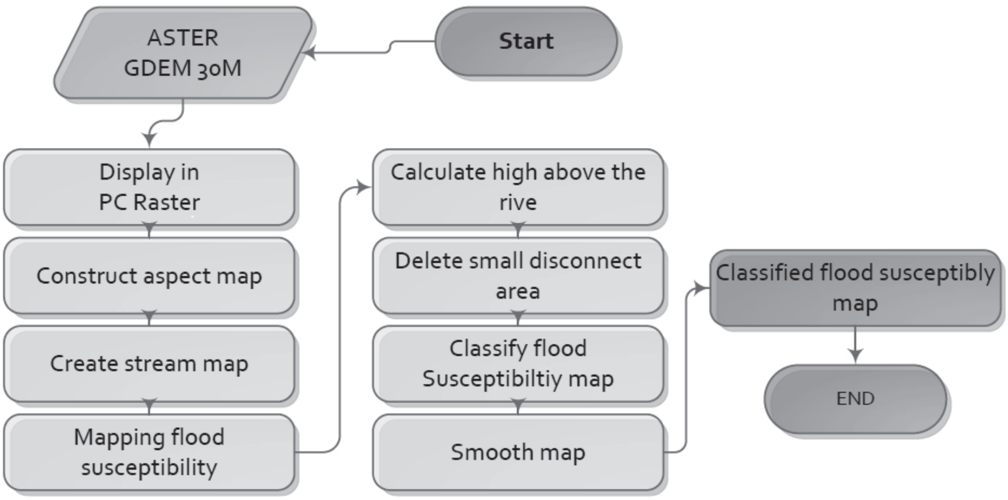


Figure 4.1; flood susceptibility flow chart after De Roo et al, 2007

The method is defined by the following main steps:

(1) Determination of the river network derived from the digital elevation model,

(2) Define the river as 'pits' – outlets of individual small local catchments. For each of those pits, the local catchment draining into this pixel is defined using the 'catchment' function.

(3) The elevation of the river pixel (the pit) is given to this entire sub basin: the river pixel is assigned the elevation from the DEM. Finally, the difference between the original DEM and the DEM with the local river altitude is estimated as the height above the river. This local height difference is sliced into three susceptibility classes. (See figure 4.2)

The process was carried out using a PC-Raster script.

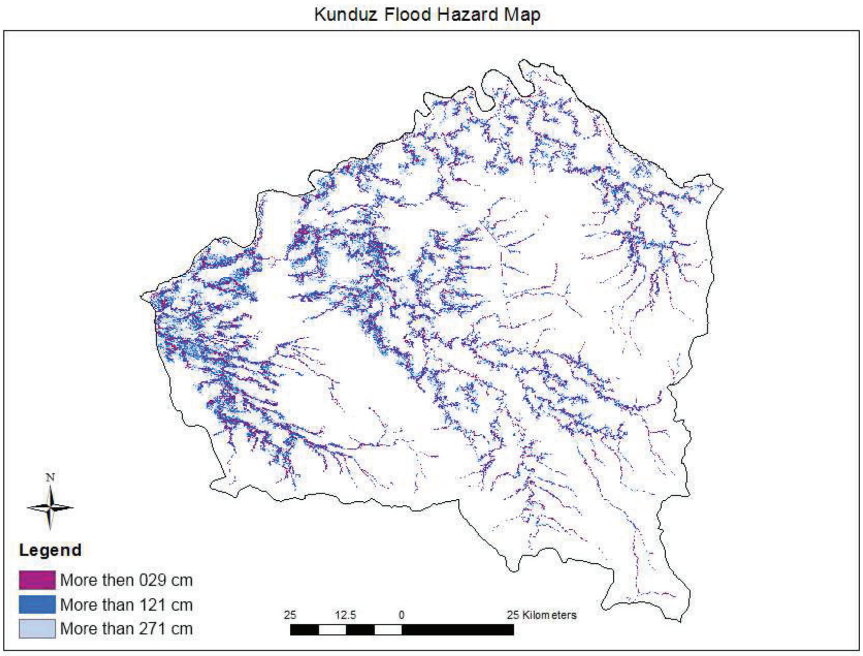


Figure 4.2; Kunduz flood susceptibility map created by using PC Raster

As mentioned in chapter 3 for collecting the possible spatial data contacts were made with many organizations and institutions. After generating the flood susceptibility map of Kunduz province a complete dataset of flood hazard for the whole of Afghanistan was obtained from Dr. Emlyn Hagen. Hagen wrote his PhD research on the topic of flood hazard in Afghanistan. The Afghanistan flood hazard map, scale 1:100,000 has been evaluated and created for the whole of Afghanistan, by using a parsimonious inundation model based on past flood events (Hagen, 2010; Hagen et al., 2010). The method used for this map is presented in figure 4-10.

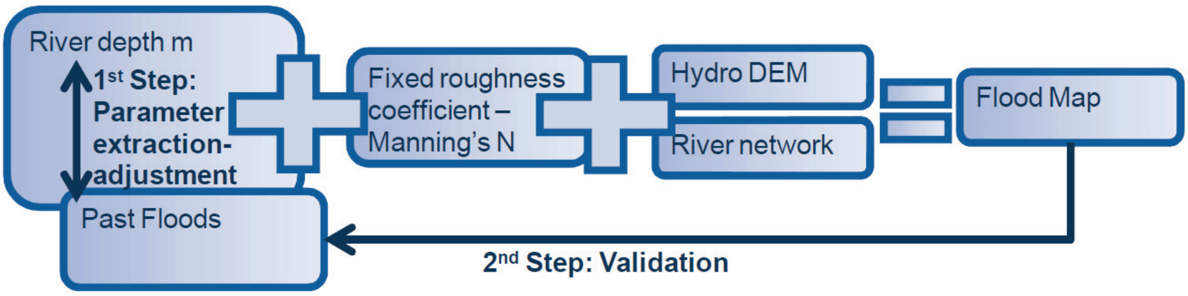


Figure 4.3; Method of flood hazard map by Emlyn Hagen

This called a reverse engineering approach. It relies on past inundation depth obtained by analysis of a high resolution DEM, satellite images and flood extent shape file of the Dartmouth Flood Observatory (DFO). In figure 4.3 a snapshot view is given from flood hazard polygon. (See figure 4-4)

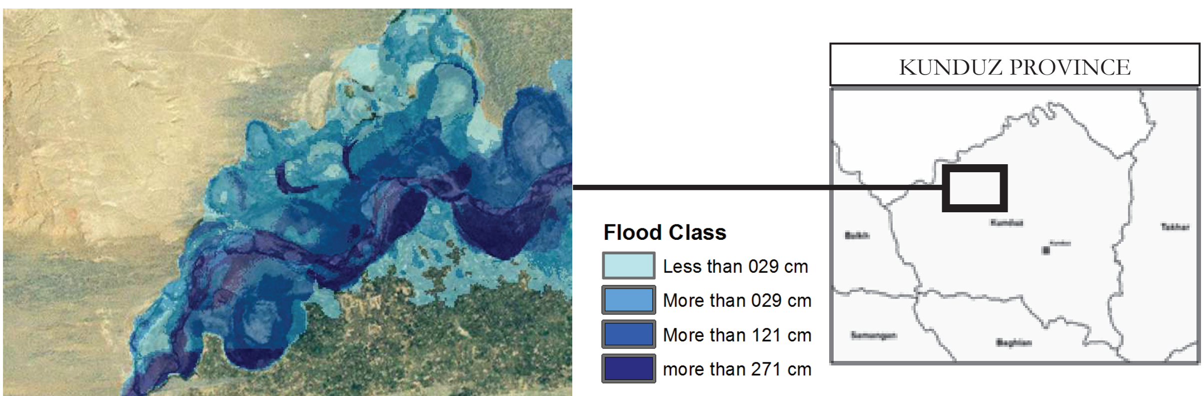


Figure 4.4; A snapshot of flood hazrd map by Emlyn Hgen overlayd on top of sattelite image

"It is very important to mention that in his analysis he used DFO data with 250-500 m resolution (Modis data) and flood zones that were visually confirmed in high resolution satellite imagery" (Hagen et al., 2010). Flood events between 1988–2006 have been used, the flood recurrence of these floods is unknown. Also is it not known if the DFO – Modis" images" give the maximum flood extent The Flood hazard map of Afghanistan by Emlyn Hagen can be used at scales of 1:250000 – 1:100000 and roughly indicate inundation areas. Part of the flood hazard map which is extracted for Kunduz province is shown in (figure-4-5)

Assumptions in regard to flood hazard map by Emlyn Hagen are as follow:

- Inundation area should covers the areas by past flood
- The inundation shouldn't go beyond the flood plain
- No intension to cover whole flood plain
- Inundation area should always be covered by river bed

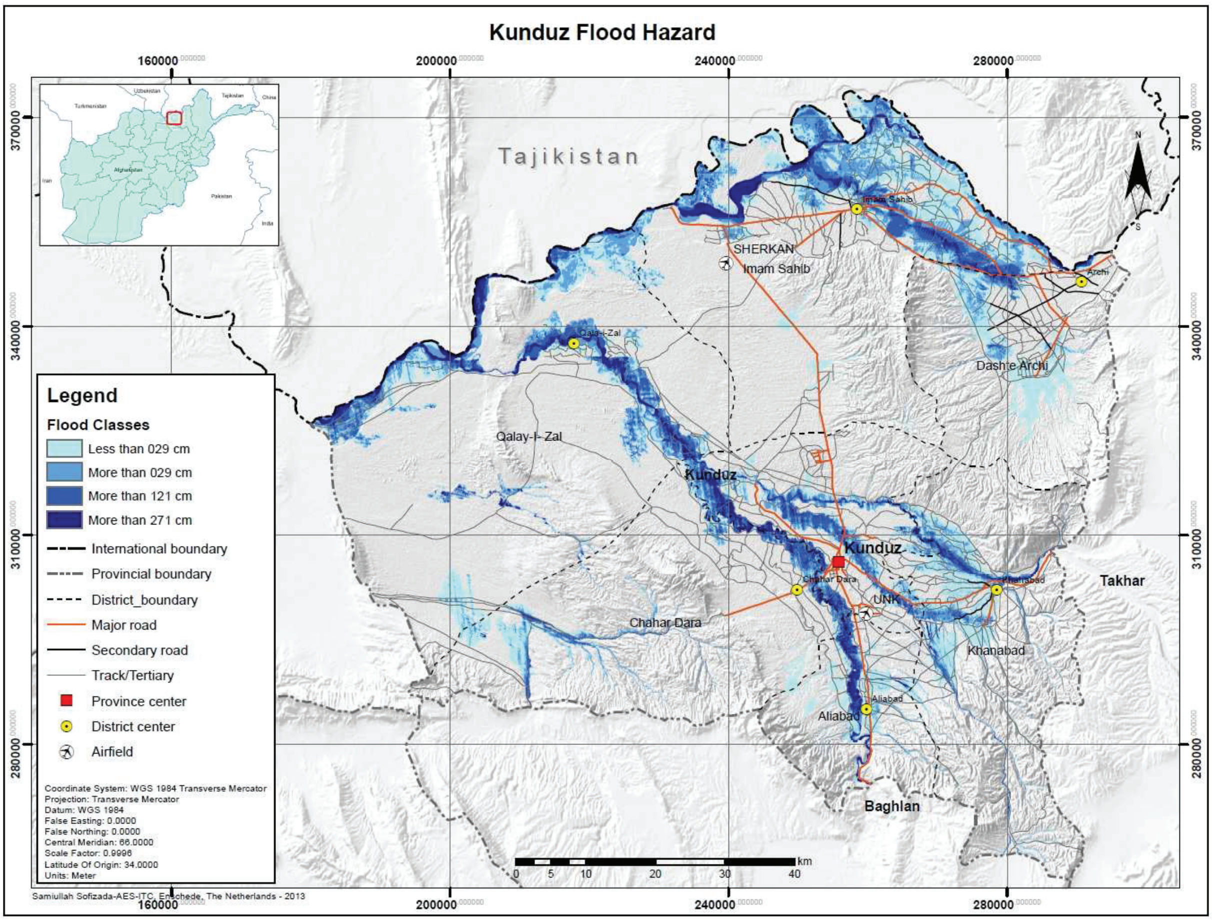


Figure 4.5; Flood hazard map of Kunduz. Source: Hagen, 2010.

In order to select the best flood hazard map for the exposure analysis in this research, a comparison has been made between the two mentioned flood hazard maps. The result of the comparison shows that the flood hazard map generated using the PC-Raster script is not representing the right information about the flood hazard in the study area. The difference is between two map is considerable. The areas which are shown as highly flooded in the flood hazard generated, by PC Raster do not match very well with the other map created by Dr. Emlyn Hagen. In other locations the area which is not indicated as flooded in flood hazard map created by Dr. Emlyn Hagen, is seriously flooded in the flood hazard map created using PC-Raster. A comparison is given in figure 4-6. Based on the comparison with other data (e.g. the high resolution image) it was decided that the flood hazard map by Dr. Emlyn Hagen represents the reality better, and therefore this map was selected for the analysis is this study. As there are no flood extends maps available it was not possible to validate the maps.

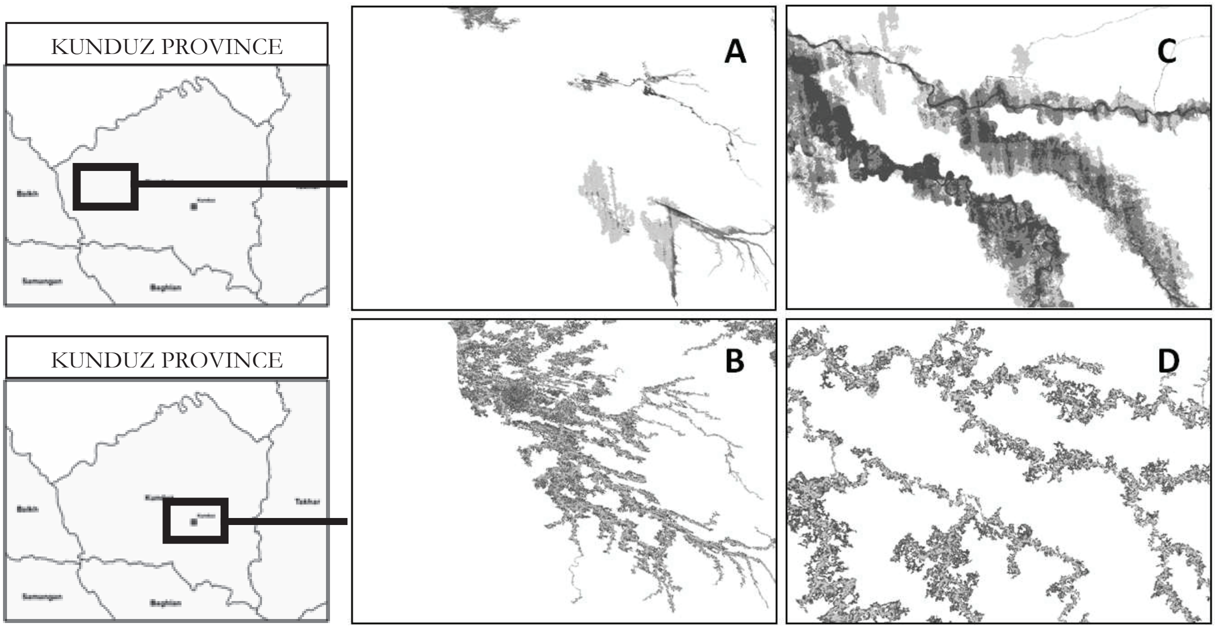


*Figure 4.6; **A**) shows an area not seriously flooded in the flood hazard map created by Dr. Emlyn Hagen. **B**) Shows the same area in as A which is seriously flooded in flood hazard map created using PC-Raster. **C**) Shows area seriously flooded in flood hazard map created by Dr. Emlyn Hagen. **D**) Shows same area in as C which is not seriously flooded in flood hazard map created by using PC-Raster.*

4.2. Landslide hazard

The territory of Kunduz of province due to its geological setting, geomorphology, climate and landscape has favourable conditions for active geological process like landslides. Landslide processes are affecting the roads, agriculture lands and population. For the qualitative assessment of landslide in this research the Spatial Multi Criteria Evaluation (SMCE) method has been applied. The hazard assessment for landslides was made by using ILWIS 3.3 Academic and ArcGIS 10. The method used for this map is presented in figure 4-10. The following layers were used for generating the landslide susceptibility map:

- Digital Elevation Model, which slope steepness and aspect was created
- Geology
- Road network
- Land Cover
- Stream
- Peak Ground Acceleration (PGA)
- Precipitation map

The hazard assessment started with structuring of the criteria tree, followed by the selection of indicators, standardization and weighting. In order to make it possible to do the multi criteria analysis all the input layers were standardised from their original values to a new value range between 0-1, by evaluating the relative importance of the classes and values with respect to landslide occurrences. It is important to mention that the indicators do not have similar measurement scales such as interval, nominal, ordinal and ratio, and they had different cartographic projections and georeferences. Therefore prior to the standardization all data were converted to the same projection system. Taking into account the mentioned elements, different standardization methods were applied for each of the indicators. For example, maps with classes were standardized using expert-based values, and continuous data was standardized using curves.

In the criteria tree the indicators were divided into two groups. The first one is related to the triggering factors which contain two indicators: Rainfall and Peak Ground Acceleration (PGA). The second group is related to the causal factors, which contains the following indicators: land cover, geology, slope, distance to major rivers, slope aspect and distance to roads. One constraint was also used in order to mask out the flat areas. (See figure 4-7)

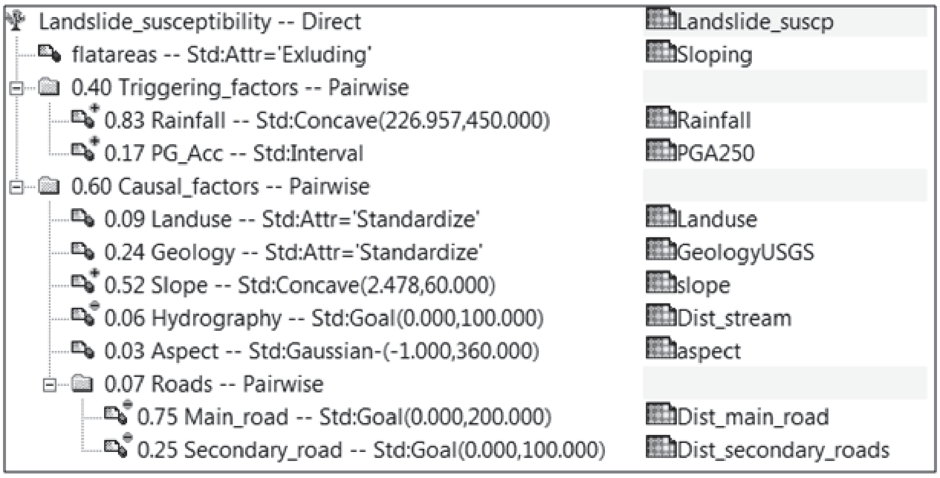


Figure 4.7; Landslide susceptibility criteria tree

For the weighting of the indicators both the direct method and the pairwise comparison method were used. The indicators of the triggering factors were weighted using the pairwise comparison method, and the rainfall was considered more important for landslide triggering than the peak ground acceleration

The indicators of the causal factors were also weighted using the pairwise comparison method. (See Figure 4-8 for the respective weights). The indicator "distance to roads" was classified into two groups: main roads and secondary roads among the indicators in the causal factor the highest importance was given to the slope and geology. For the general weighting of the input layers the direct method was applied, the value given for triggering factors is 0.400 and for the causal factor is 0.600.

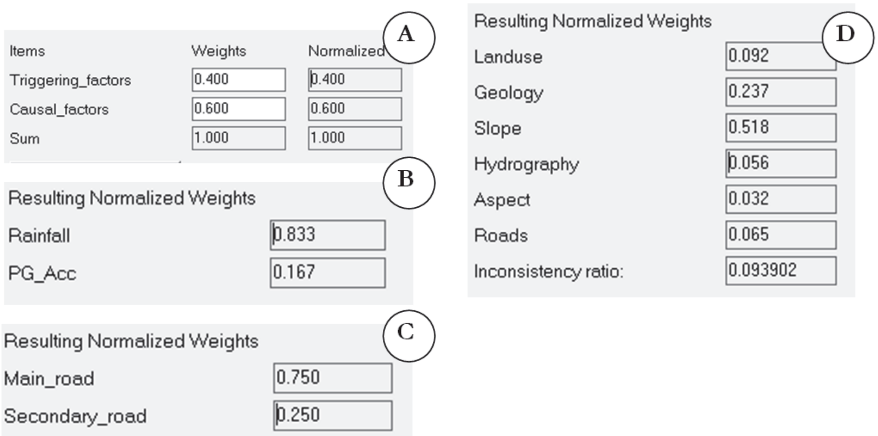


Figure 4.8; A) Overall weighting value of all layers. B) Weighting value for triggering factors. C) Weighing value of roads, D) weighting value for causal factors

After generating the score map the landslide susceptibility map was sliced into four main classes: high, moderate, low, and flat. The resulting landslide susceptibility map is not static; it should be regularly updated because a number of the given indicators (e.g. landcover) change over time. The landslide susceptibility map was validated with the result of the landslide inventory mapping which has been carried out in Kunduz province (See chapter 6). The landslide susceptibility map shown in figure 4.9.

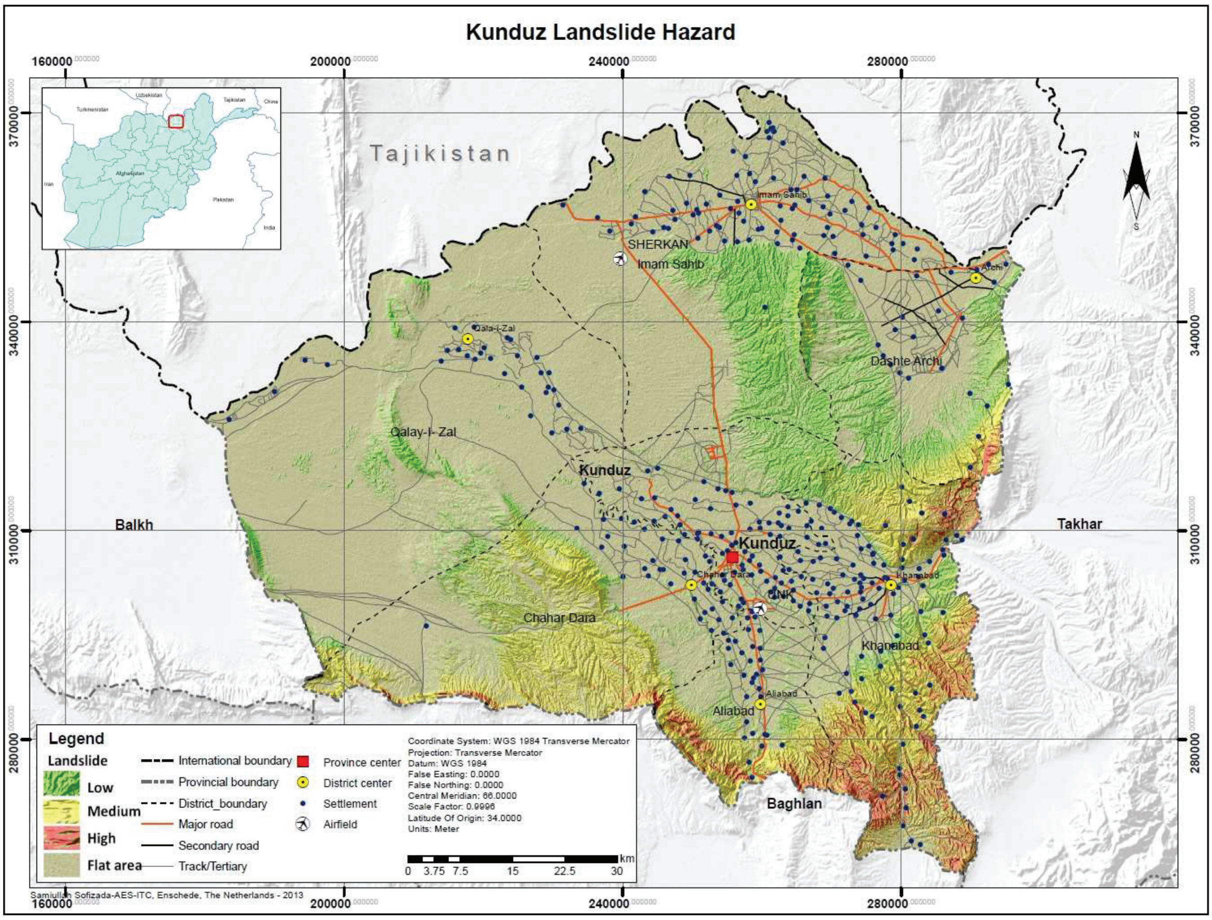


Figure 4.9; landslide hazard map of Kunduz

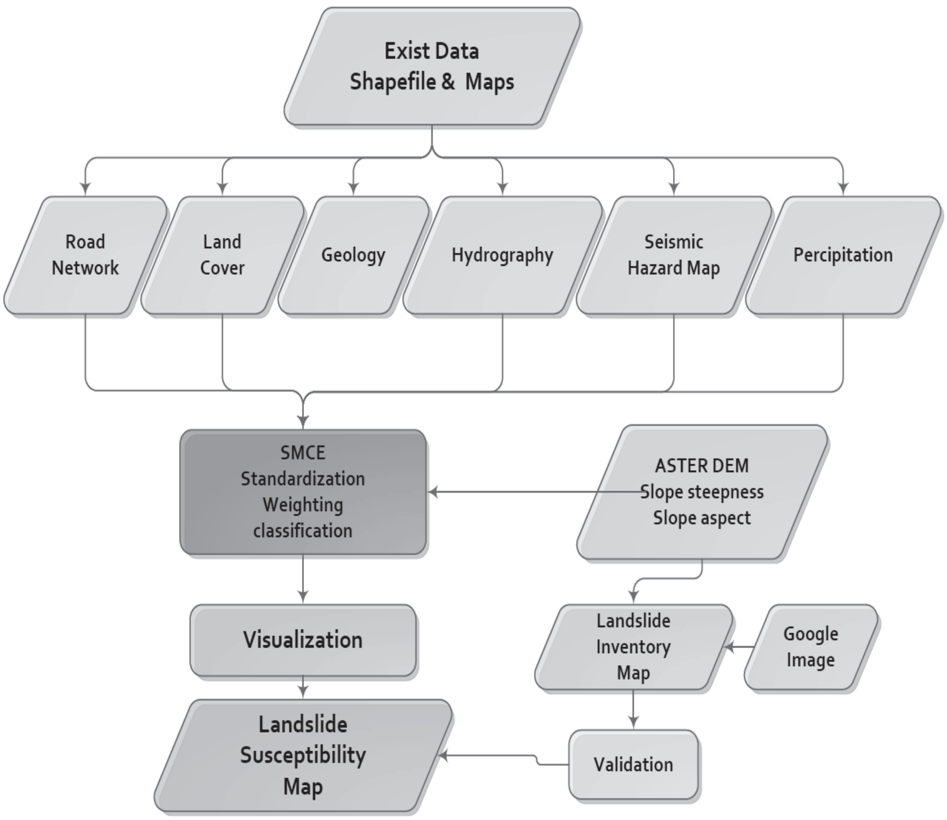


Figure 4.10; landslide susceptibility flow chart

4.3. Earthquake hazard

Afghanistan has a long history of destructive earthquakes. Between the years 1997 to 2007 more than 7000 people were killed by earthquakes in the country, including the Nahirn 1998 earthquake that killed around 4000 people. Seismologists expect large earthquakes with a magnitude up to 7 in the region driven by active tectonic processes, which may occur close to cities with high population density (Boyd et al., 2007).

The north and north east of Afghanistan are geologically active, and Kunduz province is also located in this region next to Takhar and Badakhshan provinces. The recorded earthquake events in the past show the Kunduz province has experienced many earthquakes with different magnitude. See annex 13 for an overview of recorded earthquake events in Kunduz province.

In this M.Sc research no earthquake hazard map was generated for Kunduz province as such maps were already available. An earthquake hazard map of Afghanistan was prepared by USGS and was used in this research. The USGS calculated peak ground acceleration values for different return periods (50 years, 250 years). Figure 4-11 shows the earthquake hazard map for Kunduz (PGA with 2 percent probability of exceedence in 250 years) with the recorded earthquakes on top.

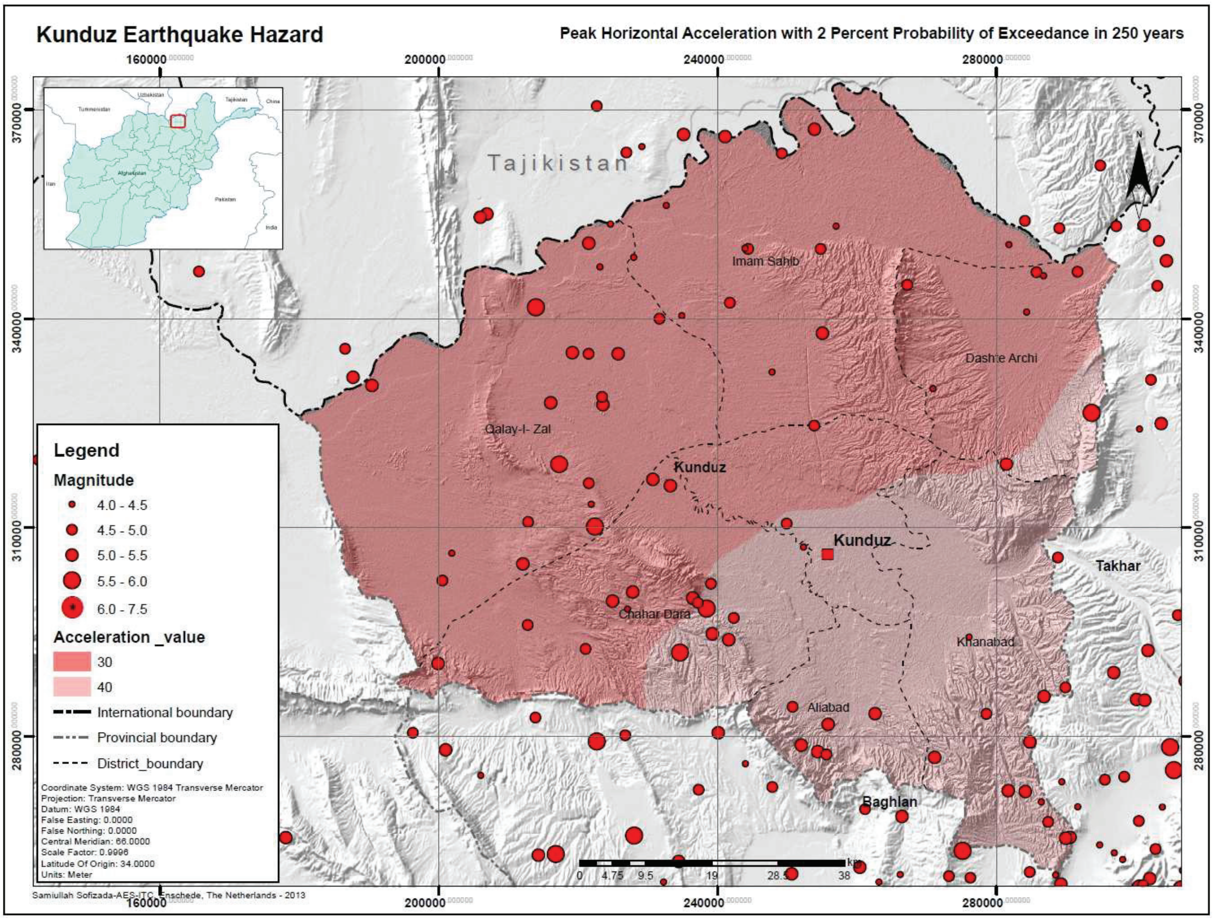


Figure 4.11; Earthquake hazard map of Kunduz with recorded earthquake events. Source: USGS

Other hazard maps, e.g. for drought, flash floods and snow avalanches were not available, and these types of hazard were therefore not analyzed in the exposure and vulnerability assessment.

5. EXPOSURE ANALYSIS

In this research one of the most important components related to the risk assessment was the exposure analysis. The level of exposure can be directly defined by the interaction of hazard zones and element at risk.
The following types of exposure were analyzed: population (number of people); roads (length of main roads and secondary roads in km); agriculture (total area of agricultural land in hectare) per hazard type and were grouped according to the administrative units (districts). The procedure of generating exposure maps shown in (figure 5-1)

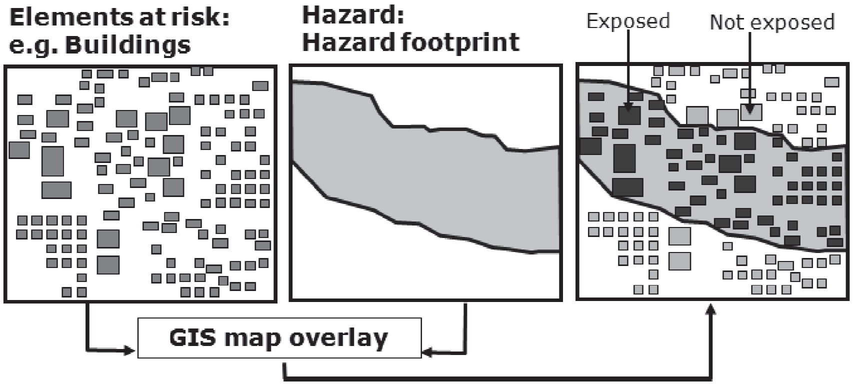


Figure 5.1; Overlay of hazard map and elements-at-risk presents information on exposure.
Source: Multi-hazard risk course, ITC

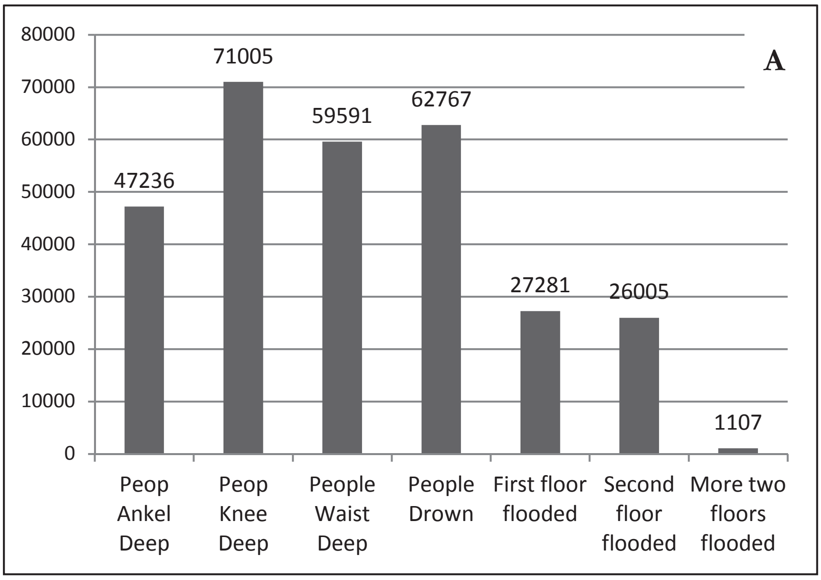
The calculations of different types of exposure have been done using script files in the ILWIS 3.3 Academic software. In general the main steps in calculating the exposure were as follow:

- Overlay of the hazard maps with element at risk using the cross operation
- Creating a joint frequency table with all combinations of both maps, in addition a map containing all possible combinations
- Overlay the resulted map with the administrative units (district)
- Aggregation of the number of elements-at-risk which are located in the different hazard classes.
- Calculation of the total percentage of different types of element-at-risk in the hazard classes, per district.
- Storing all the analyzed values in tables of exposure linked to the district map, which contains all the exposure information per district.

5.1. Exposure of Population

5.1.1. Population exposure to flood hazard

For calculating the population exposure to floods first of all the flood heights were classified in seven classes that relate with the impact of floods on people and buildings. Based on each flood class the population exposure was calculated, as the number of exposed people per cell. From the total population Kunduz province 294,992 persons which is 32% of the total population of Kunduz is exposed to flooding, even though 47000 only in the lowest class (ankle deep) and 640608 people which is 68% of Kunduz population is not expose to flood. The results show that in Kunduz province 47236 people are exposed to the lowest category (ankle deep), 71005 people are in category of knee deep, 59591 people are in category of waist deep, 62767 people are in category of first floor flooded, 27281 people are in category of second floors flooded and 1107 people are in the category of more than two floors flooded. (See figure 5-2)



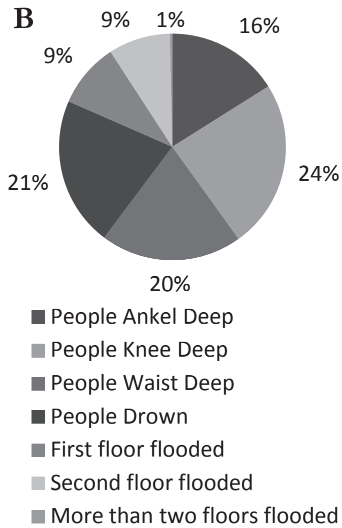


Figure 5.2; A) Population exposure to flood hazard. B) Kunduz population exposure to flood hazard by flood classes in percentage of the total number of people exposed to floods (which is 32 % of the total population of Kunduz)

Number of people which is expose to flood hazard vary among the six district of Kunduz. Khanabad District with 93600 people and Imam Sahib District 88663 people are having the highest number of people expose to flood hazard, the reason is their geomophological shape and presence of main streams of Kunduz province next to them. And the lowest number of people expose to flood is related to Chahar Dara district. (See table 5-1).

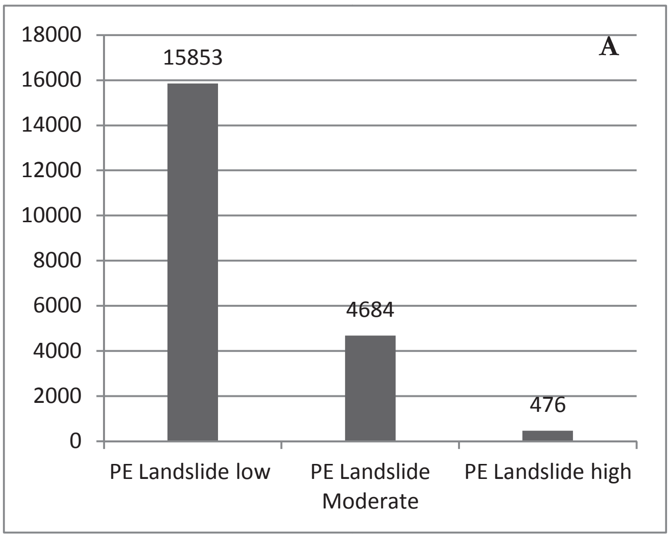
District	People Ankel Deep	People Knee Deep	People Waist Deep	People Drown	First floor flooded	Second floor flooded	More two floors flooded	Total Population
Aliabad	6892	7690	3534	2615	760	607	428	45100
Chahar Dara	744	2056	1314	2329	1200	860	5	70200
Dasht Archi	2811	3982	3309	3070	1102	1081	392	80900
Imam Sahib	10268	17278	21421	18084	7679	13893	40	221800
Khanabad	19234	24480	17691	19470	8372	4294	59	153500
Kunduz City	4052	10055	8351	8819	3940	2691	111	297800
Qalay-I-Zal	3235	5464	3971	8380	4228	2579	72	66300
Total	47236	71005	59591	62767	27281	26005	1107	935600

Table 5.1; Kunduz population exposure to flood by district

5.1.2. Population exposure to landslide hazard

Population exposure to landslide hazard was calculated based on the number of people per cell for the three landslide susceptibility classes (high, moderate and low).

From the population of Kunduz 21013 people (2.5 %) are exposed to landslide hazard and remain 914587 people (97.5 %) are not exposed to landslide hazard. Among the total population of Kunduz 15,853 people are exposed to high landslide hazard, 4,684 people are exposed to moderate landside hazard and 476 people are exposed to high landslide hazard. (See figure 5-3)



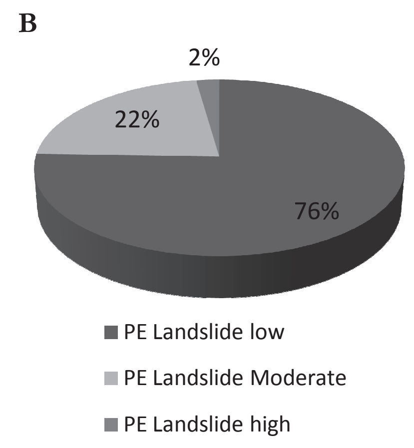


Figure 5.3; A) Kunduz population expose to landslide hazard by class. B) Kunduz population expose to landslide hazard in percentage of the total exposed population to landslides (which is 2.5% of the total population of Kunduz).

The districts Khanabad and Kunduz city are having the highest number of people exposed to landslide hazard, as well as the smaller settlements in the mountainous parts in the East of the state. (See table 5.2)

Districts	PE Landslide low	PE Landslide Moderate	PE Landslide high	Expose to landslide risk	Not expose to landslide	Population
Aliabad	1469	744	0	2213	42887	45100
Chahar Dara	753	0	0	753	69447	70200
Dasht-i- Archi	1270	104	0	1374	79526	80900
Imam Sahib	1048	0	0	1048	220752	221800
Khanabad	4415	3825	476	8716	144784	153500
Kunduz City	6878	11	0	6889	290911	297800
Qalay-I-Zal	20	0	0	20	66280	66300
Total	15853	4684	476	21013	914587	935600

Table 5.2; Population exposed to landslides by district

5.2. Exposure of Agricultural land

5.2.1. Agricultural land exposed to flood hazard

For the calculation of the exposure of agricultural land to flood hazard a domain with three flood classes was created according to the average height of the plants grown on agricultural land in Kunduz province. The main crops in Kunduz are wheat, corn, rice, maize, bean, pea, melon, almond, grapes, cotton, and based on the crop height the following three classes were used: low (less than 0.5 m of water), moderate (between 0.5 and 1 m of water) and high (more than 1 m of water). By crossing the agriculture map with the flood class map the number of pixels for each flood class was calculated. The pixel size of the input map is 30x30 meter and the area for each pixel is 900 square meter. So based on this calculation for individual pixels later on the number of hectares of exposed agricultural land was calculated per district.
The results show that in Kunduz 79152 hectare (49% of the total agriculture land) is exposed to flood hazard and 82455 hectare (51%) is not exposed. Out of the exposed land, 30224 hectare (38% of total agriculture lands exposed flood hazard) is in the category of high flood hazard, 46450 hectare (59%) in moderate flood hazard and 2478 hectares (3%) in the low flood hazard. (See figure 5.4)

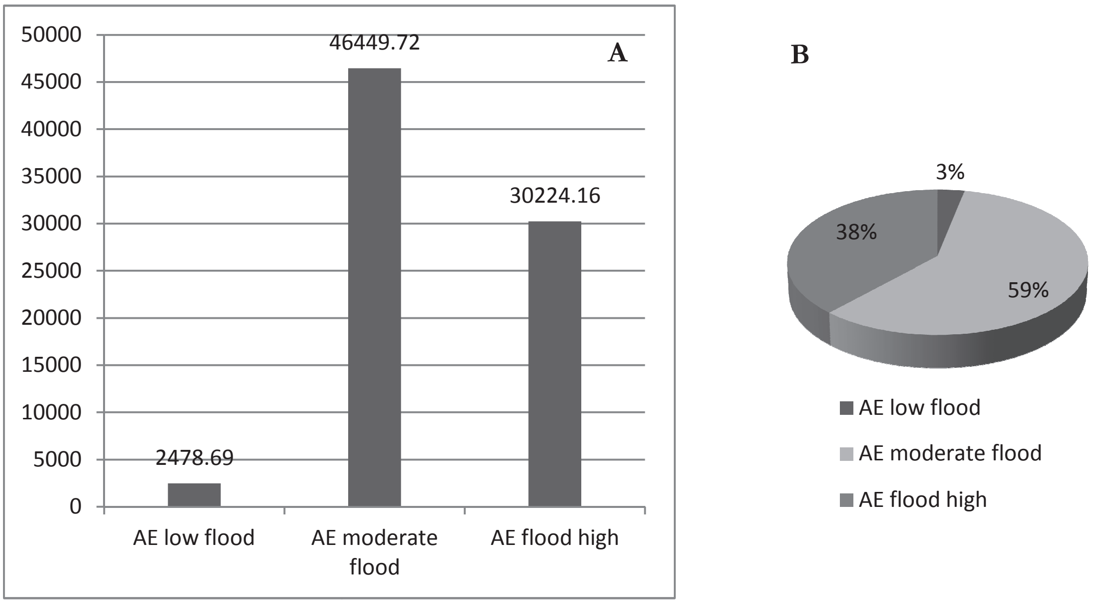


Figure 5.4; A) Kunduz agriculture lands expose to flood hazard in hectare. B) Kunduz agriculture lands expose to flood hazard in percentage of the total area of agricultural land exposed to floods (which is 49% of the total)

From the agriculture exposure analysis, the different types of crops exposed to flood hazard were also analysis. Among all the crops cultivated in Kunduz, irrigated crops and rainfed crops are mostly exposure to flood hazard and the rain fed crops in sloping terrain obviously has the lowest exposure. (See Table 5.3)

Type	AE low flood	AE moderate flood	AE flood high	total
garden	15.21	7495.74	5709.78	13220.73
Irrigated 1 crop	21.87	6576.48	2822.22	9420.57
Irrigated 2 crop	1226.61	13779.27	17339.58	32345.46
Irrigated intermittently	597.6	953.01	1922.4	3473.01
Rainfed crop flat	59.85	17168.22	2164.14	19392.21
Rainfed crop sloping	557.55	477	266.04	1300.59
total exposure	2478.69	46449.72	30224.16	79152.57

Table 5.3; Agricultural land exposed to flood hazard by type of crops in hectares.

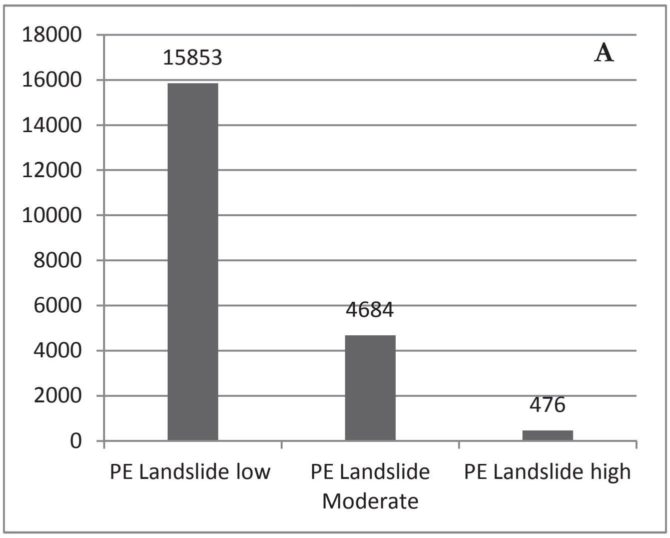
5.2.2. Agriculture exposure to landslide hazard

Agricultural land exposed to landslide hazard was basically calculated in the same way as for the flood hazard. The landslide map was classified in 3 classes (high, moderate and low).

The results were also calculated as the number of hectares. According to the result 39,256 hectare of agricultural lands (15% of the total) is exposed to landslide hazard, and the remaining 22, 8013 hectare are not exposed.

From the total agriculture lands expose to landslide hazard 9690 hectare (25% of the total agricultural land exposed to landslide hazard) is in the category of high landslide hazard, 216001 hectare (55%) is exposed to moderate landslide hazard and 7927 hectare (20%)to low landslide hazard. (See figure 5.5)

Based on the landslide classes, agriculture exposure analysis, the different types of plant expose to landslide hazard calculated, among all the plants cultivated in Kunduz irrigated crops 2 and rainfall crop area having the highest exposure value to flood hazard and the rain fed crop sloping has the lowest exposure value in regard flood hazard. (See Table 5.4)



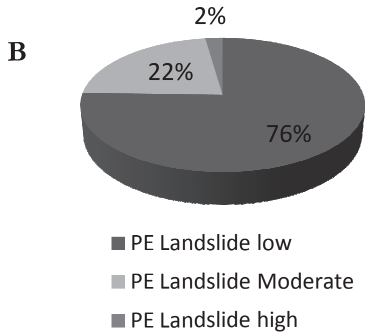


Figure 5.5; A) Agricultural land exposed to landslide hazard in hectares. B) Agriculture land exposed to landslide hazard in percentage of the total exposed land.

Type	AE landslide Low	AE landslide Moderate	AE landslide High	Total
Gardens	1.35	0.18	0	1.53
Irrigated_1_crop	1214.55	160.65	0	1375.2
Irrigated_2_crops	516.15	41.31	0	557.46
Irrigated intermittently	122.04	10.35	0	132.39
Rain fed crops flat	3297.69	1041.48	19.8	4358.97
Rain fed crops sloping	2775.06	20346.8	9670.05	32792
total	7926.84	21600.8	9689.85	39217.5

Table 5.4; Agricultural land exposed to landslide hazard by type of crop in hectares

5.3. Exposure of Roads

5.3.1. Road exposure to landslide hazard

Road exposure to landslides was calculated by crossing the road network with the landslide hazard map. After that for each class of road (main roads and secondary roads) the number of pixels for each class was calculated. In order to find the length of roads exposed to landslide, the number of pixels were multiplied by 30 (pixel size is 30 by 30 meter) and recalculated into kilometres. (See figure 5.6)

Districts	RE mainroad landslide low	RE mainroad landslide moderate	RE mainroad landslide high	RE Secondroad landslide low	RE Secondroad landslide moderate	RE Secondroad landslide high	total road length in km
Aliabad	1680	2700	570	9420	3840	1110	19.32
Chahar Dara	150	0	0	6570	5550	0	12.27
Dasht Archi	180	0	0	8580	9150	1230	19.14
Imam Sahib	5190	4500	0	9750	5160	0	24.66
Khanabad	270	2460	180	18060	42480	24270	87.72
Kunduz City	4170	2730	0	13680	2370	0	22.95
Qalay-I-Zal	0	0	0	5010	2580	0	7.59
Total in M	11640	12390	750	71070	71130	26610	193590
Total in Km	11.64	12.39	0.75	71.07	71.13	26.61	193.59

Figure 5.6; Roads exposed to landslide hazard

6. DISCUSSION AND CONCLUSION

6.1. Risk analysis

In the previous chapter the exposure of people, agricultural land and roads to floods and landslides have been analyzed. It was not possible at this stage to analyze the exposure to earthquakes, due to the fact that no building data was available for the study area, and because there is not a very large spatial variation in the earthquake hazard, as the available maps do not take into account the soil amplification and topographic amplification. For these reasons it was decided not to incorporate earthquake risk in the further analysis.

This section will focus on the estimation of possible losses, mainly focusing on the flood hazards. The first step was the generation of a composition of the flood susceptibility and landslide susceptibility maps with the element at risk such as roads, settlements and agricultural lands. (See figure 6-1)

6.1.1. Landslide risk

As most of the settlements in Kunduz province are located in flat area, the risk due to landslide hazard is not very serious. Though there are some settlements in Aliabad district in the south east of Kunduz province which may have a considerable risk to landslides, and also a second area with relatively high risk to landslides is located in the east of Khanabad district. The mentioned areas are sensitive for both settlements and the main road,. Most of the settlements are located on flatter parts on alluvial fans and valley floors, and therefore they are not expected to experience major landslide problems in terms of landslide initiation, but rather for landslide runout. As the landslide susceptibility assessment was concentrating on the identification of potential initiation areas, and no runout modelling could be done over such large areas, the majority of the settlements in these mountainous areas are not located in the highest classes of landslide susceptibility. Future work should also take into account an analysis of landslide runout, but more information is needed for that. In case of the roads most parts of the main roads are located very close to steep slopes which can increase the risk of land slide hazard, as can be seen also in the inset map of Figure 6-1. The main road which connects Kunduz with Takhar province in the east and the rest of the country is very important and large parts of this road are running below steep slopes with high to moderate landslide hazards. Therefore future work should concentrate on assessing the landslide hazard along this road in more detail.

Landslide risk assessment at this scale could be analyzed if more information is available on historical landslides and their location. Currently we only have information from landslide points that were digitized using digital image interpretation. These were mapped as points, and lack information on the date of occurrence. The points were used to validate the landslide susceptibility map. The landslide points which were mapped during inventory mapping were overlain with the landside susceptibility map. We found that the majority of the mapped landslide points (75%) were located in the high susceptibility class, and 20% in the moderate class (See also figure 6-2).

Due to time problems only a limited number of landslide points could be digitized. However, as can be seen from some of the examples in Figure 6-2 there are severe landslide problems in this study area, and landslide features can be well recognized on the high resolution images.

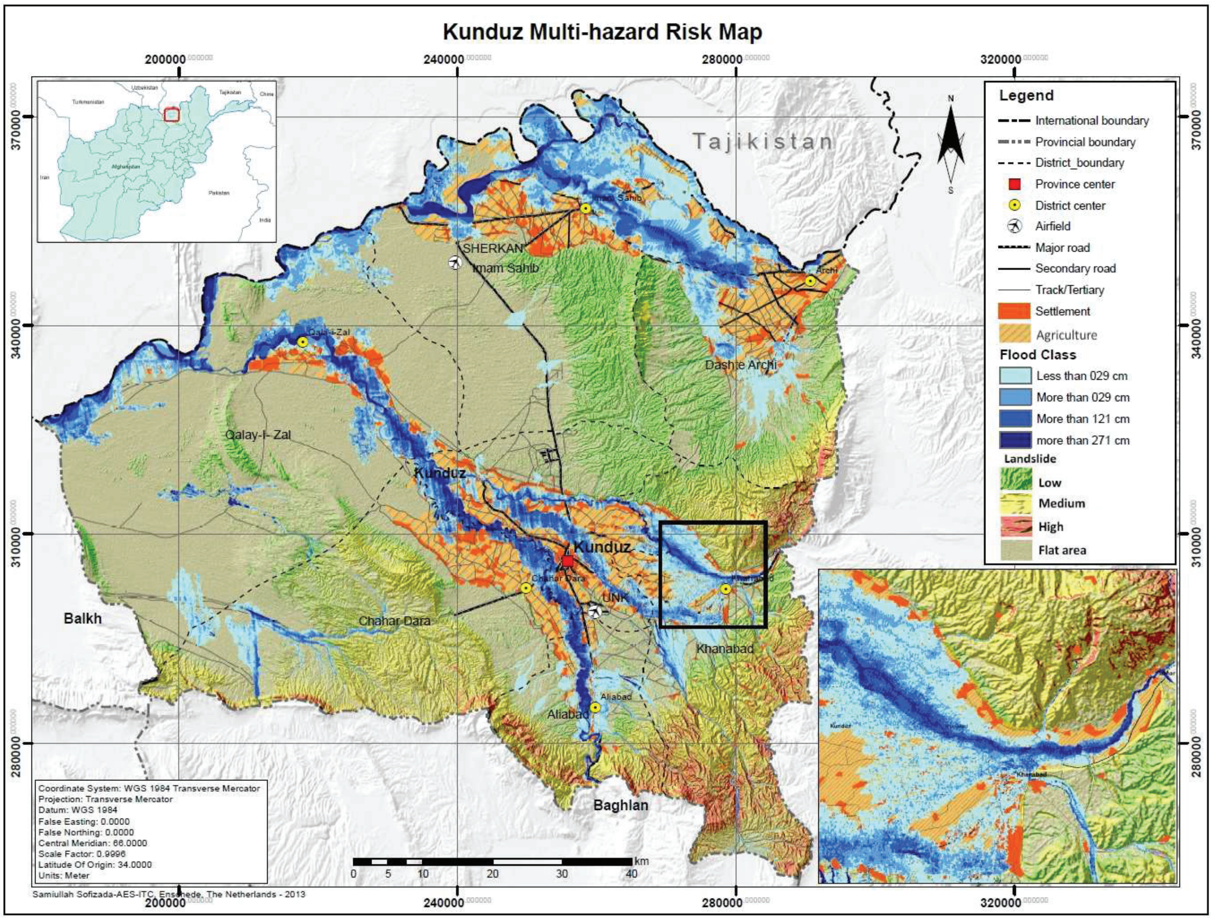


Figure 6.1: Multi-hazard risk map showing the flood susceptibility and landslide susceptibility maps together with the main elements-at-risk: settlements, agricultural land and roads. The inset map shows one of the regions with the highest level of risk, which is the eastern part where the main road is located that connects Kunduz with the rest of the country.

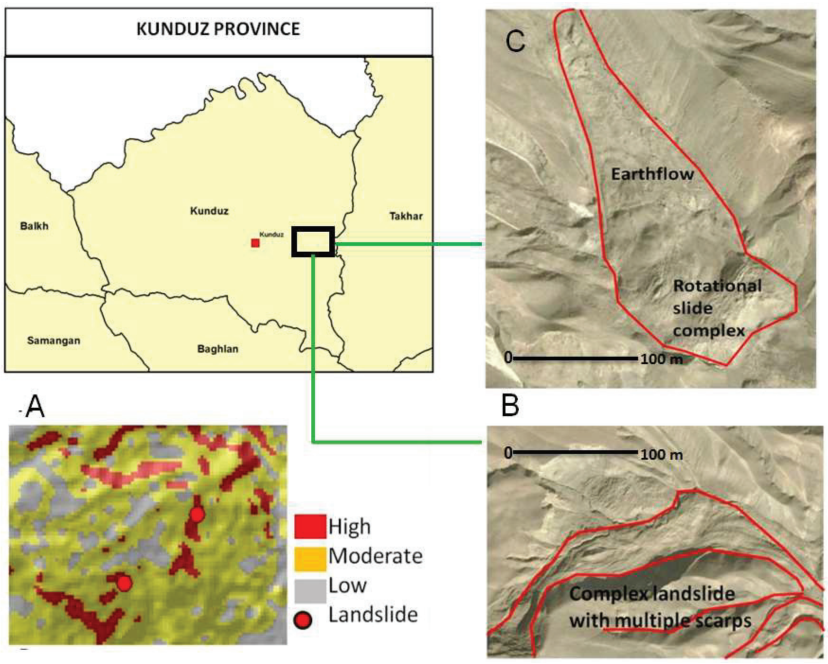


Figure 6.2; A) Example of the comparison of the landslide susceptibility map with mapped landslide points. B) Example of a complex landslide with many scarps and individual components. C) Example of an earthflow starting as a rotational landslide.

To estimate landslide risk we would need to calculate the density of landslide within the three susceptibility classes in order to get an estimation of the spatial probability. If these landslides are also of a particular time period we could then also attach a value of temporal probability. Due to the unavailability of multi-temporal landslide data this was not possible to do in this study.

6.1.2. Flood risk

Next to earthquakes, flooding is the major natural hazard with the highest losses in Kunduz province based on the literature review, and the results of the exposure analysis in Chapter 5. From the three classes of element-at-risk such as the population, agricultural land and the road network, it is clear that some of the areas in Kunduz have a very high exposure to floods.

The road network has a very important role in connecting the Kunduz province with the neighbouring provinces and with the neighbouring country of Tajikistan. The main road in Kunduz is one of the important roads that is connecting Afghanistan and the capital Kabul with Central Asia and has a key role in transportation and trade between Afghanistan and the Central Asian countries, Also Sherkhan (Bandar) port which is located between the border of Afghanistan and Tajikistan in Kunduz province is of large importance and disruption of the transport has a direct affect on the economy of the country. After some problems in Pakistan NATO and other security forces used this route as the major supply route for themselves to Afghanistan. The risk to flooding is very high in some critical points along the road network in Kunduz province. The first one is the Sherkhan (Bandar) port. The second one is some locations where the main road crosses the main river in the middle of Kunduz province and the third is in the east part of Kunduz (See inset map in Figure 6-1). The third area is located in the north of Kunduz province, which is in Imam Saheb district.

In chapter 5 the flood exposure was analyzed, and the results show the exposure is very high, especially in the locations mentioned above. Based on the flood maps produced by Emlyn Hagen we were able to calculate the number of people exposed to different flood heights. However, flood exposure is different from flood risk as we do not consider the temporal probability and extend of the floods. Unfortunately, no flood events maps are available that would allow us to link individual events with their extend and return period. In order to be able to make a general estimation of potential flood losses for population we had to make a number of assumptions:

- The flood map generated by Emlyn Hagen represents the maximum possible flood.
- The highest flood classes in this map will experience flooding most frequently, but in a frequent flood the flood height will be less.

We assume a relationship between flood height classes, population vulnerability and relative frequency as indicated in Figure 6.3 and Table 6.1. In this table we assume that a very frequent flood will only occur in the three highest classes of the flood map, and that the flood heights would then be as indicated in the table. In this way we have identified 5 scenarios of relative frequency (from very high to very low) without being able to quantify these due to lack of historical data.

Each of the flood heights is also related to population vulnerability, for which we used values of population mortality (which is the fraction of the exposed population that is likely to be killed if the flood height is at a certain level) from studies carried out in the Netherlands and elsewhere. As can be seen the mortality values are relatively low and take into account that the majority of the people are able to escape to higher ground or within top floors of buildings.

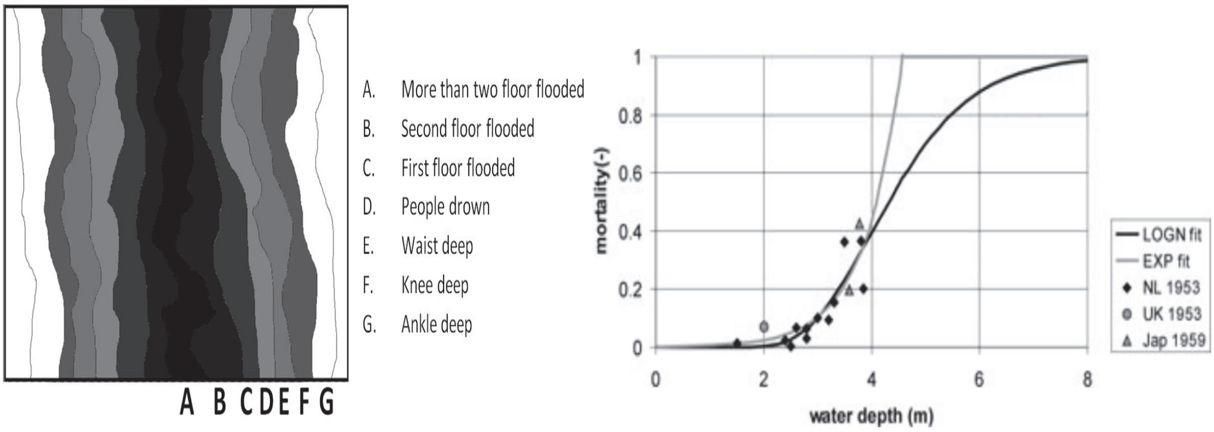


Figure 6.3: Left: Relationship between the different flood height classes used for estimation the areas that are flooded in different relative scenarios indicated in table 6.1. Right: Flood mortality curve with data from different events used in this study. Source: (Jonkman et al., 2008)

Frequency	Flood classes derived from the flood hazard map of Emlyn Hagen						
	A	B	C	D	E	F	G
Very high frequent	Waist deep V=0.01	Knee deep V=0	Ankle deep V=0	No V=0	No V=0	No V=0	No V=0
High frequency	Drown V=0.05	Waist deep V=0.01	Knee deep V=0	Ankle deep V=0	No V=0	No V=0	No V=0
Moderate frequency	First floor flooded V=0.10	Drown V=0.05	Waist deep V=0.01	Knee deep V=0	Ankle deep V=0	No V=0	V=0
Low frequency	Second floor flooded V=0.60	First floor flooded V=0.40	Drown V=0.10	Waist deep V=0.05	Knee deep V=0.01	Ankle deep V=0	No V=0
Very low frequency	More than two floors flooded V=0.60	Second floor flooded V=0.40	First floor flooded V=0.10	Drown V=0.5	Waist deep V=0.01	Knee deep V=0	Ankle deep V=0

Table 6.1: Table indicating the relationship between flood frequency (in relative terms) and the flood height classes within the flood map, and corresponding population mortality (vulnerability) values.

With the use of the flood class map derived from the flood height map of Emlyn Hagen, and the values from the table 6.2 population losses were estimated for each of the scenarios using the following steps (in ILWIS):

- Overlay of the flood class map with the settlement map, and generation of joint frequency table and map.
- Generating columns for each scenario of relative frequency that would convert the original flood height classes to the flood height classes indicated in Table 6.1
- Multiplication of the exposed population (calculated in chapter 5) with the vulnerability values indicated in Table 6.1 for each of the relative scenarios.
- Summing up population losses for entire province for each temporal scenario and plotting these in a risk curve.

The results are given in table 6.2.

Relative frequency scenario	Population losses for the entire province	
	Before correction	After correction
Very high frequency	65	38
High frequency	749	542
Moderate frequency	3226	1927
Low frequency	31886	13457
Very low frequency	31886	13457

Table 6.2: Results of the flood risk estimation for population. The losses are indicated as they were calculated on the basis of the flood map of Emlyn Hagen, and the losses after which the erroneous flood areas were removed in the north part of the province.

Since we do not have a quantification of the frequency the generation of a risk curve would not be very relevant in this stage. From the results it is clear that the population losses due to flooding are very high, especially when considering the maximum flood scenarios as indicated in the map of Emlyn Hagen.

When examining the results closely, also in the resulting map (which is not shown here are there are small points with the flood risk which cannot be properly displayed for the whole of Kunduz), we found that the flood losses in the middle part of Kunduz are quite well corresponding with the settlements located near the main river. Large discrepancies were found however in the northern part of Kunduz. When examining the existing flood map and compared it with the high resolution image, we found that there is no channel or stream in the middle of Imam Saheb district. However in the flood hazard map of Kunduz by Emlyn Hagen, the middle of the district is heavily flooded, which is not realistic. The location of a number of settlements in the middle of this high flood area, gives rise to the high values of the flood losses calculated. So it was decided to remove the flood losses from those settlements located in the erroneous flood areas in the north. The corrected values are shown in Table 6.2.

In order to compare the calculated flood losses with the historical events, a search was made about flood events that have been reported, for instance in the website of Relief Web. Table 6.3 gives a summary of the flood events that we were able to collect.

Date	Location	Damage
16/04/2007	Kunduz	821.2 hectare agriculture land was damage and 143 houses were destroyed.
11/05/2009	Kunduz	657.2 hectare of agricultural land was damaged.
2009	Kunduz	5 people died, 3448.4 hectares of agricultural land was damaged, 1 bridge, 349 houses, 11 mosques, 215 canals, 33 mills, and 6 drinking water wells were destroyed and around 1749 animals also died.
2010	Kunduz	8 people died, 2 people injured, and 500 families were affected, 274 houses were destroyed and 470 damaged. Also around 1602.8 hectares of agricultural land was damaged.
2011	Kunduz	7 people died, and 21 houses were completely destroyed.

Table 6.3: Summary of historical flood events that could be collected from different sources, e.g ReliefWeb, local contacts in Afghanistan and EM-DAT database

Based on the comparison of the flood losses that were estimated in this research and the historical damage reported for floods in Kunduz, we can concludes there is a large discrepancy in mortality values this can be caused by incorrect flood polygons, wrong assumptions in table 6.1 or early warning plays an important roles in reducing flood victims.

6.2. Data Quality

The results of the flood loss estimation show that it is crucial to analyze the quality of the spatial data that is used for multi-hazard risk assessment. It also indicates that it is quite difficult to do. Especially when there is no other dataset to compare with. Especially in the case of the flood map, we were only able to indicate the quality after having calculated the exposure and estimated losses, which turned out to be too high to be realistic. For the landslide map we have shown an indication of the quality in the previous section as well. In chapter 3 the various input maps that were collected from the internet have been presented. Although the data set was very large, there was a lot of repetition in it, or data that were too coarse to be used at the provincial scale. Therefore only a limited subset of the data was used in the actual analysis. In table 6.4 a summary is given of the data quality of these data sets, focusing on the different quality components that were outlined in the literature review chapter.

Data	Completeness	logical consistency	Positional accuracy	Lineage	Thematic accuracy	Comment
Administrative boundary-AIMS	Good	Good	Good	Up to date	Good	Used in analysis
Administrative boundary-iMMAP	Good	Good	Good	Not up to date	Good	Not used in analysis
Settlements	Not complete, 76 new settlements digitized	Good	Not Good	Not up to date	Good	Used in analysis
Roads	Good	Good	Good	Good	Good	Used in analysis
Afghanistan German geology	Not complete	Good	Good	Good	Good	Not used in analysis
Afghanistan Russian geology	Good	Good	Good	Good	Not complete	Not used in analysis
Afghanistan geology by USGS	Good	Good	Good	Good	Good	Used in analysis
National Land Cover-AIMS	Good	Good	Good	Not up to date	Good, except for the settlements	Used in analysis
Land Cover-WHO	Not complete	Good	Not good: too coarse	Not up to date	Not complete	Not used in analysis
Precipitation	Good	Good	Good	Not up to date	Not complete	Not used in analysis
High resolution image	Good	Good	Good, but varying	No information	Good, but varying	Used in analysis

Table 6.4; Summary of data quality analysis

6.3. Development of a National Risk Management Information System

In 2011 the Government of Afghanistan published a strategic national action plan (SNAP) for disaster risk reduction. In this plan they formulated two main goals:

(1) To develop the linkages between disaster risk reduction strategies, climate change adaptation processes and invulnerable development paradigms with focus on social protection measures and inclusiveness in order to support various initiatives to promote the 'community at peace' principle in Afghanistan; With the following strategic objectives

- Improve the mechanism for disaster risk management, though improved co-ordination and knowledge sharing, adequate data and information support to DRR stakeholders and support with baseline information.

- Strengthen early warning system, which should be people-centred.

(1) To minimize losses caused by disasters and climate change impacts through strategies guided by HFA, with the backdrop of peace and development, through raising of public awareness, strengthening of community resilience and enhance disaster preparedness.

With respect to hazard and risk mapping in Afghanistan a lot of work still needs to be done. A first attempt for hazard mapping was done in 2003 based on a qualitative rating of all provinces in terms of hazard occurrence. Information was collected from local governments based on knowledge of historic hazard events (Gupta, 2010). Flood zoning maps have produced by AIMS in 2005 and by Hagen in 2011. AIMS is mandated to building information management capacity in the Afghan government. It works with government ministries and has regional offices in five cities with the main in Kabul. In the period from 2004 to 2009, a pilot project for Kabul and Kunduz Province was carried out to building capacity in information management for disasters. Also a DMIS (Disaster Management Information system) was developed. However, this cannot be found anywhere online now. The ANDMA indicates also "*How the DMIS is currently being maintained and operated in ANMDA needs a deeper review especially in the context of recent disaster experiences*" (Gupta, 2010). The generation of risk assessments in specific areas for natural disasters and climate change is indicated by ANDMA as a short to long term objective in the period 2011-2015. It is also indicated as a second level priority. Up to now no concrete examples of this have been published.

In the framework of a large project funded by UNDP, called the Comprehensive Disaster and Risk Reduction Project, Afghanistan (CDRRP) one of the components was to develop a national risk management information system. This requires the collection of data on a continuous basis, updating databases, and developing their applications for DRM planning. According to the CDRRP plans it should be a decentralized system of data collection and transmission, which also requires a strong connectivity through communication/ computer networks. The CDRRP project concluded that "*In the current situation in Afghanistan, where local governments deal with a different set of priorities arising from conflict and insurgency, and are also constrained by resources, it is not feasible to expect the existence of databases and communication networks. It would also be difficult to recruit and train people who have the necessary computer skills to support the information system on a wider basis. While some kind of information management system needs to be developed, it needs to be based in the context of the current situation in Afghanistan. For instance, it is more important that information on the distribution of humanitarian assistance is widely available. The proposal mentions conducting a national risk analysis to identify and analyze hazards and vulnerabilities, and conduct more detailed regional risk analyses for geographical regions of Afghanistan. This activity is important from the point of view of planning different activities related to disaster response and mitigation. However, no risk assessment at the national level has been undertaken. Risk management information systems, though important for building DRM systems and capabilities cannot constitute an independent component, particularly in the context of Afghanistan. This is a knowledge-intensive component, and would largely depend upon the availability of expertise. In Afghanistan, it is difficult to identify such expertise. International experts cannot really sustain such efforts. So while such activities could be supported at some scale, they could not be conceived and implemented as an independent component*" (Vatsa, 2010).

6.4. National SDI

In 2007 an initiative was launched funded by USGS and USAID on the establishment of an Afghanistan Spatial Data Infrastructure (ASDI). AGCHO (the national mapping organization) and the CSO (the national statistical organization) initiated the process and requested support from USGS in this respect. A document was made entitled "Workshop Statement and ASDI Road Forward" (Sorensen et al., 2006). The document describes the major components of the ASDI and an implementation plan that outlines a cooperative initiative among all the involved agencies, organizations, and institutions. The following directions were initiated:

- ASDI stakeholder Assessment and Strategic Plan. The aim was to indentify agencies that are primary producers of the base data.

- Major Project Data Coordination. The aim is to link together some of the major projects that deal with spatial information in the country, and focus on the outputs in such a way that these are useful for more stakeholders in the country.
- ASDI Initial Portal website. The aim is to develop a prototype version of the ASDI data warehouse through which the major types of data can be accessed.
- National topographic base map database and map atlas. The aim of this was to produce a national scale baseline topographic database.
- National statistical database and atlas. The data from the CSO would be made available through this initiative
- Agency enterprise capacity building program. Focusing on increasing the capacity of staff in updating of fundamental geographic data sets (FGDS).

Although the implementation of an Afghanistan SDI has started in 2007, the development has been very slow. There are many problems involved related to ownership of data and the NSDI process, and insufficient resources to create, maintain, distribute, and use geospatial data. It has been the United States Geological survey that has actually taken the lead in this process, and initiated the Geospatial Infrastructure Development Project. USGS has been cooperating with the Afghanistan Geological Survey (AGS), the Afghanistan Ministry of Mines and Industries (MMI), and the Afghanistan Geology and Cartography Head Office (AGCHO), and collected, compiled, and digitized existing geologic, topographic and remote sensing data and used them to produce geologic, cartographic, and satellite image map sets of the entire country. They have worked with Afghan partners to develop in-country expertise in various types of mapping, and have also initiated work on a national spatial data infrastructure (NSDI) for Afghanistan. However there is yet no ASDI initial portal website and all data is stored on the USGS portal (CSO and AGCHO, 2007). The further implementation in Afghanistan depends on the various government organisations mentioned in chapter 3, and the understanding of government officials of the benefits to be gained of shared spatial data.

The table below gives an overview of what should be a desired situation with respect to stakeholders involved in spatial data for disaster risk management.

Stakeholder	Actors Main Role	Explanation
Local Communities	RC	Local communities are supposed to be direct beneficiaries of risk management policies. They could be regarded as "information consumers" when they make use of participatory mechanisms to take part in the decision making process, and therefore would require to be informed about the topics under discussion (defining insurance policies, land use management plans, etc.) Communities can also take part in the risk assessment process as "information providers", especially when considering issues related to vulnerability assessment (risk perception, etc.)
Local authorities	RC	Local authorities are mostly using risk information for local decision making. They normally do not have the capacity to generate risk information on their own.
Governmental organizations - sectors	RC RP	Ministries use risk information in their planning processes, they main role is as "information consumers". However, in many cases, the different sectors make use of their own technical resources to produce risk assessment studies; in this case they are also "providers" of information.
National basic data producers	RP	For instance national bureau of statistics, topographic surveys. Though they produce "general purpose" information, they are relevant for the risk

		assessment process.
National thematic organizations	RP	For instance: meteorological, seismological, geological that, generally, should be considered and "information producers"
Disaster management organization	RP RC	A disaster management organization is both generating risk information, and is also using this information for early warning, preparedness planning and disaster prevention.
Private sector	RP RC	Consultants can be important source for specific data for hazard, vulnerability and risk assessment. A special case is also the insurance industry, which can be a RP as RC at the same time. Sometimes the entire process of hazard, vulnerability and risk assessment is done entirely by a consulting company. The private sector as a whole is also RC as beneficiary of disaster risk reduction
NGO	RC RP	NGO's often are actively involved in collecting relevant hazard and vulnerability data at community level. They can also be RC
Universities	RP	Universities can be active in generating hazard and risk information. They can sometimes have the main role in this process
International organizations	RP RC	International organization can bring in additional support for generating hazard and risk information (e.g. World Bank) They also require risk information for making sound investments.

Table 6.5: Different "stakeholders" and "actors" in Disaster Risk Management and their possible roles as Risk Information Consumer (RC) or Risk Information Producer (RP). Adapted from Van Westen (2009)

Also the role of national Universities in this process should be strengthened. The author is working as lecturer at the faculty of Geo Sciences, in Kabul University, where training of new professionals is strongly hindered by the lack of suitable GIS software and even more so by the lack of collaboration with government organizations. Through this research I hope to contribute to increasing the capacity of this University to utilize open source software for Geo information science (e.g. ILWIS) and to utilize freely available data on the country from the internet.

LIST OF REFERENCES

AMBRASEYS, N. & BILHAM, R. 2003. Earthquakes in Afghanistan. *Seismological Research Letters,* 74**,** 107-123.

BELL, R. & GLADE, T. 2004. *Multi-hazard analysis in natural risk assessments,* USA, WIT Press.

BLONG, R. 2003. A new damage index. *Natural hazards,* 30**,** 1-23.

BOYD, O. S., MUELLER, C. S. & RUKSTALES, K. 2007. *Preliminary Earthquake Hazard Map of Afghanistan*, US Geological Survey.

BZ 1995. Disasters and emergencies in Switzerland, a comparative table (KATANOS). Bundesamt für Zivilschutz (BZ). *Bern***,** 37 - 41.

CANTON, L. G. 2006. *Emergency management: concepts and strategies for effective programs*, Wiley-Interscience.

CAPRA 2009. Central American Probabilistic Risk Assessment (CAPRA). World Bank. www.ecapra.org.

CARDONA, O. D. 2005. Indicators for Disaster Risk and Risk Management. Program for Latin America and the Caribbean: Summary Report, Manizales, Columbia: Instituto de Estudios Ambientales, Universidad Nacional de Columbia.

CIESIN. 2005. *Global Multihazard Proportional Economic Loss Risk Deciles. Center for Hazards and Risk Research (CHRR); Center for International Earth Science Information Network (CIESIN), Columbia University. Palisades, Y, http://www.ldeo.columbia.edu/chrr/research/hotspots/* [Online].

COULONDRE, S., LIBOUREL, T. & SPÉRY, L. Metadata and GIS. Proceedings of GIS PlaNET'98, the 1st International Conference and Exhibition on Geographic Information, 1998. Citeseer.

CRONE, A. J. 2007. Earthquakes Pose a Serious Hazard in Afghanistan. US Geological Survey Fact Sheet FS 2007-3027, 4 p. Afghanistan Project No. 155.

CSO & AGCHO 2007. Afghanistan Spatial Data Infrastructure (ASDI), Central Statistic Office (CSO)-Afghan Geodesy and Cartography Head Office (AGCHO). http://www.afghanistan.cr.usgs.gov/downloadfile.php?file=ASDI.

CSO & AGCHO 2007 ASDI - Proposal for the Establishment of the Foundation Program Coordination Office. Discussion draft. Financial and technical support of the United States Geological Survey (USGS) and the United States Agency for International Development (USAID). Afghanistan Central Statistics Office, Afghanistan Geodesy and Cartography Head Office.

DE ROO, A., BARREDO, J., LAVALLE, C., BODIS, K. & BONK, R. 2007. Potential Flood Hazard and Risk Mapping at Pan-European Scale. Digital Terrain Modelling. Lecture Notes in Geoinformation and Cartography, 2007, 183-202. 183-202.

DILLEY, M. 2005. *Natural disaster hotspots: a global risk analysis*, World Bank Publications.

DILLEY, M., CHEN, R. S., DEICHMANN, U., LERNER-LAM, A. L., ARNOLD, M., AGWE, J., BUYS, P., KJEKSTAD, O. & LYON, B. A. Y., G. 2005. Natural Disaster Hotspots: A Global Risk Analysis. The World Bank, Hazard Management Unit, Washington, D.C. Disaster Risk Management Series No. 5,. 132 pp.

EBI, K., WOODRUFF, R., VON HILDEBRAND, A. & CORVALAN, C. 2007. Climate Change-related Health Impacts in the Hindu Kush–Himalayas. *EcoHealth,* 4**,** 264-270.

EL MORJANI, Z. E. A., EBENER, S., BOOS, J., GHAFFAR, E. A. & MUSANI, A. 2007. Modelling the spatial distribution of five natural hazards in the context of the WHO/EMRO Atlas of Disaster Risk as a step towards the reduction of the health impact related to disasters. *International journal of health geographics,* 6**,** 8.

ENIA, J. S. 2012. Peace in its wake? The 2004 tsunami and internal conflict in Indonesia and Sri Lanka. P 9 - 21 http://www.princeton.edu/jpia/past-issues-1/2008/1.pdf.

ERIC, C., WOOD, MARK, S., MOHAMMAD, F. Z. & SAUD, A. A. 2007. The Development of a Spatial Data Infrastructure in Afghanistan, http://www.gsdi.org/gsdiconf/gsdi10/papers/TS18.2paper.pdf.

FAVRE, R. & KAMAL, G. M. 2004. Watershed atlas of Afghanistan. *Kabul: Ministry of Irriga*.

FERRIER, N. & HAQUE, C. E. 2003. Hazards risk assessment methodology for emergency managers: A standardized framework for application. *Natural hazards,* 28**,** 271-290.

GALTUNG, J. 1969. Violence, peace, and peace research. *Journal of peace research,* 6**,** 167-191.

GEONODE 2010. Initiative of OpenGeo and the World Bank. http://www.geonode.org/.

GOODHAND, J., KLEM, B., FONSEKA, D., KEETHAPONCALAN, S. & SARDESAI, S. 2005. *Aid, Conflict, and Peacebuilding in Sri Lanka, 2000-2005*, Asia Foundation Colombo.

GRANGER, K., JONES, T., LEIBA, M., SCOTT, G. & ORGANISATION, A. G. S. 1999. Community risk in Cairns: a multi-hazard risk assessment. *Australian Journal of Emergency Management,* 14**,** 25-26.
GREIVING, S., FLEISCHHAUER, M. & LÜCKENKÖTTER, J. 2006. A Methodology for an integrated risk assessment of spatially relevant hazards. *Journal of Environmental Planning and Management,* 49**,** 1-19.
GRÜNTHAL, G., THIEKEN, A., SCHWARZ, J., RADTKE, K., SMOLKA, A. & MERZ, B. 2006. Comparative risk assessments for the city of Cologne–storms, floods, earthquakes. *Natural Hazards,* 38**,** 21-44.
GUPTA, M. 2010. National Disaster Management Plan of Afghanistan, pg 08 - 22, http://www.andma.gov.af/Contents/295/Documents/226/Updated_Afghanistan_NDMP.pdf.
HAGEN, E. 2010. *Afghanistan Flood Hazard Mapping.* National University of Singapore, P 18 - 74, PhD Thesis.
HAGEN, E. & LU, X. 2011. Let us create flood hazard maps for developing countries. *Natural Hazards,* 58**,** 841-843.
HAGEN, E., SHRODER, J., LU, X. & TEUFERT, J. F. 2010. Reverse engineered flood hazard mapping in Afghanistan: A parsimonious flood map model for developing countries. *Quaternary International,* 226**,** 82-91.
HAGEN, E. & TEUFERT, J. 2009. Flooding in Afghanistan: A crisis. *Threats to Global Water Security***,** 179-185.
IFRCRC 2012. World Disasters Report, International Federation of Red Cross and Red Crescent Societies. Switzerland.
JONKMAN, S. N., KOK, M. & VRIJLING, J. K. 2008. Flood risk assessment in the Netherlands: A case study for dike ring South Holland. *Risk Analysis,* 28**,** 1357-1374.
KAPPES, M., KEILER, M. & GLADE, T. From single-to multi-hazard risk analyses: a concept addressing emerging challenges. 2010. 351-356.
KAPPES, M., KEILER, M., VON ELVERFELDT, K. & GLADE, T. 2012. Challenges of analyzing multi-hazard risk: a review. *Natural Hazards***,** 1-34.
KLAS, W. & SHETH, A. 1994. Metadata for digital media. *SIGMOD RECORD,* 23**,** 19-19.
LIBRARY OF CONGRESS – FEDERAL RESEARCH DIVISION. 2008. *Afghanistan : a country study / Federal Research Division, Library of Congress.* [Online]. Baton Rouge, LA : Claitor's Pub. Division, c2001.: Library of Congress – Federal Research Division. Available: http://memory.loc.gov/frd/cs/profiles/Afghanistan.pdf [Accessed August 26 2012].
MARZOCCHI, W., GARCIA-ARISTIZABAL, A., GASPARINI, P., MASTELLONE, M. & DI RUOCCO, A. 2012. Basic principles of multi-risk assessment: a case study in Italy. *Natural Hazards,* 62**,** 551-573.
MHERE BWANA, M. 1998. Establishment of a GIS database and data quality assessment from digital line graph data sets in Spatial data transfer standard SDTS format. Enschede: ITC.
NORRIS, F. H. 2003. Disasters and domestic violence. *A National Center for PTSD Fact Sheet online at www. ncptsd. org/facts/disasters/fs_domestic. html Last accessed August,* 14**,** 2003.
ORCHESTRA. 2009. *Reference Model–ORCHESTRA Architecture (RM-OA). EC ORCHESTRA project.* [Online]. Available: http://www.eu-orchestra.org/documents.shtml.
POULLADA, L. B. 1973. *Reform and rebellion in Afghanistan, 1919-1929: King Amanullah's failure to modernize a tribal society*, Cornell University Press Ithaca and London.
RUBIN, B. R. 1996. Afghanistan: The forgotten crisis. *Refugee Survey Quarterly,* 15**,** 1-35.
SCHMIDT, J., MATCHAM, I., REESE, S., KING, A., BELL, R., HENDERSON, R., SMART, G., COUSINS, J., SMITH, W. & HERON, D. 2011. Quantitative multi-risk analysis for natural hazards: a framework for multi-risk modelling. *Natural Hazards,* 58**,** 1169-1192.
SORENSEN, MARK, SAYEGH & FARIS 2006. The initiation, growth, and sustainment of SDI in the Middle East—Notes from the trenches. *Information Technology for Development,* 13**,** 95-100.
TCP. 2012. *Development Tracking in Helmand Wiki, Afghan Geodesy and Cartography Head Office (AGCHO), Transational Crisis Project (TCP)* [Online]. Available: http://development-tracking-helmand.wikispaces.com/AGCHO [Accessed 02/01 2013].
UNDRO 1977. Composite vulnerability analysis. A methodology and case study of the metro manila area. Revised technical report of the technical advisory mission (oct. 1976-febr. 1977).
VAN WESTEN, C. J. Remote Sensing and GIS for Natural Hazards Assessment and Disaster Risk Management.

VAN WESTEN, C. J., MONTOYA, A. L., BOERBOOM, L. G. J. & BADILLA COTO, E. 2002. Multi - hazard risk assessment using GIS in urban areas : a case study for the city of Turrialba, Costa Rica. *In: Proceedings of the regional workshop on best practices in disaster mitigation : lessons learned from the Asian urban disaster mitigation program and other initiatives, 24-26 September 2002, Bali, Indonesia. pp. 120-136*.

VATSA, K. S. 2010. Comprehensive Disaster and Risk Reduction Project, Afghanistan. P 05 - 16.

VEKERDY, Z., DOST, R. J. J., REININK, G. & PARTOW, H. 2006. History of environmental change in the Sistan Basin : based on satellite image analysis: 1976 - 2005. Geneva & Enschede: United Nations Environmental Programme (UNEP) & International Training Center (ITC).

WFP. 2012. *Food Security Atlas of Afghanistan. World Food Program (WFP)* [Online]. Available: http://www.foodsecurityatlas.org/afg/country [Accessed 02/04 2013].

WIKIPEDIA. 2012. *Kunduz Province. Wikipedia the free Encyclopedia* [Online]. Available: http://en.wikipedia.org/wiki/Kunduz_Province [Accessed 02/01 2013].

WISNER, B. 2009. Interactions between Conflict and Natural Hazards: Swords, Ploughshares, Earthquakes, Floods and Storms. *In:* BRAUCH, H. G., SPRING, Ú. O., GRIN, J., MESJASZ, C., KAMERI-MBOTE, P., BEHERA, N. C., CHOUROU, B. & KRUMMENACHER, H. (eds.). Springer Berlin Heidelberg.

WISNER, B., BLAIKIE, P. & CANNON, T. 2004. At risk: natural hazards, peoples vulnerability and disasters. . *London*.

ANNEXES

Annex 1: Afghanistan National Landcover Metadata

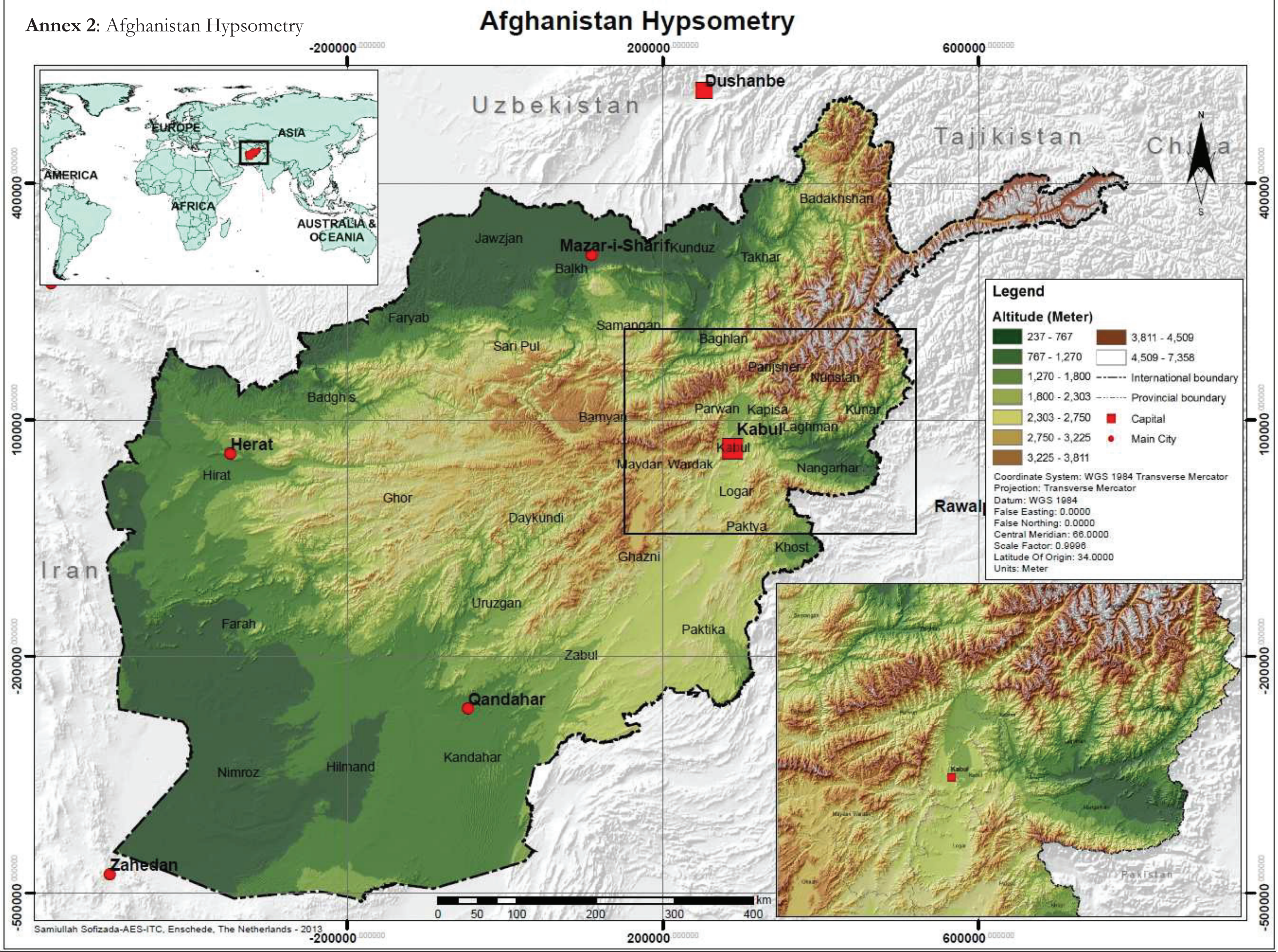
```
Identification_Information:
  Citation:
    Citation_Information:
      Originator: Afghanistan Information Management Service(AIMS)
      Publication_Date: 1997
      Title: National Landcover
      Geospatial_Data_Presentation_Form: Vector Digital Data
      Publication_Information:
        Publication_Place: Islamabad, Pakistan
        Publisher: Afghanistan Information Management Sevice(AIMS)
      Online_Linkage: <http://www.aims.org.af/home/sroots.asp?seckeyz=z2&secido=2&seckeyt=a10>
  Description:
    Abstract: This layer depicts (nationwide rain fed crops, natural forests, permanent marshlands, seasonal
marshlands, intensively cultivated, sand dunes, sand covered areas, rocks, outcrop/bare soil, fruit trees,
vine yards, gardens, and pistachio), mapped at 1:250,000 scale.  The source of this layer is Food and
Agriculture Organization (FAO) and the dates of the satellite is 1992.
    Purpose: This layer provides a ready reference for country landcover and type of landuse at 1:250,000
scale. Not for use at scales larger than 1:250,000. Data at this scale is suitable for general use in
regional studies and planning.
  Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 1997-2004
    Currentness_Reference: Source Dates
  Status:
    Progress: Complete
    Maintenance_and_Update_Frequency: As needed
  Spatial_Domain:
    Bounding_Coordinates:
      West_Bounding_Coordinate: 60
      East_Bounding_Coordinate: 75
      North_Bounding_Coordinate: 39
      South_Bounding_Coordinate: 29
  Keywords:
    Theme:
      Theme_Keyword_Thesaurus: Landcover
      Theme_Keyword: Agriculture land
      Theme_Keyword: Forest
      Theme_Keyword: Landuse
    Place:
      Place_Keyword: Afghanistan
      Place_Keyword: Kabul
      Place_Keyword: Afghanistan Information Management Service(AIMS)
  Access_Constraints: Secondary distribution by permission only. Please visit Afghanistan Information
Management Service (AIMS) office for permission. Any secondary distribution must have this documentation
appended.
  Use_Constraints:
    Users must assume responsibility in determining the usability of this data for their purposes. Digital
maps retain the accuracy of their source materials. In the use of AIMS GIS data, please check sources,
scale, accuracy, currentness and other available information. Please confirm that you are using the most
recent copy of both data and metadata from the AIMS GIS Data Catalog. The Afghanistan Information Managment
Service (AIMS) provides notice of updates and corrections directly to the AIMS GIS Technical Group.

    AIMS is not responsible for local edits to data or metadata. Updates, corrections, and feedback,
incorporated in the AIMS GIS database are made in accordance with "Data Standards for AIMS Geographic
Information Systems".
  Point_of_Contact:
    Contact_Information:
      Contact_Person_Primary:
        Contact_Person: Zohra Sulaiman
        Contact_Organization: Afghanistan Information Management Service (AIMS)
      Contact_Position: Staff Assistant
      Contact_Address:
        Address_Type: Mailing and Physical Address
        Address:
          UNDP/AIMS Salang Watt
          Next to Inhesarat
          House No.12
        City: Kabul
        State_or_Province: Kabul
        Postal_Code: PO Box 005
        Country: Afghanistan
      Contact_Voice_Telephone: 00-93(0)70-248827
      Contact_Facsimile_Telephone: None
      Contact_Electronic_Mail_Address: info@aims.org.af
      Hours_of_Service: Sunday through Thursday 0800 - 1700 (GMT +4:30)
  Native_Data_Set_Environment: Tkme, standard software for Metadata creation provided by United States
Geological Survey (USGS)
Data_Quality_Information:
```

```
  Attribute_Accuracy:
  Completeness_Report: Data set is complete
  Lineage:
    Source_Information:
      Source_Citation:
        Citation_Information:
          Originator: United Nations Food and Agriculture Organization(UNFAO)
          Publication_Date: 1993
          Title: National Landcover
          Geospatial_Data_Presentation_Form: Vector digital data
          Series_Information:
          Publication_Information:
          Online_Linkage: <http://www.aims.org.af/home/sroots.asp?seckeyz=z2&secido=2&seckeyt=a10>
      Type_of_Source_Media: Vector digital data
    Process_Step:
      Process_Description: This layer, contains landcover for Afganistan. The shapefile is polygon layer and
was created in  ArcView 3.x.  Shapefile attributes were carefully examined for accuracy based on existing
source material (LandSat Imagery)and limitations of scale. The shapefile was CLEANED and BUILT with POLYGON
shapfile.
      Process_Date: 1990-2004
Spatial_Data_Organization_Information:
  Direct_Spatial_Reference_Method: Vector
  Point_and_Vector_Object_Information:
    SDTS_Terms_Description:
      SDTS_Point_and_Vector_Object_Type: Polygon
      Point_and_Vector_Object_Count: 22792 records
  Raster_Object_Information:
    Raster_Object_Type: None
Spatial_Reference_Information:
  Horizontal_Coordinate_System_Definition:
    Geographic:
      Latitude_Resolution: 0.000000
      Longitude_Resolution: 0.000000
      Geographic_Coordinate_Units: Decimal degrees
    Geodetic_Model:
      Horizontal_Datum_Name: WGS84
      Ellipsoid_Name: WGS84
      Semi-major_Axis: 6378206.400000
      Denominator_of_Flattening_Ratio: 294.978698
Entity_and_Attribute_Information:
  Detailed_Description:
    Entity_Type:
      Entity_Type_Label: national landcover.dbf
Distribution_Information:
  Resource_Description: None
  Standard_Order_Process:
    Digital_Form:
      Digital_Transfer_Information:
        Transfer_Size: 52.5MB
Metadata_Reference_Information:
  Metadata_Date: 02/03/2005
  Metadata_Review_Date: None
  Metadata_Contact:
    Contact_Information:
      Contact_Person_Primary:
        Contact_Person: Ahmad Munir Qureshi
        Contact_Organization: Afghanistan Information Management Service (AIMS)
      Contact_Position: Geographic Information System (GIS) Assistant
      Contact_Address:
        Address_Type: Mailing and Physical Address
        Address:
          UNDP/AIMS Salang Watt
          Next to Inhesarat
          House No.12.
        City: Kabul
        State_or_Province: Kabul
        Postal_Code: Central Post Office Box No 005
        Country: Afghanistan
      Contact_Voice_Telephone: 00-93(0)79347536
      Contact_Electronic_Mail_Address: ahmad.qureshi@aims.org.af
      Hours_of_Service: Sunday through Thursday 0800 - 1700hrs (GMT +4:30)
  Metadata_Standard_Name: AIMS Mapping Standard Metadata
  Metadata_Standard_Version: AIMS-STD-001-2004
  Metadata_Time_Convention: Local Time
  Metadata_Extensions:
    Online_Linkage: <http://www.aims.org.af/home/sroots.asp?seckeyz=z2&secido=2&seckeyt=a10>
    Profile_Name: AIMS Mapping Standard Metadata
```

The geodata, maps and shapefiles found on the MapCruzin.com website may come from a variety of government and private sources. While we try to assure the accuracy of this material, we cannot promise that it is absolutely accurate. We do promise that using this will be fun, entertaining or educational. Beyond this, we make no guarantee as to its suitability for any purpose. We assume no liability or responsibility for errors or inaccuracies. Please understand that you use this at your own risk.

Visit mapcruzin.com for more free shapefiles, maps, GIS software, tools and resources.

Annex 2: Afghanistan Hypsometry

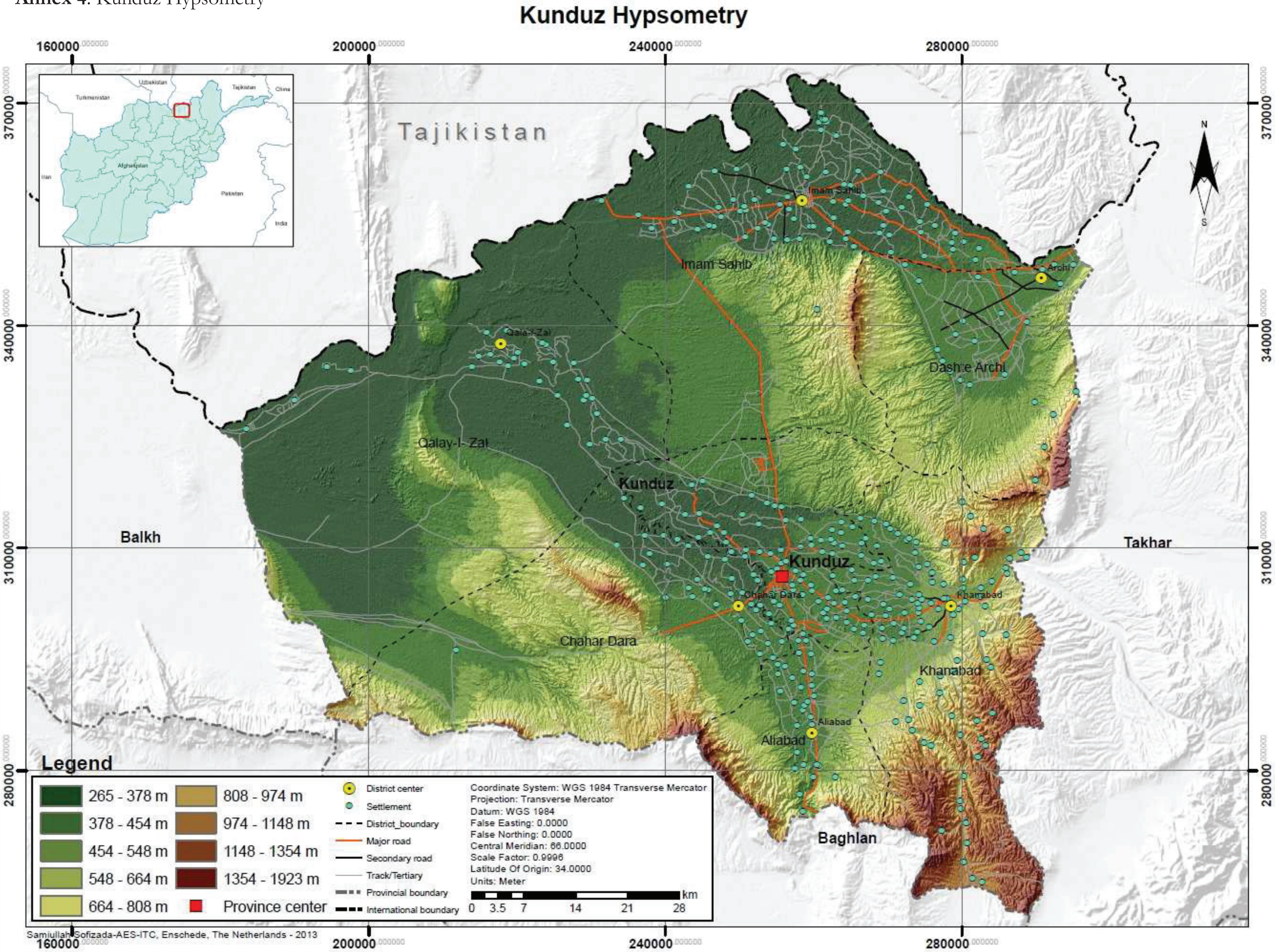


Annex 3: List of collected data

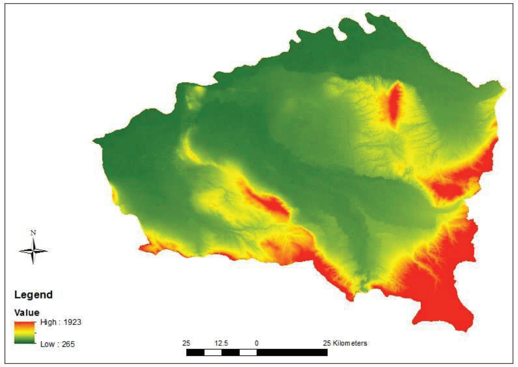
Data	Type	Date	Source	Usage	Comment
AFG_admin_34_0	Polygon Shapefile	2009	AIMS	Used	Country boundary
AFG_admin_34_1	Polygon Shapefile	2009	AIMS	Used	Province boundary
AFG_admin_34_2	Polygon Shapefile	2009	AIMS	Used	District boundary
AFG_roads	Line Shapefile	2009	ESRI	Used	different type of road
AFG_locations	Point Shapefile		ESRI	Used	obtained from USGS
AFG_water_area	Polygon Shapefile	2009	AIMS	Not used	lakes, dams
Google_Image	Raster		Google	Used	3.5 meter resolution
AFG_populaton	Polygon Shapefile	2011	i-MMAP	Used	Population data by CSO
AFG_SRTM_DEM_90m	Raster		USGS	Used	90 m resolution
Kunduz_ASTER_GDEM_30m	Raster		ASTER WEB	Used	30 m resolution
Afghanistan_Russian_Geology_Tectonics	Line Shapefile		USGS	Used	obtained from USGS
Afghanistan_Russian_Geology_Units	Polygon Shapefile		USGS	Not used	obtained from USGS
Afghanistan_Russian_Inset_Largest_Faults	Line Shapefile		USGS	Used	obtained from USGS
AFG_german500k_Dunes.shp	Polygon Shapefile		USGS	Not used	obtained from USGS
AFG_german500k_geology.shp	Polygon Shapefile		USGS	Not used	obtained from USGS
AFG_german500k_structure.shp	Line Shapefile		USGS	Used	obtained from USGS
Afghanistan_Russian_Inset_Tectonic_Regions	Polygon Shapefile		USGS	Not used	obtained from USGS
Afghanistan_Russian_Misc_Structural_Areas	Polygon Shapefile		USGS	Not used	obtained from USGS
Afghanistan_Russian_Tectonic_Regions	Polygon Shapefile		USGS	Not used	obtained from USGS
Afghanistan_Russian_Tectonic_Structure	Line Shapefile		USGS	Used	obtained from USGS
AFG_airports_airfields	Point Shapefile	2000	AIMS	Used	obtained from USGS
Cultivated_area	Polygon Shapefile	1997	AIMS	Used	1:250,000
AFG_LandScan_population	Raster	2008	Dr.Emlyn Hagen	Not used	100 m resolution
Health_facilities	Point Shapefile	2003	AIMS	Not used	obtained from USGS
AFG_international_airports	Point Shapefile	2000	AIMS	Not used	obtained from USGS
Irrigated_areas	Polygon Shapefile	1997	AIMS	Used	obtained from USGS
AFG_lakes	Polygon Shapefile	1997	AIMS	Not used	obtained from USGS
AFG_National Landcover	Polygon Shapefile	1997	AIMS	Used	obtained from USGS
AFG_river_line	Line Shapefile	1990	USAID	Used	1:100,000
AFG_river_region	Polygon Shapefile	1997	AIMS	Used	obtained from USGS
AFG_settlements_1	Point Shapefile		GRUMP	Not used	obtained from USGS

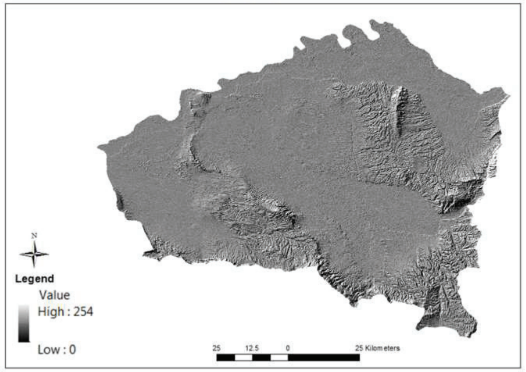
AFG_settlements_2	Point Shapefile	1997	AIMS	Used	obtained from USGS
AFG_watershed	Polygon Shapefile	2003	AIMS	Not used	obtained from USGS
AFG_weather_stations	Point Shapefile		WHO	Not used	
AFG_percipitation	Raster		WHO	Not used	0.008333, very coarse
AFG_Landcover	Raster		WHO	Used	0.008333, very coarse
AFG_geology	Polygon Shapefile		WHO	Not used	
AFG_SRTM_DEM	Raster		WHO	Not used	10660
AFG_geology_USGS	PDF		USGS	Used	
Kunduz_slope	Raster			Used	using ASTER GDEM
Kunduz_aspect	Raster			Used	using ASTER GDEM
Kunduz_curvature	Raster			Used	using ASTER GDEM
Kunduz_hillshade	Raster			Used	using ASTER GDEM

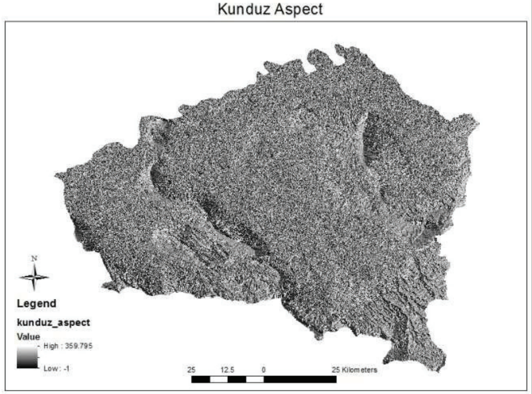
Annex 4: Kunduz Hypsometry

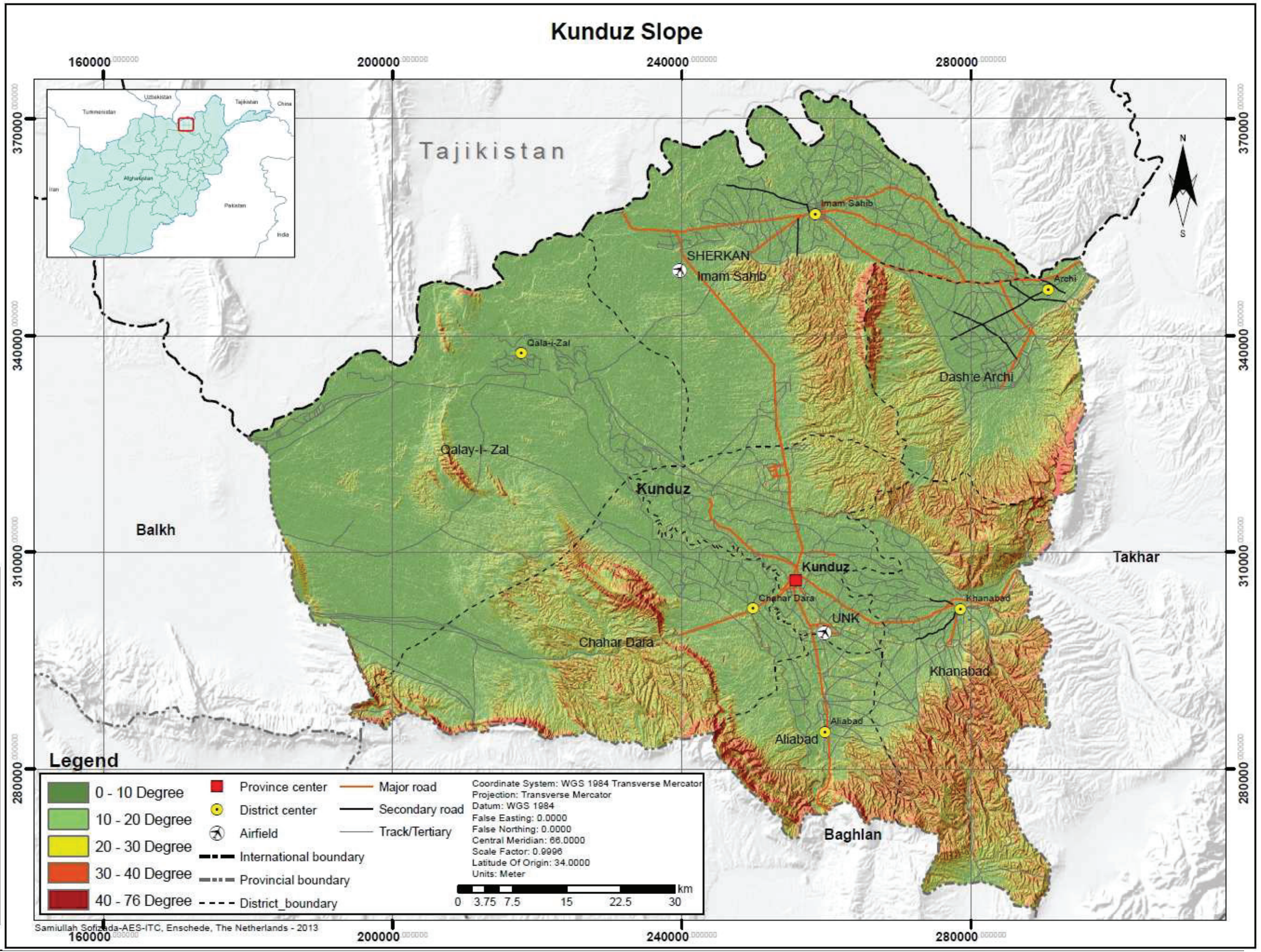


Annex 5: List of maps Generated from ASTER GDM 30 m

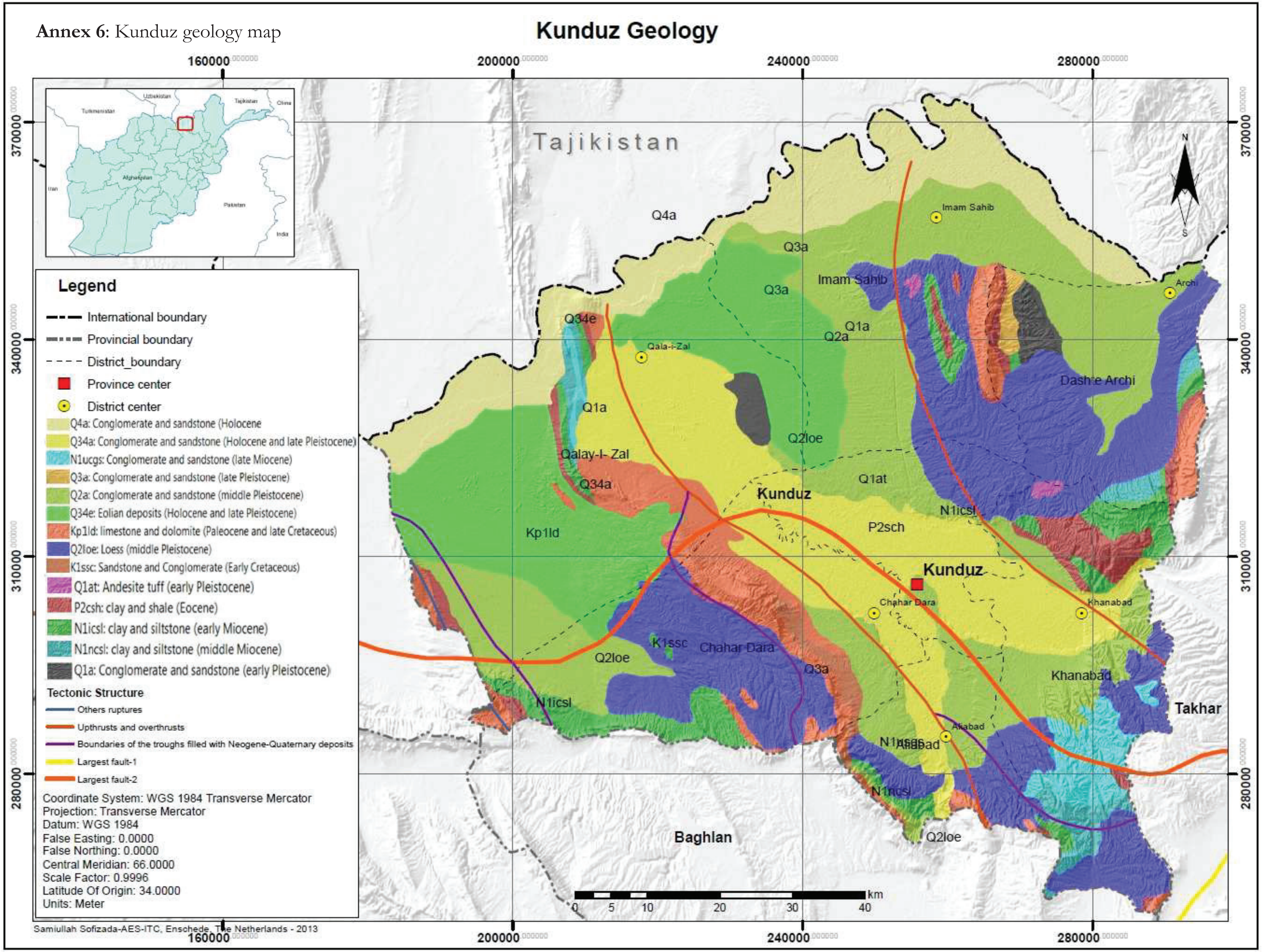




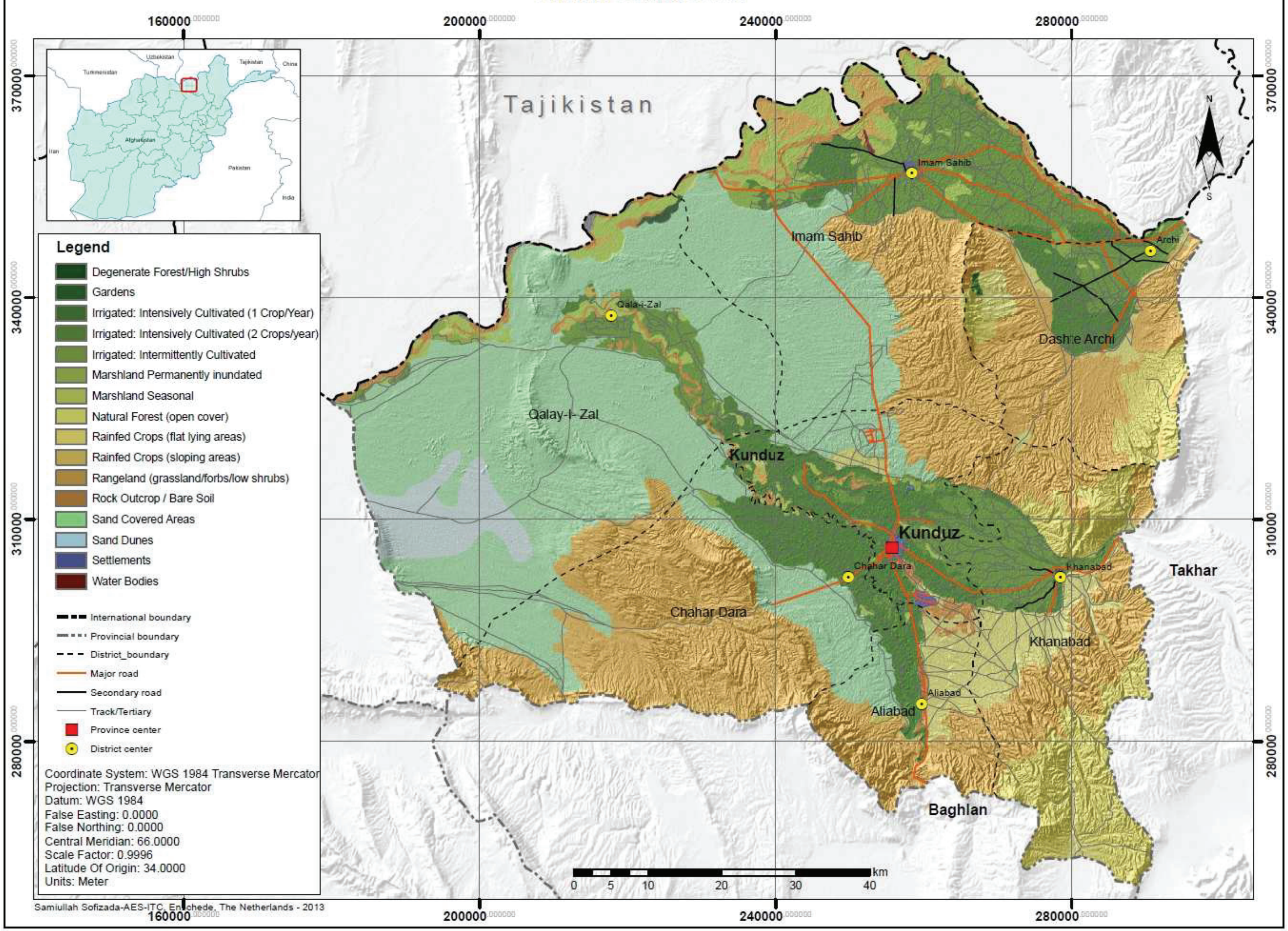




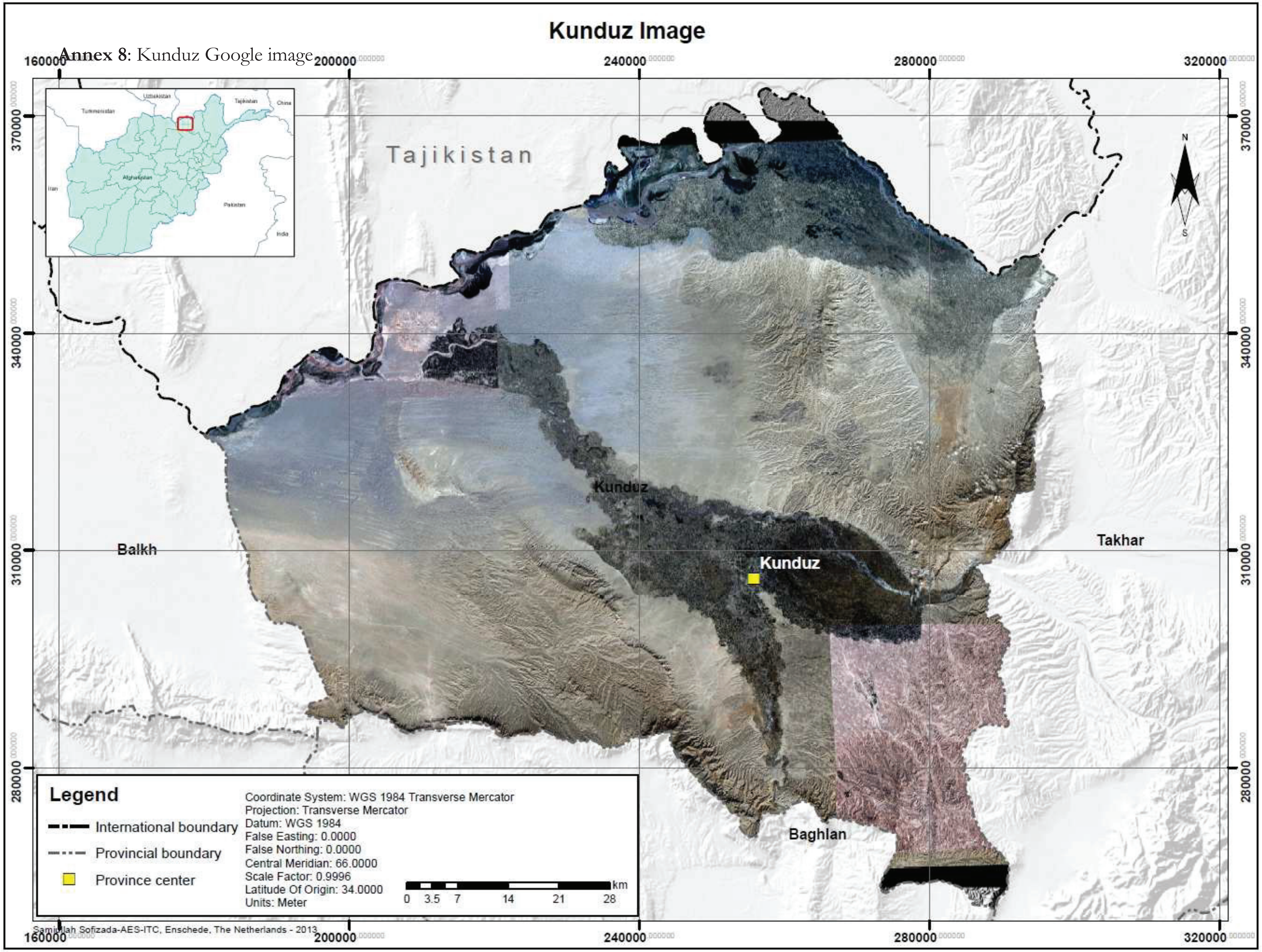
Annex 6: Kunduz geology map



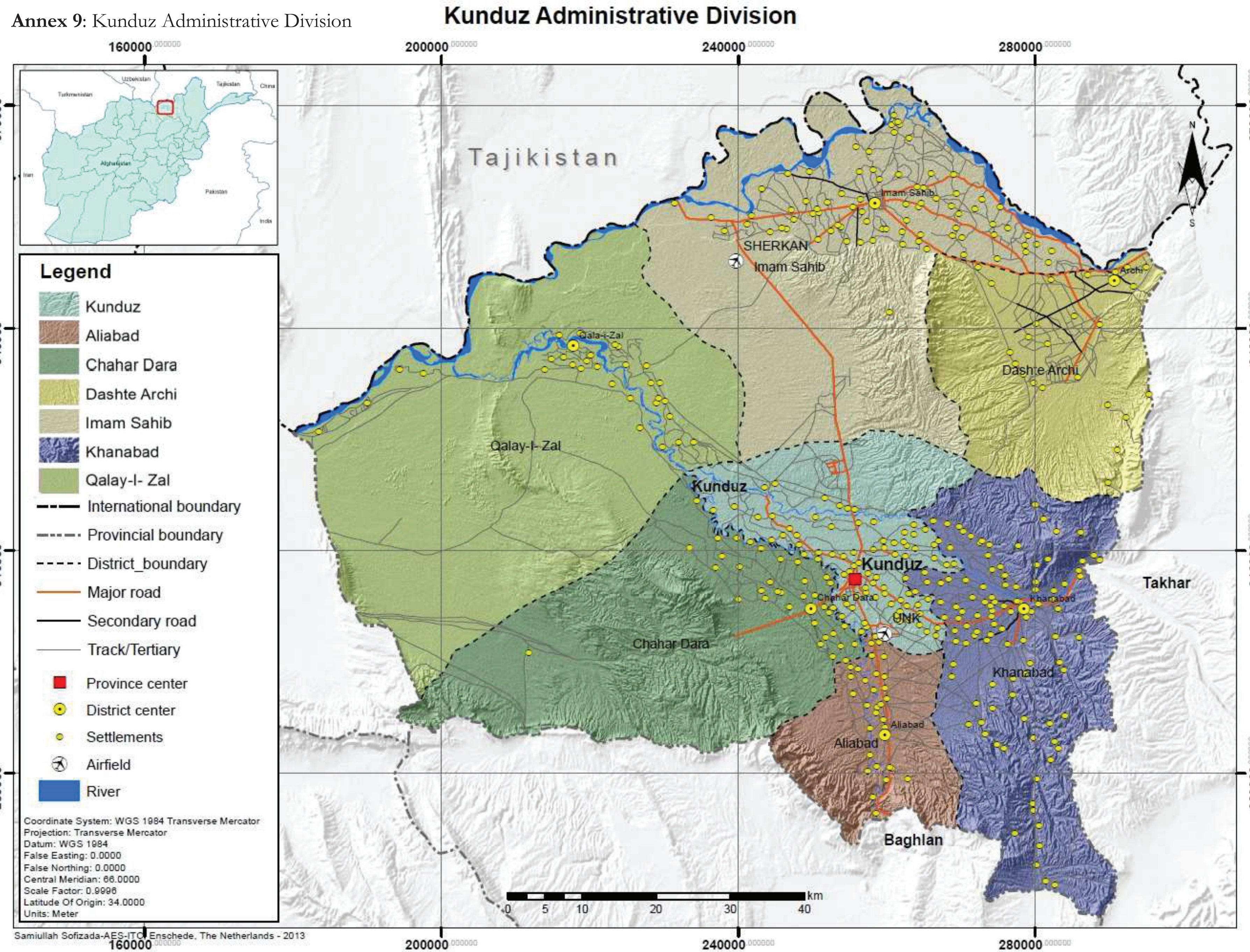
Annex 7: Kunduz landcover map



Annex 8: Kunduz Google image



Annex 9: Kunduz Administrative Division

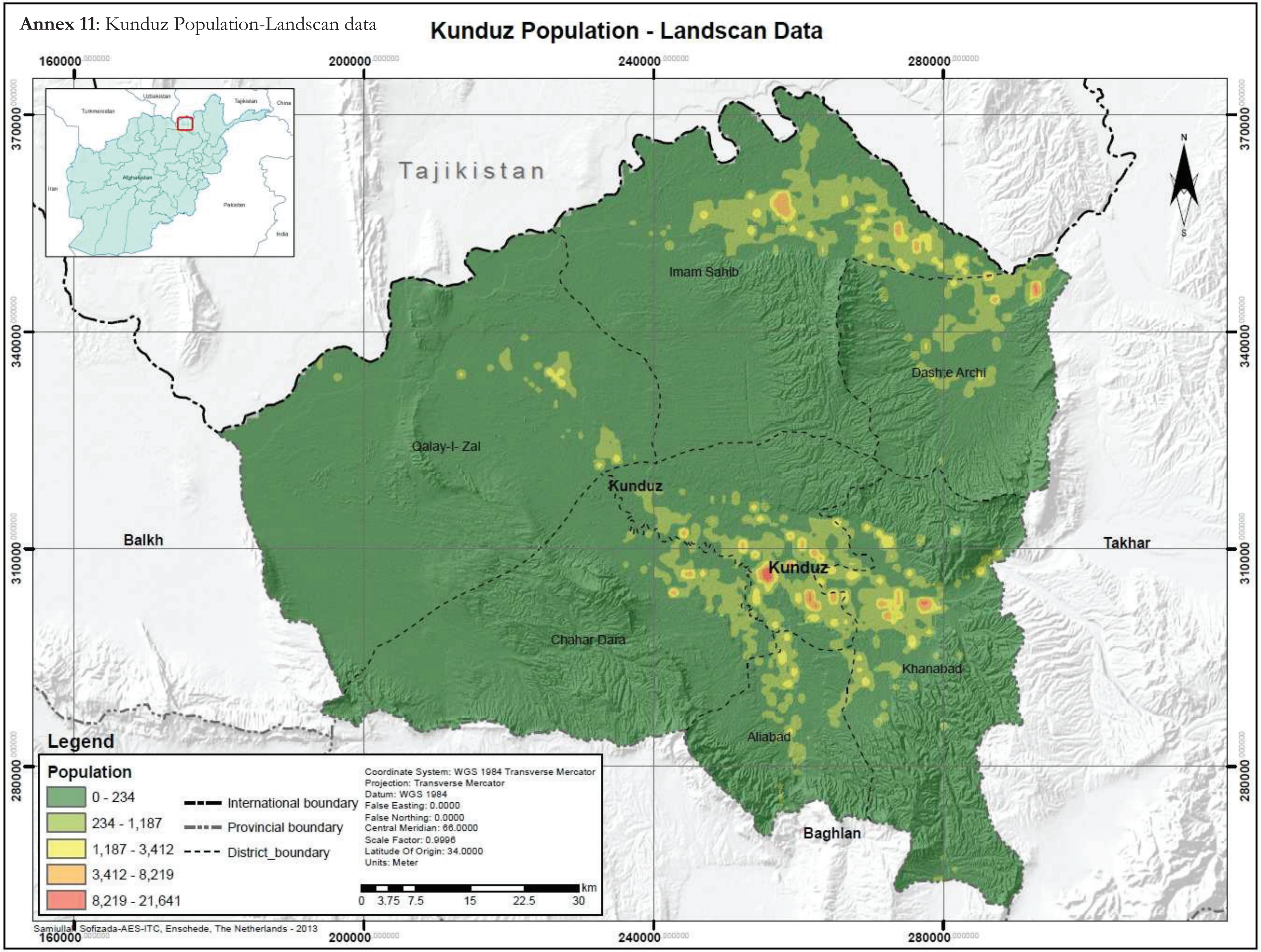


Annex 10: list of hazard collected data

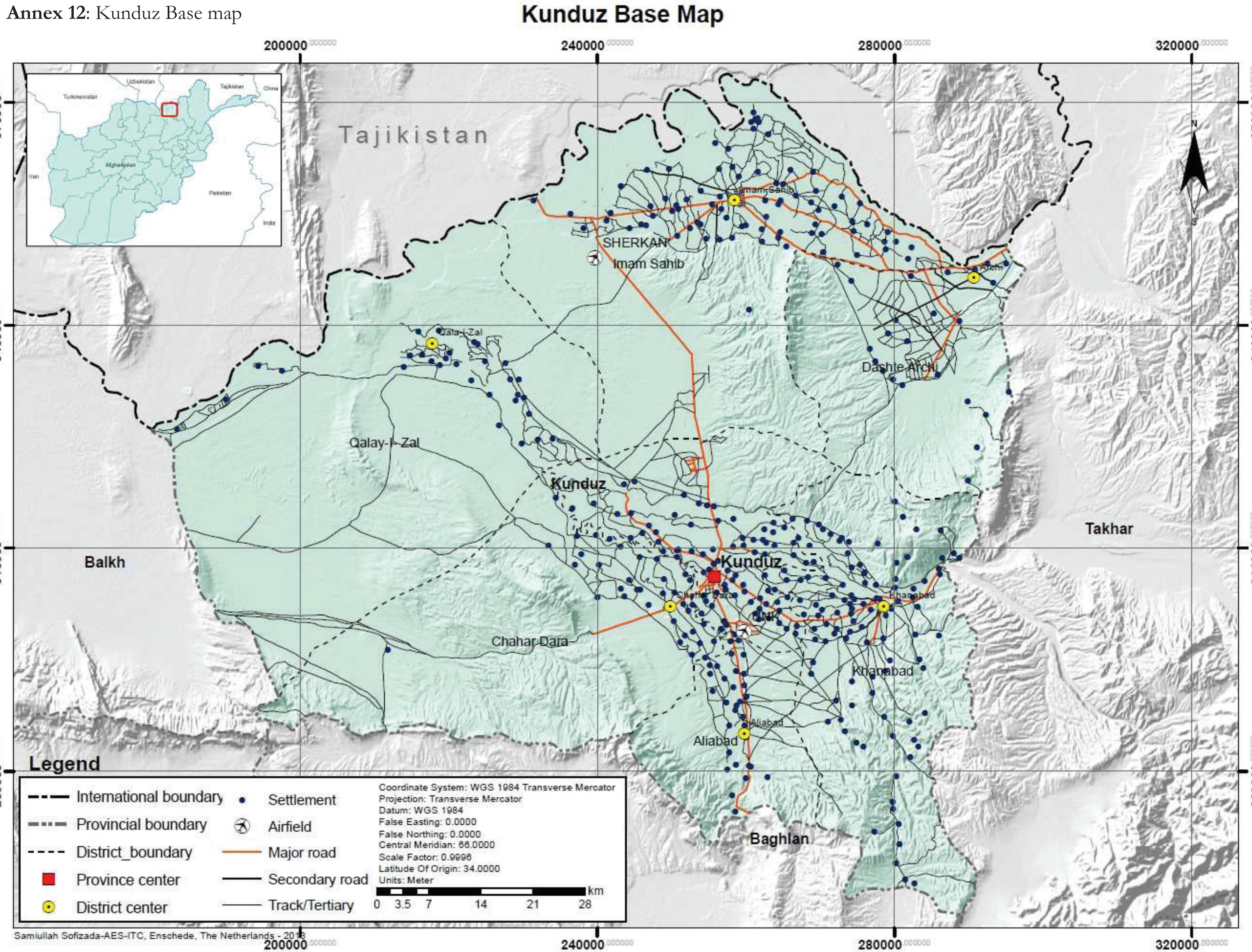
Data	Type	Date	Source
Afghanistan flood hazard map 029 cm	Polygon shape file	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map 0121 cm	Polygon shape file	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map 0271 cm	Polygon shape file	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map	Raster	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map 029cm AmuDarya Basin	Kml	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map 029cm FarahRod Basin	Kml	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map 029cm Helmand Basin	Kml	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map 029cm Indus Basin	Kml	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map 029cm Northern Basin	Kml	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map 121cm AmuDarya Basin	Kml	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map 121cm FarahRod Basin	Kml	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map 121cm Helmand Basin	Kml	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map 121cm Indus Basin	Kml	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map 121cm Northern Basin	Kml	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map 271cm AmuDarya Basin	Kml	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map 271cm FarahRod Basin	Kml	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map 271cm Helmand Basin	Kml	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map 271cm Indus Basin	Kml	14/07/2009	Emlyn Hagen
Afghanistan flood hazard map 271cm Northern Basin	Kml	14/07/2009	Emlyn Hagen
Afghanistan 1% earthquke hazard in 050	Line shape file	2007	USGS
Afghanistan 1% earthquke hazard in 050	Polygon shape file	2007	USGS
Afghanistan 1% earthquke hazard in 050	Point shape file	2007	USGS
Afghanistan 1% earthquke hazard in 250	Line shape file	2007	USGS
Afghanistan 1% earthquke hazard in 250	Polygon shape file	2007	USGS
Afghanistan 1% earthquke hazard in 250	Point shape file	2007	USGS
Afghanistan 5% earthquke hazard in 050	Line shape file	2007	USGS
Afghanistan 5% earthquke hazard in 050	Polygon shape file	2007	USGS
Afghanistan 5% earthquke hazard in 050	Point shape file	2007	USGS
Afghanistan 5% earthquke hazard in 250	Line shape file	2007	USGS

Afghanistan 5% earthquke hazard in 250	Polygon shape file	2007	USGS
Afghanistan 5% earthquke hazard in 250	Point shape file	2007	USGS
Afghanistan peak ground acceleration 050	Line shape file	2007	USGS
Afghanistan peak ground acceleration 250	Polygon shape file	2007	USGS
Afghanistan peak ground acceleration 250 intensity	Point shape file	2007	USGS
Afghanistan seismicity	Point shape file	2007	USGS
Afghanistan earthquake Master catalog	Txt	2007	USGS
Afghanistan earthquake Sub-threshold catalog	Txt	2007	USGS
Afghanistan earthquake Summary catalog	Txt	2007	USGS
Afghan Seismicity	Point shape file	2007	USGS
Afghanistan Isoseismal Epicenters	Point shape file	2007	USGS
Dartmouth Flood Observatory Afghanistan Single Feature	Polygon shape file		Emlyn Hagen
Dartmouth Flood Observatory Merged Layers With Stats	Polygon shape file		Emlyn Hagen
Dartmouth Floods Observatory Merged Layers	Polygon shape file		Emlyn Hagen

Annex 11: Kunduz Population-Landscan data



Annex 12: Kunduz Base map



Annex 13: Kunduz Recorded Earthquake events