Developing an approach for analysing the possible impact of natural hazards on cultural heritage: a case study in the Upper Svaneti region of Georgia

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by

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Abstract

The possible impact of natural hazards on cultural heritage represents an important issue that requires a multi-disciplinary approach. The assessment of the state of conservation of individual cultural heritage objects is an essential element in the overall assessment of vulnerability. The protection of cultural heritage from natural hazards requires also a comprehensive strategy that includes risk assessment and the participation of the local community. This study aims to develop an approach to assess the possible impacts of landslides and avalanches on cultural heritage. It also aims to explore ways of integrating risk elements into cultural management plans. Two communities in Upper Svaneti in Georgia (Ushguli and Mulakhi) were chosen as a test sites because of their rich cultural heritage surrounded by a priori natural hazard prone environment.

The vulnerability of 60 cultural heritage objects has been evaluated through a conservation index calculation which served as an input in a Spatial Multi-criteria Evaluation (SMCE) using ILWIS software. Factor parameters for landslide (slope, landcover, lithology and drainage density) and avalanche (slope, insolation, slope curvature and landcover) have been used to calculate hazard susceptibility in the study areas using SMCE. Hazard risk was finally calculated combining hazard susceptibility areas and cultural heritage objects vulnerability.

A combination of local and expert knowledge has been used to extract information on both cultural heritage and natural hazards.

Findings show that the cultural heritage objects assessed in this study are not particularly affected by landslides and avalanches. Rather, it is the lack of maintenance the main factor influencing the degradation of these cultural heritage features.

Existing management plans were also analysed with the aim of assessing the presence/absence of hazard elements in those plans. The findings show that hazard risk is generally not included in cultural management plans. Finally some guidelines and recommendations are given related to natural hazards and cultural heritage in the context of the study areas.

This study attempts to demonstrate how a non-expert based approach can be used to assess vulnerability of cultural heritage hence priorities of action can be taken.

Keywords: Cultural heritage; Conservation index; Local knowledge; Expert knowledge; Landslide; Avalanche; SMCE; Multi-hazard mapping; Management plans.

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დიდი მადლობა to all of them...

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1. Introduction

1.1. Research Background and Significance

The right to a cultural heritage is an integral element of humanity, as implied in Article 27 of the United Nation' Universal Declaration of Human Rights, (Mitsakaki and Laoupi, 2009).

The preservation of Cultural Heritage is very important as it represents the legacy of human beings on the planet as well as evidence of their activities in different living conditions and environments (Canuti et al., 2009).

However, cultural heritage is vanishing at a global scale, especially in developing countries and if this trend continues, many significant cultural features which represent the remaining foundations of humankind's history will be lost forever (Global Heritage Fund, 2009).

According to the Global Heritage Fund (2009), the losses in the past decade include ancient monuments, buildings, archaeological sites, and even entire historic cities and townscapes, all of which had survived for hundreds or even thousands of years. The damage to cultural heritage sites appears widespread and accelerating and represents a permanent loss to the planet, comparable to endangered species loss. On the whole, the loss of cultural heritage "will deprive present and future generations of the possibility to enjoy and learn lessons from the accumulated wisdom of the past" (De Silva, 2003).

Although international and local awareness of this crisis remains low (Global Heritage Fund, 2009), there is an increased concern for the preservation of cultural heritage as it provides important resources for culture, tourism and the economy (Lollino and Audisio, 2006). Many of these architectural features have a high artistic and cultural value, but they are immobile entities subject to different types of disruptions (Canuti et al., 2009).

Landslides, floods and earthquakes impact many cultural heritage sites every year severely damaging and sometimes completely destroying the cultural assets in question. For example, the devastating floods in central Europe in 2002 severly damaged many cultural assets in World Heritage towns such as Cesky Krumlov and Prague (Taboroff, 2003). BBC News (2002) commented from the flooded city of Dresden that, "The people here have been as concerned for their own properties as they are for the future of their historic buildings". Also the city of Bam in Iran, included in the list of Unesco's World Heritage Sites, was struck by an earthquake in 2003 completely destroying the 2000 year old Citadel which was considered one of the best surviving mud citadels before the quake (BBC News, 2003).

On top of that, the number and intensity of natural disasters are expected to rise in the course of the climatic changes now being observed on the earth (World Bank, 2006), with the consequent adverse effects on the world's cultural heritage.

Without sufficient funding and expertise for prevention, few developing countries can prepare effectively to reduce their cultural heritage sites' exposure to risk, remaining vulnerable to damage or destruction from natural hazards (Global Heritage Fund, 2009). However, with adequate expertise and funding, appropriate strategies can be put in place and proper risk management plans can be built including cultural heritage risk assessments in their general plans. However, the current picture, especially in developing countries, is that risk management plans get neglected with time due to changing priorities or lack of enthusiasm from management (De Silva, 2003). According to Meier and Will (2007), experiences in the field of cultural heritage and disaster management are still relatively scattered, and there is a great need for clarification of fundamental issues including risk assessment; the possibilities and limitations of technical adaptation and retrofitting of historic buildings to withstand disasters; and the paradox of endangerment through prevention. Furthermore, ethical aspects should be addressed in relation to potential conflicts between the urgent protection of people and the protection of cultural property (Meier and Will, 2007). Taboroff (2000) recognises cultural heritage being at risk from natural hazards, especially in low-income countries. She considers that the risk increases in the absence of adequate risk estimation, evaluation, and reduction measures. According to Taboroff (2000) the reason behind the nearly complete absence of effective risk management of cultural assets is because of inadequate knowledge of the assets themselves, failure to calculate the true cost of loss damage, and the difficulty of putting a value on the nonmarket nature of many cultural heritage values. More recently, Abhas (2010) also recognises the importance of the socioeconomic value of cultural heritage as a way of mitigating risk before disaster strikes.

A study by the International Council on Monuments and Sites (ICOMOS) in 14 mainly industrialised countries showed that natural hazard risk analyses are not generally included into overall cultural heritage management plans, meaning also that developing countries are even less ready to deal with the protection of cultural heritage from natural disasters (Taboroff, 2003).

1.2. Research Problem

Georgia as in other Republics of the former Soviet Union suffered in a dramatic way the influence of the Soviet period. Stalin's rule (1929-1953) was characterised as a period of unconditional and implicit power over the official culture and ideology. In post-soviet times and especially during the period 1993-2003, Georgia faced financial problems and engaged in a political overhaul aimed at balancing national and liberal-democratic ideas. The cultural infrastructure that remained from the Soviet period required reform. Cultural policy in Georgia had no clear strategic focus, even though it was declared as one of the state's priorities. However, a systematic change in cultural policy can be seen at the end of 2003. Government priorities shifted and were focused on institutional reform, protection of cultural heritage and rehabilitation of infrastructure in the sphere of culture (COMPENDIUM, 2010).

Upper Svaneti is a mountainous region situated in the northwest of Georgia. This area has strong cultural heritage and traditions which are highly valued by many of the Svan population (Engel et al., 2006). Many important architectural monuments are found in this region, such as prominent churches, many of which have murals of the Middle Ages; and residential/defensive architecture, in the form of towers, and fortified dwellings, many of which date back also to the Middle Ages (GPAP-Georgia Protected Areas Development Project, 2008).

To preserve both the cultural and scenic value of cultural heritage objects in an exceptional mountain landscape the village Chazhashi (one of the 4 villages in Ushguli community, Mestia district, Upper Svaneti) was included in UNESCO World Heritage List in 1996 (UNESCO, 2010). Therefore, the Georgian State, especially the National Agency for Cultural Heritage Preservation of Georgia, and some other national and international organizations such as ICOMOS Georgia; Georgian Arts and Culture Centre; and UNESCO itself, are eager to preserve the culture heritage of these communities (Engel et al., 2006). However, the reality shows that at present no adequate management structure and related human resources, no state funding for the preservation of cultural heritage sites in Upper Svaneti are available (Marina Khenia, ICOMOS-Georgia, personal communication, 14th September, 2010). Neither a cultural heritage census nor information on the state of conservation of cultural heritage features for the area is available (COMPENDIUM, 2010) with the exception of a conservation plan carried out by ICOMOS in the village of Chazhashi in 2001 (ICOMOS, 2001a). The result is a progressive general decay of the cultural heritage features in Upper Svaneti.

Due to its climatic, topographic and geomorphic conditions, Upper Svaneti is also an area prone to natural hazards (Engel et al., 2006). Consequently, cultural heritage objects may be at risk of such natural events showing different levels of vulnerability depending on their state of conservation. Another important element at risk in the area is the only road linking the main town of Mestia to the Ushguli community as it gets often blocked by avalanches and landslides, especially during the up to nine months of winter and spring (Ushguli local community member, personal communication, 21th September, 2010). As a result, the Ushguli community gets frequently isolated from the outer world (ICOMOS, 2001a). Looking at which types of natural hazards may affect cultural heritage in Georgia, Abhas (2010), for example, gives an account on cultural heritage prevention and conservation measures related to seismic activity, such as stabilising buildings and archiving old manuscripts. In Upper Svaneti, floods, avalanches and landslides are reported to be the main natural hazards (Engel et al., 2006). The Upper Svaneti Protected Areas Management Plan (2008) also recognizes seismic activity together with landslides, avalanches and rockslides as main threats to cultural heritage in this region.

In the same way as for cultural heritage information, data on natural hazards in the area is very scarce and of poor quality (Georgi Gapradashvili, NEA, personal communication, 14th September, 2010); There is very little thematic information available with overall inadequate (i.e. too general) map scales. Also, historical information on natural processes is mainly non-existent. That makes gathering data from local knowledge an important source of information in this research.

There is a need to develop strategies that clearly integrate cultural heritage and natural hazards information into overall land use and environmental management plans in Upper Svaneti. For that purpose, natural processes, cultural heritage features and other elements at risk, should be clearly identified and analysed.

1.2.1. Uniqueness of the buildings assessed

Three distinctive building groups can be found in the study area: 1. Medieval (historic Svanish architecture); 2. Vernacular architecture (first half of the 20th c.); 3. Modern public buildings (second half of the 20th c.) (ICOMOS, 2001a).

The buildings assessed in this study (towers; churches; an especial winter dwelling call machubi; and fortified dwellings) (see Appendix 2) are included within the medieval group. They are considered as having especially significant artistic, architectural and historic values, at both, national and international level. For locals, these structures have been a sign of identity for centuries. At present, this cultural heritage objects together with the exceptional landscape, act also as a claim for tourists and travellers bringing some economic inputs to the community. Consequently, any harm or deterioration suffered by these cultural heritage buildings may have different negative repercussions on the community.

Within the different typologies assessed, it is considered that churches and towers have the highest intrinsic value. In a society with strong religious believes churches in the study area represent an essential feature. Moreover, they contain precious icons, paintings and murals. Towers are the major architectural feature determining the landscape outline in the region. They are even perceived as a symbol of Svaneti (ICOMOS, 2001a).

1.3. General Objective

The main purpose of this study is to develop an approach to analyse the exposure of cultural heritage sites to natural hazards. This approach, tested in the Upper Svaneti region of Georgia, aims also to evaluate the prospects of integrating hazard risk aspects of these cultural heritage sites into management plans. Special focus is on cultural heritage in the Ushguli and Mulakhi communities.

1.4. Specific Objectives and Research Questions

1. To identify and differentiate cultural heritage as physical elements at risk
   a. Which types of cultural heritage do occur and where?
   b. What other types of elements at risk (in some way related to cultural heritage) can be identified?
   c. What is the state of conservation of cultural heritage objects (and how is it changing over time)?

2. To accomplish a hazard identification and hazard susceptibility evaluation
   a. Which hazards have occurred and may occur in the future in the study area?
   b. Which areas might be affected by hazardous events in the future?
   c. Which identified (see objective 1) elements at risk are exposed to natural hazards?

3. To evaluate, using Spatial Multi-Criteria Evaluation (SMCE), the vulnerability of cultural heritage to natural hazards
   a. What is the level of risk of cultural heritage objects as a function of natural hazards?
   b. Prioritize the cultural heritage sites as well as individual cultural heritage objects with respect to their vulnerability to natural hazards?
   c. What level of vulnerability is acceptable?

4. To incorporate risk management elements into existing cultural heritage conservation and management plans
    a. How to develop a non-expert based approach that can be used to assess and monitor the state of conservation of cultural heritage sites (in hazard context)?
    b. How can a combination of local and expert knowledge be used to identify and assess natural hazards in the study area?
    c. What relevant and feasible protective measures could be put in place to reduce hazard exposure and/or decay of cultural heritage?

1.5. Hypothesis

The state of conservation (and monitoring) of cultural heritage as physical elements at risk is an important aspect in assessing its vulnerability in an overall multi-hazard spatial multi-criteria evaluation. SMCE is a useful tool to prioritize the vulnerability of cultural heritage sites. Furthermore, a multi-hazard risk assessment approach incorporated in cultural heritage planning should be understandable and applicable for non-hazard experts.

1.6. Thesis Outline

The thesis has been divided into eight chapters. The first four chapters contain an introduction of the research, literature review, a description of the study area and an overview of the methodology. Chapter five deals with the analysis of the state of conservation of cultural heritage features; it looks first at technical characteristics of the buildings to later assess in a quantitative manner the state of conservation of cultural heritage objects. Chapter six deals with the risk assessment process in response to the vulnerability of the main physical elements at risk and the hazard assessment with special attention to cultural heritage vulnerability. Chapter seven looks into ways of incorporating risk management elements into cultural heritage conservation and management plans. The final chapter concludes the entire research and ends with recommendations. Chapters four to seven constitute the main parts of the research.

2. Literature Review

2.1. Cultural Heritage

2.1.1. Definitions

Cultural Heritage: The definition of cultural heritage has been historically restricted to monuments, archaeological sites, and movable heritage collections, but more recently it also includes historic urban areas, vernacular heritage, cultural landscapes, and even living dimensions of heritage (Abhas, 2010). ICOMOS (2002) defines cultural heritage as "an expression of the ways of living developed by a community and passed on from generation to generation, including customs, practices, places, objects, artistic expressions and values". Cultural heritage is often expressed as either "*intangible*" or "*tangible*" cultural heritage.

Intangible cultural heritage is "embracing all forms of traditional and popular or folk culture, the collective works originating in a given community and based on tradition" (ICOMOS, 2002).

Tangible cultural heritage "encompasses the vast created works of humankind, including places of human habitation, villages, towns and cities, buildings, structures, art works, documents, handicrafts, musical instruments, furniture, clothing and items of personal decoration, religious, ritual and funerary objects, tools, machinery and equipment, and industrial systems" (ICOMOS, 2002).

Table 2.1 below shows cultural heritage classification according to the Convention concerning the Protection of the World Cultural and Natural Heritage (UNESCO, 1972).

Table 2.1: Classification of cultural heritage (UNESCO, 1972).

Class	Definition
Monuments	Architectural works, works of monumental sculpture and painting, elements or structures of an archaeological nature, inscriptions, cave dwellings and combinations of features, which are of outstanding universal value from the point of view of history, art or science.
Groups of buildings	Groups of separate or connected buildings which, because of their architecture, their homogeneity or their place in the landscape, are of outstanding universal value from the point of view of history, art or science.
Sites	Works of man or the combined works of nature and man, and areas including archaeological sites which are of outstanding universal value from the historical, aesthetic, ethnological or anthropological point of view.

In a recent study, Hua (2010) recognises the need to clarify the current cultural heritage classification as it proves to be unclear and full of confusing concepts. Hua calls for a re-classification of cultural heritage "according to their nature and functions, protection methods, management and exhibition requirements dictated by their different nature".

2.1.2. Cultural heritage and natural hazards

The threat to cultural heritage posed by natural hazards is reported in various studies (Shapira, 1986, Lanza, 2003, Fukuoka et al., 2005, Lollino and Audisio, 2006, Sánchez et al., 2007, Gizzi, 2008, Canuti et al., 2009, Iriarte et al., 2010). Different types of natural hazards may have an impact on cultural heritage. For example, Lanza (2003) analyses the threat posed by flooding in the historic city centre of Genoa, Italy. Lanza performs a rather simple GIS analysis to map flood prone areas based only on historical data since hydrologic and hydraulic information was not available. Lanza's approach shows that even with little data available some fair and useful results can be obtained. Also Holicky and Sykora (2010) investigate the effects of floods on cultural heritage following the events of 2002 in Czech Republic. Herle et al. (2010) examine in their work the geotechnical problems of cultural heritage due to floods.

Landslides may also represent an important threat to cultural heritage as observed by Bromhead et al. (2006). The impact of landslides on cultural heritage and its implication for conservation and risk prevention is examined by Canuti et al. (2009). They look into several case studies in different settings around the world such as Moscow (Russia), Slovakia, Machu Pichu in Peru, and Umbria in Italy. The variety of approaches showed to the problem of landslides and cultural heritage in Canuti's paper reflect the multitudes of interests associated with this topic.

Different ways to deal with natural hazards affecting cultural heritage are reported in the literature. For example, Fukuoka et al. (2005) conduct a landslide hazard assessment on the mountainous slopes of the ancient imperial resort palace of Lishan, Xian, China. In this study a detailed slope stability investigation is performed. However, the structural capacity of the cultural heritage objects to withstand the hazard impact is not considered. Abhas (2010) presents six guiding principles for cultural heritage conservation related to natural hazards (Table 2.2).

Taboroff (2003) emphasises that the only way forward is to incorporate cultural heritage into disaster mitigation and management approaches. Governmental agencies, cultural heritage and disaster management professionals should work together in order to achieve effective preparedness and mitigation strategies (Taboroff, 2003).

Table 2.2: Guiding principles for cultural heritage conservation (Abhas, 2010).

PRINCIPLE	DESCRIPTION
1	Cultural heritage conservation helps a community not only protect economically valuable physical assets, but also preserve its practices, history, and environment, and a sense of continuity and identity.
2	Cultural property may be more at risk from the secondary effects of a disaster than from the disaster itself, therefore quick action will be needed.
3	Built vernacular heritage offers a record of a society's continuous adaptation to social and environmental challenges, including extreme events, such as past disasters. This record can often be drawn on to design mitigation strategies for new construction or retrofitting.
4	Communities should prioritize which cultural assets to preserve, considering both cultural meaning and livelihood implications, although reaching a consensus may be difficult.
5	Cultural heritage conservation plans are best designed before a disaster, but, in their absence, heritage authorities can and should collaborate to develop effective post-disaster heritage conservation strategies.
6	Because vernacular cultural properties are sometimes capable of withstanding local climate conditions, they may serve as safe havens where surrounding communities can temporarily relocate.

Lazzari et al. (2009) and Canuti et al. (2009) strongly emphasize the fact that knowing the state of conservation of the cultural heritage features is important information in order to assess their vulnerability in a natural hazard risk assessment context.

2.1.3. State of conservation assessment

There are not that many studies concerning approaches for the assessment of the state of conservation of built structures within a cultural heritage context. Existing studies mainly concentrate on the assessment of ordinary buildings from an architectural /engineering perspective. Working procedures are normally quite complex and require a lot of expertise, as is also shown in the following examples.

Some of the studies found on a cultural heritage context deal with the assessment of seismic vulnerability of historic buildings. For example, D'Ayala and Speranza (2002) use an electronic form to collect data on the state of conservation of historic buildings in earthquake prone urban areas. They developed an electronic form which is able to collect many data about the characteristics of the building, such as geometric characteristics of the facade and openings and structural characteristics. The data collected via the electronic form are stored in a database and directly available for on-line evaluation of the building seismic vulnerability (D'Ayala and Speranza, 2002). This way of collecting data about the state of conservation of cultural objects is effective but requires a lot of resources to build the software interface, the electronic form and the database.

Another rather complex way of assessing the state of conservation of cultural heritage buildings is presented by Grinzato et al. (2002). In their study they use infrared thermography for the monitoring of historic buildings. Their procedure aims to monitor and assess the wall's structure and the moisture content of buildings using digital and analytical thermal modelling and thermo-graphic equipment. Grinzato et al. (2002) consider the monitoring of water content in historic buildings a very important parameter for the assessment of the state of conservation. They comment on the fact that the presence of water in a structure and its changes of state (solid-liquid-vapour) are highly responsible for the damage of building's materials. According to them, the knowledge of water content within walls is fundamental for decay analysis especially in cold climatic conditions. Again, Grinzato et al. procedure proves effective but requires a lot of expertise and expensive equipment.

Canuti et al. (2009) adopt a much more straightforward approach for state of conservation analysis of cultural heritage objects in Machu Picchu (Peru), in relation to their vulnerability to landslides. They define a damage value for each type of element at risk based on an *in situ* survey catalogue. Table 2.3 shows the parameters used to assess the state of conservation of the different cultural heritage features. This methodology is considered efficient in remote environments and when not too many resources are available as it does not require expensive devices and complex procedures. Consequently, it is seen as well suited for application in developing countries.

Table 2.3: Parameters used to assess the state of conservation of cultural heritage features (adapted from Canuti et al. 2009).

PARAMETER	DESCRIPTION
Geometric properties	In terms of height and wall thickness, in order to correlate these data with the impact force of fast slope movements.
Presence of restoration works	Useful to understand past damage as well as the present capacity to resist to a landslide with a given intensity.
Presence or absence of coverage (roof)	Fundamental parameter to understand the impact of weathering on structures.
Presence of cracks	In order to reconstruct damage derived from the interaction between structure and soil.
Presence of strain processess	Sinking, swelling, tilting.
Presence of humidity/biological degradation	Decreasing of resisting sections.

The state of conservation assessment performed in this study (see section 4.2) is inspired on the work of Lazzari et al. (2009), including some elements (see Table 2.3) of Canuti et al. (2009). Lazzari et al. (2009) develop a methodology to calculate in a quantitative manner the state of conservation of the historically built heritage of a medieval village in southern Italy. They collect typological characteristics of individual buildings through a field survey using a pre-designed form (see Table 2.4); this forms the basis for a GIS-based analysis to detect priorities of intervention for structural recovery and management of surveyed buildings in relation to geomorphologic and anthropogenic risk. The vulnerability of the historical buildings is evaluated through a decay index (*DIx*) calculation (Table 2.4). For the present study, this adapted approach was chosen because it allows non-experts in the field of cultural heritage to perform an objective survey on the state of conservation of cultural heritage objects. Moreover, the results of the survey can be integrated into a GIS to eventually deliver priorities of intervention based on the vulnerability of the cultural heritage assets to natural hazards.

Table 2.4: Example of decay index calculation for a specific building (Lazzari et al. 2009).

STATE OF CONSERVATION AND DECAY INDEX								
		Score	1	2	3			
- roofs:	Decay due to Lack of Maintenance (DLM)	(x 3)	X			=		3
- facades:		(x 3)		X		=		6
- fastenings:		(x 1)	X			=		1
- common parts:		(x 3)		X		=		6
- ground floor slabs:		(x 3)		X		=		6
- other floors slabs:		(x 3p)	X			=		9
- decay for masonry moisture (DM)		(x 3)		X		=		6
-structural damages (SD) (lesions, cracks, collapses)		(x 6)		X		=	1	2
		WEIGHTED TOTAL SCORE (Wt)					4	9
		DECAY INDEX				**1,**	**5**	**8**

Istructions				Valutazione del degrado		
Moisture (DM)	1 heavy	2 medium	3 light	to 1,30	EXTREME	
Structural damage (SD):	1 very heavy	2 heavy	3 moderate	1,31-1,60	**VERY HIGH**	X
Decay due to Lack of Maintenance (DLM)	1 bad	2 quite good	3 good	1,61-1,95	HIGH	
p = floors number				1,95-2,40	MODERATE	
				2,41-3,00	LOW	
The decay index is obtained dividing the weighted total score (Wt) by the sum of the coefficients (22 + 3p).						

2.2. Multi-hazard risk assessment

2.2.1. Definitions

Natural hazard: UNISDR (2009) defines a natural hazard as a "natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage". A disaster may occur when those natural hazards have severe effects on human beings (Blaikie et al., 1994). In van Westen (2009) natural hazards are defined as "natural processes or phenomena within the earth's system (lithosphere, hydrosphere, biosphere or atmosphere) that may constitute a damaging event (such as earthquakes, volcanic eruptions, hurricanes). A natural hazard may cause a disaster to a vulnerable society."

Vulnerability: Different definitions for vulnerability can be found in the literature as different groups, such as academic staff from different disciplines, disaster management agencies and development corporations, may have distinct views (van Westen, 2009). UNISDR (2009) defines vulnerability as the "characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard". Blaikie et al. (1994) define vulnerability as "the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from impacts of a hazard". Some definitions relate solely to physical vulnerability (UNDRO, 1991), while others also incorporate economic, social or environmental factors (Blaikie et al., 1994, Villagrán de León, 2006).

Risk: UNISDR (2009) defines risk as "the probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between (natural, human-induced or man-made) hazards and vulnerable conditions in a given area and time period". Risk can be presented conceptually with the following basic equation:

Risk = Hazard * Vulnerability / Capacity

Figure 2.1 gives a graphical representation of risk. Here risk is the area where vulnerability and hazard meet resulting from the intersection of hazard with the value of elements at risk by the way of their vulnerability (Crozier and Glade, 2005).

Elements at risk: According to UNISDR (2004) elements at risk include population, properties, economic activities, or any other defined values exposed to hazards in a given area. Elements at risk are also referred to as assets and their amount can be quantified either in numbers (buildings, people), in monetary value (replacement costs, market costs), area or perception (importance of elements at risk).

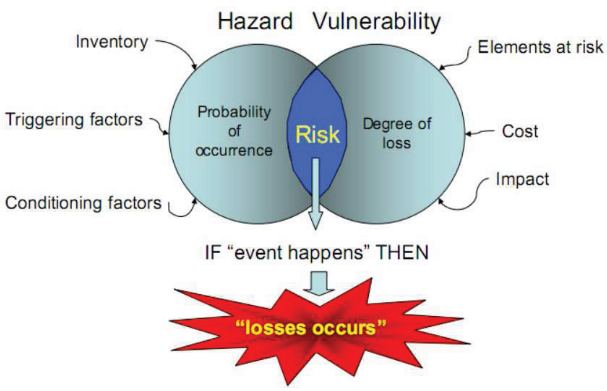

Figure 2.1: Graphical representation of risk and its consequences (Alexander, 2002, cited in Castellanos Abella, 2008a).

2.2.2. Risk assessment

UNISDR (2009) describes risk assessment as "a methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend".

Risk assessments (and associated risk mapping) include: a review of the characteristics of hazards such as their location, intensity, frequency and probability; the analysis of exposure and vulnerability including the physical social, health, economic and environmental dimensions; and the evaluation of the effectiveness of prevailing and alternative coping capacities in respect to likely risk scenarios (UNISDR, 2009).

Generally speaking methods of hazard assessment may be qualitative or quantitative (Aleotti and Chowdhury, 1999, Ayalew and Yamagishi, 2005a). More recently however the assessment approaches have been further divided in qualitative, semi-quantitative and quantitative (Chowdhury and Flentje, 2003) (Table 2.5). According to Castellanos Abella (2008a) the main difference between qualitative and semi-quantitative methods is the assignment of weights given certain criteria. This study will apply spatial multi-criteria evaluation semi-quantitative approach for vulnerability assessment using combinations of weighted index/parameter maps.

Table 2.5: Risk assessment methods (Castellanos Abella, 2008a)

METHOD	PRINCIPLE
Qualitative	Based on risk classes categorized by expert judgment. Risk classes: High, Moderate and Low.
Semi-quantitative	Based on ranking and weights assignments by a given criteria. Risk index: ranked values (0-1, 0-10 or 0-100).
Quantitative	Based on probabilities or percentage of losses expected. Risk value: probabilistic values (0-1) over certain amount of monetary or human loss.

2.2.3. SMCE for hazard and vulnerability assessment

The theory behind spatial multi-criteria evaluation (SMCE) is based on the Analytical Hierarchy Process (AHP) developed by Saaty (1980). AHP is a multi-objective, multi-criteria decision-making process which allows the user to obtain results in a scale of preferences from a set of alternatives (Yalcin, 2008). AHP has been widely use in site selection, suitability analysis, regional planning and natural hazard susceptibility analysis (Ayalew et al., 2005b).

From a decision-making perspective, multi-criteria evaluation can be expressed in a matrix (Triantaphyllou, 2000) (Table 2.6). The matrix A contains the criteria in one axis (C_1 to C_n), and a list of possible alternatives, from which a decision has to be taken on the other axis (A_1 to A_m). Each cell in the matrix (a_{ij}) indicates the performance of a particular alternative in terms of a particular criterion (Triantaphyllou, 2000).

Table 2.6: Multi-criteria decision matrix (Triantaphyllou, 2000).

	C_1	C_2	C_3	…	C_n
	$(w_1$	w_2	w_3	…	$w_n)$
A_1	a_{11}	a_{12}	a_{13}	…	a_{1n}
A_2	a_{21}	a_{22}	a_{23}	…	a_{2n}
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
A_m	a_{m1}	a_{m2}	a_{m3}	…	a_{mn}

The value of each cell in the matrix is composed of the multiplication of the standardised value (between 0 and 1) of the criterion for the particular alternative, multiplied by the weight (W_1 to W_n) related to the criterion. Once the matrix has been filled, the final value can be obtained by adding up all cells values of the different criteria for the particular alternative (e.g. a_{11} *to* a_{1n} for alternative A_1) (Triantaphyllou, 2000).

For implementing this matrix according to AHP, three principles steps need to be considered: i) decomposition, ii) comparative judgement and iii) synthesis of priorities (Malczewski, 1996). The first one decomposes the problem (and the weights) into a hierarchical structure. The second one considers the weighting process, employing the pairwise comparisons of the criteria, and the synthesis is related to the multiplications among the hierarchical levels. Additionally, in the spatial implementation of this procedure (Figure 2.2), every criterion (C_j) becomes a raster layer, and every pixel (or set of pixels) of the final composite index map eventually becomes an alternative *Aj* (Malczewski, 1999). The goal (risk index) has been decomposed into criteria levels C_{L1} and C_{L2}. The intermediate levels are often indicated as sub-goals or objectives (e.g. in level 1, the sub-goals are a "hazard index" and a "vulnerability index"). Each criterion of each level will also have as assigned weight. Therefore, the values for the layers of the intermediate levels are obtained through the summation of the performance for the alternative at lower levels. As the criteria consist of raster maps, their spatial performance (a_{ij}) and the alternative (A_i) will be identified for particular raster cells (Malczewski, 1999).

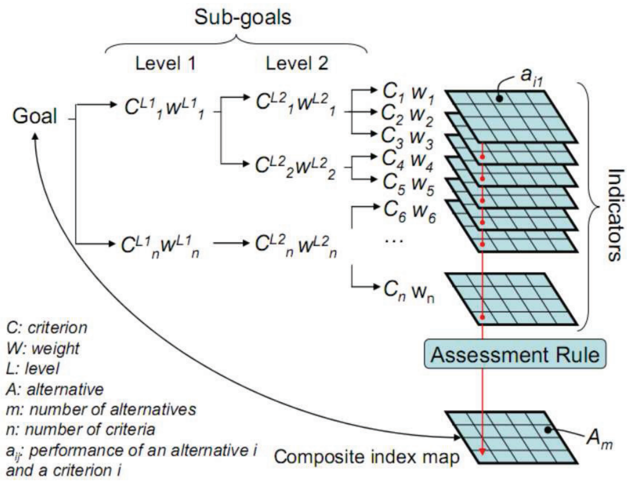

Figure 2.2: Schematic procedure for spatial multi-criteria evaluation based on the analytical hierarchical process (Castellanos Abella, 2008a, van Westen, 2009).

The composite risk index map is obtained by an assessment rule (sometimes also called decision rule), which is calculated by adding up the performance of all cell values of the different criteria (a_{ij}) for the particular alternative. However, the performance of every element in the matrix (a_{ij}), is obtained in a different way:

$$a_{ij} = v_{ij}^{*} \prod_{L=0}^{h} w_j^L$$

[eq. 2.1]

In equation 2.1, v_{ij} refers to the standardised value of criterion (C_j) for alternative (A_i), and weight w^l_j refers to the weight of criterion (C_j) for level L (0-h levels). During the analysis, it could be desirable (and sometimes necessary for a better definition of the weights w^l_j) to produce the intermediate criteria maps (Malczewski, 1996). In this case, eq. 2.1 should not be applied because weights need to be multiplied with the standardised values only up to the specific level of the intermediate maps. The intermediate maps might also be combined using different methods (van Westen, 2009). SMCE has been recently introduced in hazard susceptibility and risk assessment studies (Ayalew et al., 2005b, Castellanos Abella and Van Westen, 2008b, Yalcin, 2008, Akgun and Türk, 2010).

2.2.4. Hazard indicators

As far as landslide susceptibility is concerned, a number of common hazard conditioning indicators are found in the literature. Van Westen et al. (2008) give an overview of environmental factors, and their relevance for landslide susceptibility and hazard assessment (Table 2.7).

This study focuses on a set of parameters chosen based on data availability and field data collection priorities. These are:

Slope gradient

Slope gradient is considered the most important factor influencing gravitational movements down slope because sliding of loose material is directly related to slope gradient (Dai et al., 2002, Liu JG et al., 2004, van Westen et al., 2008). According to Ayalew and Yamagishi (2005a) slope gradient at local scales affects the presence of soil moisture as well as the level of pore pressure and can lead to slope instability.

Lithology

Lithology influences to a great extent the occurrence of landslides as different parent materials have different degrees of weathering which may control the scale of landsliding (Carrara et al., 1991, Zeng and Wang, 2009, Wati et al., 2010). For example, hard and massive rocks are resistant to weathering whereas rocks composed of sandstone are more vulnerable to weathering so that it is more susceptible to landslide (Wati et al., 2010).

Table 2.7: Overview of environmental factors and their relevance for landslide susceptibility and hazard assessment (van Westen et al., 2008). (H= highly applicable, M= moderately applicable, and L= Less applicable).

Group	Data layers and types	Relevance for landslide susceptibility and hazard assessment	Scales of analysis			
			Regional	Medium	Large	Detailed
Digital Elevation Models	Slope gradient	Most important factor in gravitational movements	L	H	H	H
	Slope direction	Might reflect differences in soil moisture and vegetation	H	H	H	H
	Slope length/shape	Indicator for slope hydrology	M	H	H	H
	Flow direction	Used in slope hydrological modeling	L	M	H	H
	Flow accumulation	Used in slope hydrological modeling	L	M	H	H
	Internal relief	In small scale assessment as indicator for type of terrain	H	M	L	L
	Drainage density	In small scale assessment as indicator for type of terrain	H	M	L	L
Geology	Rock types	Based on engineering properties on rock types	H	H	H	H
	Weathering	Depth of profile is an important factor	L	M	H	H
	Discontinuities	Discontinuity sets and characteristics	L	M	H	H
	Structural aspects	Geological structure in relation with slope angle/direction	H	H	H	H
	Faults	Distance from active faults or width of fault zones	H	H	H	H
Soils	Soil types	Engineering soils with genetic or geotechnical properties	M	H	H	H
	Soild depth	Soil depth based on boreholes, geophysics and outcrops	L	M	H	H
	Geotechnical prop.	Grainsize, cohesion, friction angle, bulk density	L	M	H	H
	Hydrological prop.	Pore volume, saturated conductivity, PF curve	L	M	H	H
Hydrology	Water table	Spatially and temporal depth to ground water table	L	L	M	H
	Soil moisture	Spatially and temporal soil moisture content	L	L	M	H
	Hydrological	Interception, Evapotranspiration, throughfall, overland flow,	M	H	H	H
	Strean network	Buffer zones around streams	H	H	H	L
Geomorphology	Physiographic units	First subdivision of the terrain in zones	H	M	L	L
	Terrain Mapping	Homogeneous units of lithology, morphography and	H	M	L	L
	Geomorphology	Genetic classification of main landform building processes	H	H	M	L
	Slope facets	Geomorphological subdivision of terrain in slope facets	H	H	H	L
Landuse	Land use map	Type of land use/land cover	H	H	H	H
	Land use changes	Temporal varying land use/land cover	M	H	H	H
	Vegetation	Type, canopy cover, rooting depth, root cohesion, weight	L	M	H	H
	Roads	Bufferes around roads in sloping areas with road cuts	M	H	H	H
	Buildings	Slope cuts made for building construction	M	H	H	H

Landcover

According to van Westen et al. (2008), landcover is one of the main factors in slope stability analysis. Landcover as a landslide factor, is also the most influenced by human activities as it is easy to manage and change (Akgun and Türk, 2010). It is thought that vegetation contributes positively to land stability (van Westen et al., 2008).

Drainage density

Drainage density is the ratio of the total length of the stream to the area of the drainage basin measured in km/km^2 (Yalcin, 2008). As drainage density increase so does the surface movement due to a decrease in infiltration capacity and that may encourage landslide occurrence (Pachauri et al., 1998; Nagarajan et al., 2000; Cevik and Topal, 2003; Yalcin, 2005) cited in Yalcin (2008).

As far as avalanche susceptibility mapping is concerned, a number of common hazard conditioning indicators are found in the literature:

Slope gradient

It is considered the most important topographical parameter in understanding and predicting potential avalanches as it is directly related to gravitational forces influencing mass movement down slope; being found in several studies dealing with avalanche susceptibility analysis (Gruber, 2001, Kriz, 2001, Maggioni and Gruber, 2003, Ghinoi and Chung, 2005, Nadim et al., 2006, Gruber and Bartelt, 2007, Barbolini et al., 2009, Wright, 2009, Biskupič and Barka, 2010). There is a general consent among authors about the relationship between slope gradient and avalanche probability. This relationship is summarised in Table 2.8.

Table 2.8: Slope and avalanche probability (Kriz, 2001)

SLOPE	AVALANCHE PROBABILITY
below 10^o	Practically no avalanches are triggered
10^o - 28^o	Avalanches are scarce
28^o - 45^o	Major danger zone for avalanche triggering
above 45^o	High avalanche frequency, however low snow accumulation due to steepness

Aspect (insolation)

Also considered an important parameter in avalanche studies as it influences the amount of heat reaching the surface (Maggioni and Gruber, 2003, Ghinoi and Chung, 2005, Wright, 2009, Biskupič and Barka, 2010). As temperatures drop in winter, a cold snowpack tends to develop more persistent weak layers than a warm one. Consequently, north and east facing slopes which receive very little heat from the sun especially in mid winter, are more prone to avalanches (Wright, 2009). This process is especially prevalent between 30° and 55° latitude (Wright, 2009). The area of study of this research is at approximately 43° latitude, hence falling within that range.

Aspect (windloading)

Windloading can also play an important role in avalanche hazard mapping (Wright, 2009) as slopes can be piled with accumulated snow blown from the top of a hill; or from the side, in a process called cross-loading, into protected pockets on the leeward side of ridges.

Slope curvature

This is considered a determining factor for the spatial delimitation of avalanche release areas (Maggioni and Gruber, 2003, Ghinoi and Chung, 2005, Barbolini et al., 2009, Wright, 2009, Biskupič and Barka, 2010). Terrain with concave plan curvature is more prone to avalanche initiation as it traps windblown snow from all directions, while convex plan curvature areas have a shallower snow pack with the consequent reduced risk of avalanche instigation (Barbolini et al., 2009).

Landcover type

Landcover type, as a measure for surface roughness, is a key factor in keeping snow firmly fixed to the ground (Ghinoi and Chung, 2005, Barbolini et al., 2009, Biskupič and Barka, 2010). An area covered by forest, for example, inhibits large avalanche formation as it influences both the amount of deposited snow and the stability of the snow itself as compared to, for example, an area cover with grass (Barbolini et al., 2009).

Elevation

Ghinoi and Chung (2005) use elevation as an additional parameter for avalanche susceptibility mapping as they consider that elevation may influence the amount of snow precipitation.

Snow cover

Lehning et al. (1999) and Ghinoi and Chung (2005) incorporate the snow cover factor in their studies of avalanche susceptibility as this parameter offers obvious significant information related to the amount of snow present in a given area. However, this factor is not always easy to include in avalanche studies as it needs a large net of snow measurement stations (which not many countries have) in order to obtain the information required.

2.2.5. Local knowledge and expert knowledge in hazard assessment

Community-based and individual local knowledge is important for developing an understanding of the disaster risk situation as well as for designing community-based preventive measures (Dekens, 2007, Mc Call, 2008). However, not all this knowledge is normally available as locals are not directly aware of it because they do not normally communicate this to outsiders (Mc Call, 2008). Different techniques and tools exist to extract this valuable information. Peters (2008), for example, uses sketch maps for community-based risk assessment. The idea behind sketch maps is to make drawings together with the locals to identify and locate, among others, past natural hazards events, elements at risk and/or protective structures (IFRC, 2008). Semi-structured interviews are also a useful tool for extracting information from locals (Mustelin et al., 2010, Pittman et al., 2010). The typical information that can be gathered by these means is related, among others, to: community risk perception; elements at risk and assessment of the community level of preparedness (Peters, 2008).

Gathering information from expert knowledge, on the other hand, involves consulting with experts of relevant fields related to the study at hand. This can be done through interviews and consulting literature sources. The experts themselves can gather scientifically based information on the field using more sophisticated tools compared to local knowledge techniques such as, mobile GIS, GPS and inclinometers. For example, mobile GIS connected to a GPS may allow for digitization of points of interest in the field which helps to identify features such as past hazard events and exposed elements at risk. Also remote sensing and GIS techniques are used to acquire expert information. For example, landslides can be interpreted from stereo images and digitized into a mobile GIS used later in the field to check boundaries and record landslide attributes (van Westen, 2009).

3. Study Area

3.1. Historical Background

Svaneti is one of the oldest historic-geographical provinces of Georgia. Due to its geographical and climatic conditions, Svaneti was historically isolated from the upheavals occurring in bordering regions, while keeping always in pace with the Georgian state (ICOMOS, 2001a). This fact made Svaneti a sort of sanctuary for the preservation of cultural heritage of Georgian as well as of foreign provenance. Moreover, Svaneti was a significant cultural centre of different art expressions including paintings, metal works, and specially ecclesiastical and secular architecture (ICOMOS, 2001a).

3.2. Location and extent

Svaneti is located on the southern slopes of the Great Caucasus Ridge. The study area is located within the Upper Svaneti region (Figure 3.1). It comprises the communities of Ushguli and Mulakhi as well as the road connecting Ushguli with the main town of Mestia. The official outline has been used to delineate the boundaries of both communities.

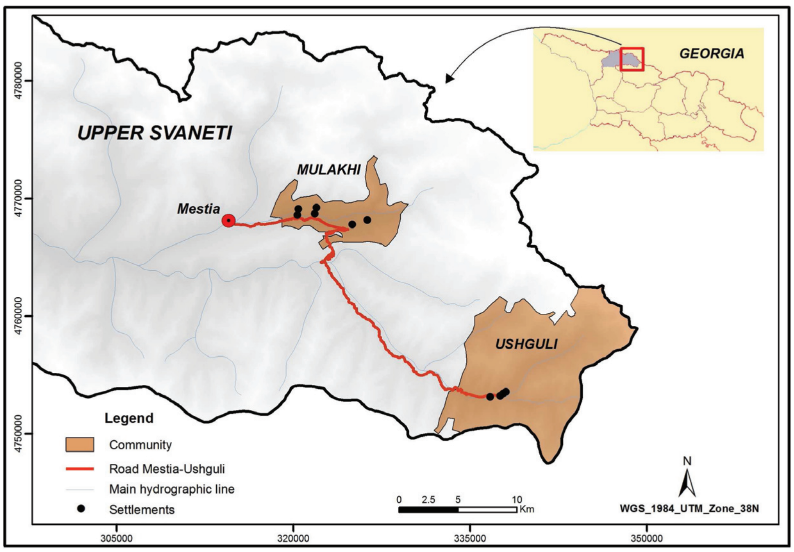

Figure 3.1: Study area

Ushguli community is located in the south-eastern part of Upper Svaneti with an area of approximately 130 km^2. It consists of four settlements: Murkmeli, Chazhashi, Chvibiani and Zhibiani. Mulakhi community is located in the centre-eastern part of Upper Svaneti, extending for about 38 km^2. It consists of eleven villages. For practical reasons in this study, six of those eleven villages were considered: Artskheli, Lakhiri, Zhamushi, Chvabiani, Zhabeshi and Murshkeli.

3.3. Climate

The climate at altitudes below 3000 m above MSL is characterized by high precipitation, cold long winters and relatively short cool summers. At altitudes higher than 3000 m above MSL a humid climate with permanent snow and glaciers is present. Table 3.1 shows climatic data summary for Mestia town.

Table 3.1: Climatic data from Mestia (GPAP, 2008)

Station	Height above MSL (m)	Average temperature (°C)			Relative humidity (%)	Precipitation (mm)		
		January	August	Annual	Average annual	Annual	Summer	Winter
Mestia	1441	-6	16.4	5.7	75	992	243	226

3.4. Topography and Geomorphology

The study area has a pronounced and complex relief (Figure 3.2). In Ushguli, approximately 72% of the area is steep with gradients between 20° and 40°. In Mulakhi, more than half of the area (55%) falls under that range. The settlements in Ushguli are all found on the lower part of the valley whereas in Mulakhi four of the six villages visited are found directly on the slopes; the other two settlements being in a flatter location. At altitudes higher than 1500 m above MSL, mainly paleo-glacial relief with trough gorges and moraines is developed within the area of study. Erosion landforms are also significant; they are found in the area that was left when the glaciers retreated. Narrow and deep canyons and gorges are typical for these formations. Numerous debris cones, formed by periodic mudflows, are found at the bottom of the eroded gorges. Riverine terraces located on various altitudes are also present in some locations (GPAP-Georgia Protected Areas Development Project, 2008).

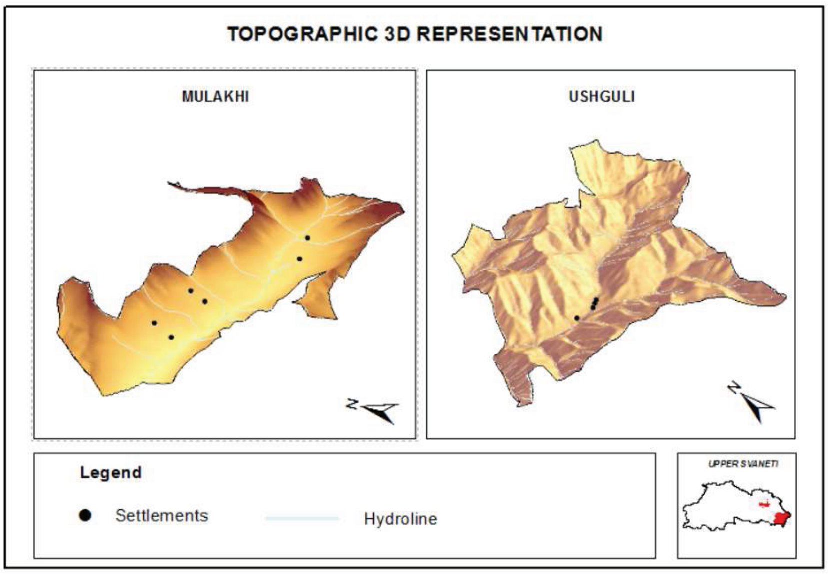

Figure 3.2: 3D representation of the study areas.

3.5. Geology and Lithology

Based on the geology map 1:50000, the study area comprises four geological periods: (1) Quaternary including blocks, boulders and gravel; (2) Cretaceous including limestones and marls; (3) Jurassic including clays, shales and sandstone and (4) Devonian including granites, quartz and migmatites. (See Appendix 1 for Lithology map).

3.6. Land cover and land use

Agricultural and cattle breeding activities comprise the main land use in the study area especially in Ushguli where 67% of the area is managed grassland. In Mulakhi, managed grassland covers approximately 40% of the area. The rest of the area of study is covered by forest (fir, spruce, white birch, European aspen, beech, ash, goat willow, high mountain sycamore); scrubland; rock outcrops and glacier in different proportions.

3.7. Human-Environment Interaction

The area of study embraces a set of environmental and socio-economic parameters that result in a complex interaction between the people and their surroundings. The main form of land use for these communities is cattle breeding. This may eventually lead to overgrazing. Tree felling for fuelwood (cooking, heating) is widely practised.

Lack of proper environmental management strategies may lead to natural resources over-exploitation which in turn may exacerbate the impact of natural hazards in the area.

As a region with a significant cultural heritage, the state of conservation of these cultural heritage features is of importance for the economic development of the area. Tourist's influx to the area, especially in summer, may be economically very significant for the region as they are attracted by the rich cultural and landscape heritage. However, a progressive decay of cultural heritage features mainly due to lack of maintenance, may lead to a decrease in number of tourists to the region with the resulting impact on the local economy.

The harsh climatic conditions and frequent occurrence of natural hazards influences the socio-economic condition of the area. For example, the only access road connecting Ushguli and Mulakhi communities to the main town of Mestia gets often blocked by snow, rockfalls and minor landslides. Consequently, in winter time settlements become often isolated from the outer world sometimes during months and may avert the influx of tourists, cultural heritage maintenance and socio-economic development in general. The final outcome may be an out flux of local people to other regions with better environmental and socio-economic conditions. There is a need thus in the region to put in place proper management strategies that integrate in a sustainable way agriculture, tourism, cultural heritage and disaster management activities.

4. Research Methodology

4.1. Method Overview

The methodological overview for this study is presented in figure 4.1. It consists of three interconnected blocks:

- The first block deals with the assessment of the state of conservation of cultural heritage as pre-defined element at risk (see section 4.2). The process goes from an *in situ* assessment of individual cultural heritage objects to the assessment of their state of conservation based on certain parameters.
- The second block deals with the multi-hazard assessment of the study area using spatial multi-criteria evaluation (see section 4.5). Here, hazard and vulnerability factor maps are produced based on selected conditioning parameters and cultural heritage objects as pre-defined elements at risk respectively. The final product is multi-hazard risk information for cultural heritage objects in the study areas. Moreover, an additional assessment is performed on the main access road in the area of study. Here, "hotspots" are identified and mapped in order to show the most vulnerable areas along the road related to natural processes and its possible indirect impact on the state of conservation of cultural heritage features.
- The third block deals with the exploration and analysis of existing management plans related to cultural heritage and natural hazards (see Chapter 7). The aim is to give guidance to the authorities about how to integrate those two components to improve management strategies.

This methodology although basic in nature it is considered to be appropriate especially because it can be carried out by non-experts in the fields of disaster and cultural heritage management.

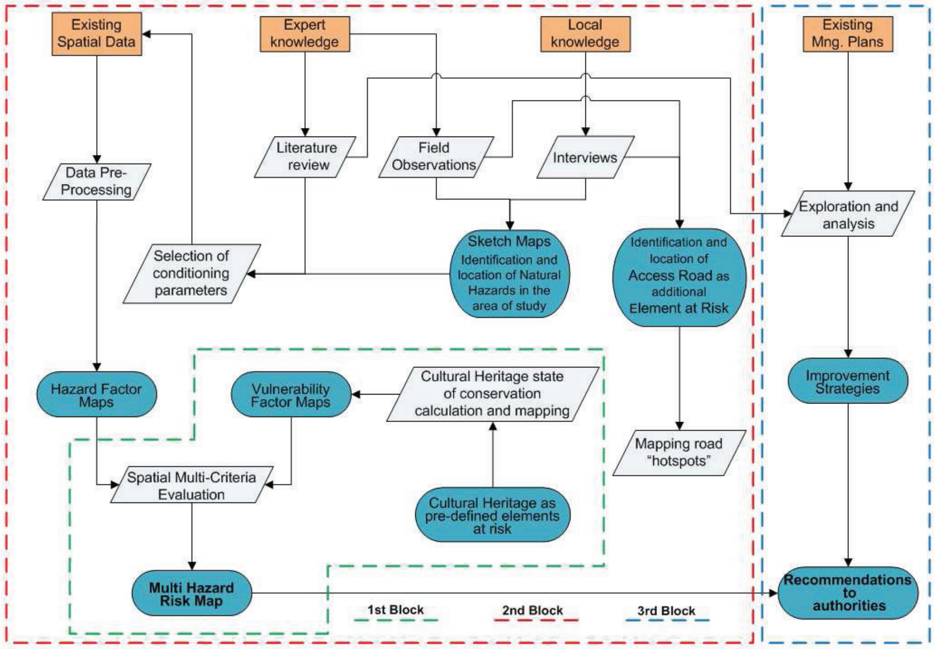

Figure 4.1: Schematic flow of the overall research process

4.1.1. Input data

The input data for this study consisted of primary and secondary data (Table 4.1 and Table 4.2). The quality of the data was analyzed examining the different layers in ArcGis 10 to identify any kind of abnormalities such as topology irregularities, extreme values and different coordinate systems.

Table 4.1: Input dataset (Primary data).

PRIMARY DATA		
Description	**Type**	**Acquisition from**
Cultural Heritage features - Mulakhi community	Point	Field work
Cultural Heritage features - Ushguli community	Point	Field work
Hot Spots along the road from Mestia to Ushguli	Point	Field work
Mudflows and avalanches pathways in the two communities	Polyline	Field work
Road between Mestia and Ushguli	Polyline	Field work

Table 4.2: Input dataset (Secondary data).

SECONDARY DATA			
Description	**Type**	**Source**	**Acquisition from**
Outline of Upper Svaneti	Polygon	-	CENN
Land cover types in Upper Svaneti	Polygon	Topographic maps 1:50000. Year 1985	CENN
Communities in Upper Svaneti	Polygon	-	CENN
Hydro lines in Upper Svaneti	Polyline	Topographic maps 1:50000. Year 1985	CENN
Soils - Upper Svaneti 1:500.000	Polygon	Geology maps 1:50000. Year 1958	NEA
Digital Elevation Model - Upper Svaneti 20x20m	Raster	Topographic maps 1:50000. Year 1985	CENN
Topographic maps - Upper Svaneti 1:50.000. Year 1985	Raster	-	CENN
Geology maps - Upper Svaneti 1:50.000. Year 1958	Raster	-	NEA
Google Earth Image for Ushguli community	Raster	Google Earth. June 2006	-

4.2. Assessment of Cultural Heritage State of Conservation

4.2.1. Working sheet design

In order to assess the state of conservation of individual cultural heritage features on the field, a working sheet (see Appendix 3) was designed based on the work of Canuti et al. (2009), Lazzari et al. (2009) (see also section 2.1.3) and Nino Kublashvili, a Georgian expert in building restoration and conservation. The working sheet has two major parts: The first part aims to gather general information about the cultural object such as typology, number of floors, presence of restoration works, human use and topographic position. The second part focuses on the level of damage of the feature on a scale from “Very Heavy” to “Low”. The parameters assessed include cracks, partial collapses, sinking, tilting, roof damage, humidity degradation and biological degradation. Due to the rather simple building structure of the objects assessed, these parameters are considered as appropriate to perform a basic state of conservation assessment (Lazzari et al. 2009).

4.2.2. Data collection

Using the working sheet explained above, data were collected on cultural heritage objects in Ushguli and Mulakhi communities. The cultural objects assessed were selected at random covering all sorts of typologies present in the different settlements (towers, machubis, fortified dwellings and churches). In Ushguli, a total number of 30 cultural heritage objects were surveyed in the four villages included in the community. According to the list of historic cultural monuments compiled by the Upper Svaneti Protected Areas Management Plan (GPAP, 2008) there is a total of

116 cultural heritage objects in Ushguli. Consequently, 26% of the total cultural objects in Ushguli community were surveyed.

In Mulakhi community, a total number of 30 cultural heritage objects were surveyed in six of the eleven villages included in the community. The total number of cultural heritage features in those six settlements is 99 (GPAP, 2008) meaning that 30% of the total cultural heritage objects were surveyed. According to the Municipal Development Fund of Georgia (MDF) (2010) there are approximately 311 towers, 150 churches and more than 100 machubis in Upper Svaneti. Finally, field data were stored and organised in spreadsheets.

4.2.3. Quantifying the state of conservation

Based on the work of Lazzari et al. (2009) (see section 2.1.3), a State of Conservation Index (SCI_x) was calculated for each individual cultural heritage object assessed. The calculation was performed in a spreadsheet (MS Excel) for each individual object filling a digital form (Table 4.3) based on the information gathered from the working sheets. Four major decay/damage classes were considered:

- Decay of the roof: Gonçalves et al. (2009) comments on the vital importance of the state of conservation of the roof, where usually degradation starts, to preserve the whole integrity of historic buildings.
- Decay due to misuse: Using the cultural heritage features as animal shelter, for example, may have an impact especially on the foundations of the buildings as excrements and urine have a degradation effect on floors and walls (ICOMOS, 2001a, UNECE, 2003).
- Decay due to moisture/biological degradation: Humidity and biological action have also an important impact on historic buildings. Accumulated humidity can form in holes in the walls, freezing in the winter, melting in the spring, and destroying mortar, thus separating internal and external layers and weakening the structure of buildings (Canuti et al., 2009, Lazzari et al., 2009, UNECE, 2003).
- Structural damages: Cracks, partial collapses, sinking and tilting are vital parameters in assessing the state of conservation of cultural heritage assets (Canuti et al., 2009, Lazzari et al., 2009).

Table 4.3: Example of State on Conservation Index (*SCIx*) calculation.

STATE OF CONSERVATION INDEX - Building No. 4 (Ushguli)							
	Score	1	2	3	4		
Roof (Decay due to lack of maintenance DLM)	(x6)	X				=	6
Decay due to misuse (DM)	(x3)			X		=	9
Decay for masonry moisture/biological degradation (DMBD)	(x3)				X	=	12
Structural damages (SD) (cracks, partial collapses, sinking, tilting)	(x6)		X			=	12
Number of floors (f)	4						
$\sum coef$	22	WEIGHTED TOTAL SCORE (*Wt*)					39
STATE OF CONSERVATION INDEX (*SCIx*)							**1.77**

Level of decay				State of conservation valuation		
1	2	3	4	to 0,89	RUIN	
Very Heavy	Heavy	Moderate	Low	0,90 - 1,83	**VERY BAD**	**X**
				1,84 - 2,22	BAD	
				2,23 - 2,82	MODERATE	
				2,83 - 3,51	GOOD	
				3,52 - 4,00	VERY GOOD	

The state of conservation index is obtained dividing the weighted total score (*Wt*) by the sum of the coefficients ($\sum coef$) and number of floors (f)

The next step in the calculation was to assign weights to each one of the above decay/damage classes. The weights were given based on the level of decay varying from "Very Heavy" to "Low" (1 to 4) and they were then multiplied by an amplifying factor ("score") based on literature sources (Canuti et al., 2009, Lazzari et al., 2009, UNECE, 2003), expert opinion, and the results from the data gathered through the working sheets (see section 5.4). Consequently, the weights for "decay due to misuse" and "decay due to humidity and biological action" were multiplied by an amplifying factor equal to 3, whereas "roof decay" and "structural damage" weights were multiplied by an amplifying factor equal to 6 that represent more essential conditions for the conservation of a historic building.
As shown in Table 4.3, the *SCIx* was obtained dividing the weighted total score (*Wt*) by the sum of coefficients ($\sum coef$) determined by the sum of the score plus the number of floors (*f*):

$$SCIx = \frac{Wt}{\sum coef} \qquad where, \qquad \sum coef = 18 + 4$$

The number of floors is added to the summation of scores considering the height of the object as an aggravating factor in the state of conservation of the building. Building height is a very important construction characteristic to evaluate the vulnerability of the buildings to natural hazards (van Westen, 2009) as taller buildings become more vulnerable to mass impact. Moreover, the number of floors (height) was also considered related to the maintenance of the roof (easiness/uneasiness of access).
The quantitative valuation of the state of conservation of the cultural heritage features goes from 0 to 4 split into six groups, corresponding to a qualitative scale going from "Ruin" to "Very Good".

4.2.4. State of conservation mapping

A mobile GIS configuration (Ipaq with ESRI-ArcPad 7) connected to a GPS was used to take coordinates of each one of the cultural heritage objects examined. Furthermore, a picture was taken for each one of the cultural heritage objects. Once back from the fieldwork, the GPS points recorded were directly transferred into ArcGis10 and the attribute table was filled with attributes such as working sheet-id; village name; community name; type of feature; and state of conservation index. The pictures taken were also hyperlinked to the cultural heritage objects layer in ArcGis so it could be displayed if necessary. Two layers were produced: one representing the state of conservation of cultural heritage objects in Ushguli community; and one representing the state of conservation of cultural heritage objects in Mulakhi. The layers produced are input to the Spatial Multi-criteria Analysis (see section 4.5.3).

4.3. Community-based / Expert Knowledge Data Collection

4.3.1. Interviews

Prior to the actual field work two "unstructured" interviews were conducted in Tbilisi (with the help of a translator) with two experts in the fields of natural hazards and cultural heritage.

Senior geologist Tchichico Djanelidze (CENN) was interviewed the 13th September 2010 with the purpose of obtaining information about the main natural hazards occurring in the area of study as well as the main causes influencing their incidence.

Senior cultural heritage expert Marina Khenia (ICOMOS-Georgia) was interviewed the 14th of September 2010 with the aim to obtain general information about cultural heritage in Upper Svaneti.

Once in the study area, a series of semi-structured interviews (see Appendix 3) were conducted in the communities of Ushguli and Mulakhi in order to obtain information from local knowledge about natural hazards and elements at risk (translation was also needed). Each interview included nineteen questions divided in three sections:

- hazard general information
- hazard exposure information
- hazard perception

Normally a group of people would gather spontaneously and join the conversations converting what was first an interview into a group discussion. Consequently, a certain degree of improvisation was required to achieve the required goal.

4.3.2. Field observations

Field observations were considered to detect and record evidence of past natural hazards as well as to contrast/support information acquired from the local community. This evidence was acquired detecting some features such as scars/cracks in buildings, terrain scars/cracks, terrain debris remnants (rocks, displaced stones), scars in vegetation, presence/absence of vegetation and bending poles. Mobile GIS connected to a GPS was used to take coordinates of points of interest such as past avalanche and landslide pathways.

4.3.3. Map sketching

Sketch maps were drawn with locals in order to determine historical avalanche and landslides pathways as well as to obtain information about the possible exposed elements at risk. To help with this task, a Google Earth image was used in Ushguli community. For Mulakhi the low spatial resolution of the images prevented from using them. Furthermore, topographic paper maps at a scale 1:50000 covering the study area acquired in a private Georgian company (GeoLand) were also used. Mobile GIS connected to a GPS was used to take coordinates of points of interest when drawing the sketch maps to facilitate transforming the information gathered into digital form.

4.4. Main Accessibility Road Assessment

4.4.1. “Hotspots” GPS recording and mapping

The road linking the main town of Mestia to Ushguli is considered an important element at risk as it represents the only transportation facility available. The general state of the road is very poor making driving conditions rather difficult. With the aim of identifying which areas are more susceptible to become blocked by natural phenomena *hot spots* were examined along the road. This was done driving along the unpaved 43.7 km road and taking GPS readings in the points where remains of past/recent rockfalls and landslides could be visually identified. Also streams crossing the road were recorded as they are considered having a significant erosive effect on the road as well as leaving considerable amounts of debris during precipitation. This may also lead to the road being blocked. The road itself was digitized with a mobile GIS configuration connected to a GPS on the way from Ushguli to Mestia, and the same was done with the *hot spots* on the way back. Overall, it took approximately five hours to cover the 87 km due to the complexity of the terrain making driving conditions quite difficult. The digitized points obtained in the field were later transferred into ArcGis10 and the attribute table of the layer was filled differentiating the points between "rockfall", "landslide" and "crossing stream".

4.5. Multi-Hazard Risk Analysis using SMCE

Given the limitations on data availability and quality as well as time constrains for this study, it was decided to produce a semi-quantitative multi-hazard risk index analysis focusing on landslides and avalanches using the spatial multi-criteria evaluation module integrated in ILWIS (Integrated Land and Water Information System). The multi-hazard risk index for the different areas of study use indicator maps derived from expert and local knowledge as well as existing data gathered from national information sources.

4.5.1. Hazard susceptibility mapping

A hazard susceptibility analysis was performed in turn for landslides and avalanches in the communities of Ushguli and Mulakhi. The methodology followed (Figure 4.2) is the same for each community and natural hazard, only varying the conditioning factors used for landslides and avalanches.

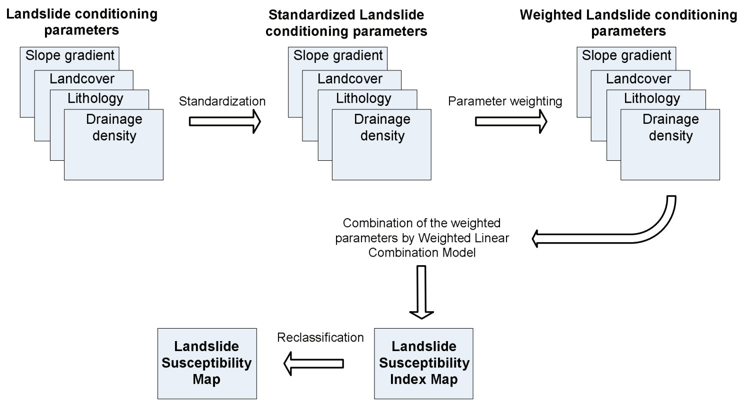

Figure 4.2: Hazard susceptibility analysis approach (example for landslide).

The conditioning landslide and avalanche factors selected for this study are listed in table 4.4. Those factors are found in most of the studies consulted (see also section 2.2.4) and are considered relevant bearing in mind data availability, the area of study and the scope of this work. Some other factors are discarded mainly because of the lack of available data and their lower relevance at the scale of the study area.

Table 4.4: Conditioning factors used in this study.

HAZARD SUSCEPTIBILITY ANALYSIS FACTORS	
Landslide	**Avalanche**
Slope gradient	Slope gradient
Lithology	Aspect (insolation)
Landcover	Slope curvature
Drainage density	Landcover

Conditioning factors (see also section 2.2.4 and Appendix 1 for maps) used for **landslide** hazard assessment in Ushguli and Mulakhi communities:

Slope gradient

Slope was derived from the 20x20 m existing Digital Elevation Model (DEM). The resulting layer was then reclassified based on studies in landslide susceptibility mapping (Akgun and Türk, 2010, Ayalew and Yamagishi, 2005a, Yalcin, 2008); each class representing a level of susceptibility to landslide initiation (Table 4.5). Next, the layer was imported into ILWIS from ArcGis10.

Table 4.5: Slope classes and ranking susceptibility level (1=highest; 3=lowest).

SLOPE GRADIENT CLASS	RANKING SUSCEPTIBILITY LEVEL
<5^{o}	3
6^{o} - 20^{o}	2
20^{o} - 40^{o}	1
>40^{o}	3

Landcover

An existing landcover map derived from the topographic 1:50,000 was used. The layer came in shape format from the MATRA project. Its quality was poor in terms of topology so it had to be fixed accordingly in ArcGis 10. Then, the layer was compared visually to the Google earth image (June 2006) in order to detect any changes in landcover; but it was observed that it remains the same as socio-economic activities in the area have varied very little in the last centuries. It was also checked to better define the landcover classes. The original classes had some degree of uncertainty so they were reclassified into five more understandable classes related to level of susceptibility to landslide initiation (Table 4.6). “Small city” class was dismissed as it was not consider an environmental conditioning parameter. “Small city" was given the class that surround it, that is "Grassland". Next, the vector layer was rasterized and imported into ILWIS from ArcGis10.

Table 4.6: Reclassification of landcover classes and susceptibility level (1=highest; 5=lowest).

ORIGINAL CLASSES	RECLASS	RANKING SUSCEPTIBILITY LEVEL
Forest deep Forest light	Forest	3
Land Small city	Grassland	1
Scrub	Scrubland	2
Rocky	Rocky	4
Glacier	Glacier	5

Lithology

For this study the existing 1:50,000 geology map made by the former Soviet Union in 1958 was used as it was the only data available. The maps had been scanned and georeferenced by the National Environmental Agency of Georgia. The maps were then mosaicked for the area of study, digitized and the attribute table filled with the corresponding lithology information. The resulting vector layers were reclassified based on Ayalew and Yamagishi (2005), Yalcin (2008), Hofmann (2009) and Akgun and Türk (2010); each class representing a level of weathering susceptibility related to landslide initiation (Table 4.7). Next, the vector layer was rasterized and imported into ILWIS from ArcGis10.

Table 4.7: Lithology classes and ranking susceptibility level (1=highest; 3=lowest).

LITHOLOGY CLASS	RANKING SUSCEPTIBILITY LEVEL
Blocks, boulders and gravels	2
Clay, shales and sandstones	1
Moraine debris	3
Granites, quartz diorites and migmatites	3
Limestone and marls	1

Drainage density

Due to the characteristics of the area of study with a high number of streams meeting the main river it was considered that drainage density could play a significant role as landslide conditioning factor. To produce the map of drainage density ArcGis10 was used. First, the area was divided into various basins using the existing DEM as a source layer. Then, first, second and third order streams of the drainage network were used to calculate the drainage density separately for each basin. Next, the layer was reclassified based on the work of Luo et al. (2007), Nithya and Prasana (2010) and considering the fact that the higher the drainage density the more prone to landslide initiation (Table 4.8). After that, the vector layer was rasterized and imported into ILWIS from ArcGis10.

Table 4.8: Drainage density classes and ranking susceptibility level (1=highest; 3=lowest).

DRAINAGE DENSITY CLASS (km/km^2)	RANKING SUSCEPTIBILITY LEVEL
<1	5
1 - 1.5	4
1.5 - 2	3
2 - 2.5	2
>2.5	1

In order to facilitate spatial multi-criteria evaluation, the above input layers needed to be standardised from their original class values to the value range of 0-1. As all the above factors were already represented as class values indicating levels of susceptibility, the ranking method integrated in ILWIS was adopted. The classes were ranked according to their level susceptibility (see tables above). Finally, weights were given to the different factor maps based on the literature sources described in section 2.2.4 to show their relative importance with one another. Pair wise comparison method was used giving a consistency ratio (CR) of 0.04 indicating a reasonable level of consistency in the pair-wise comparison of the factors. Table 4.9 below shows an overview of the procedure explained above.

Table 4.9: Overview of standardization and weighting method for factors used (landslide).

LANDSLIDE SUSCEPTIBILITY INDEX			
FACTORS	STANDARDIZATION	WEIGHTING	
		VALUE	METHOD
Slope	Ranking	0.56	Pairwise
Lithology		0.26	
Landcover		0.12	
Drainage density		0.06	

Conditioning factors (see also section 2.2.4 and Appendix 1 for maps) used for **avalanche** hazard assessment in Ushguli and Mulakhi communities:

Slope gradient

The same slope layer used for the landslide analysis was used for avalanche but this time a different reclassification was performed based on literature sources cited in section 2.2.4. (see Table 2.8 and Table 4.10). Each class represents a level of susceptibility to avalanche initiation. Next, the layer was imported into ILWIS from ArcGis10.

Table 4.10: Slope classes and ranking susceptibility level (1=highest; 4=lowest).

SLOPE GRADIENT CLASS	RANKING SUSCEPTIBILITY LEVEL
$<10^o$	4
10^o - 28^o	2
28^o - 45^o	1
$>45^o$	3

Aspect (insolation)

Aspect was derived from the existing DEM and reclassified into eight classes based on the literature sources cited in section 2.2.4. Each class represents a level of susceptibility to avalanche initiation (Table 4.11). Next, the layer was imported into ILWIS from ArcGis10.

Table 4.11: Aspect classes and ranking susceptibility level (1=highest; 4=lowest).

ASPECT (insolation) CLASS	RANKING SUSCEPTIBILITY LEVEL
North	1
North East	1
East	1
South East	2
South	3
South West	3
West	3
North West	2

Slope curvature

The idea was to calculate ridges and gullies (convex and concave surfaces). The procedure followed that proposed by Wright (2009). Slope curvature was derived from the existing DEM using ArcGis10 3D-Analyst extension. The resulting raster layer was reclassified to pick up the most prominent ridges and gullies (Table 4.12) showing levels of avalanche susceptibility. These classes reflect the fact that ridges (positive values) are less prone to avalanche than gullies (negative values), and that the more prominent the ridge, the less prone it will generally be to avalanche initiation.

Table 4.12: Slope curvature classes and ranking susceptibility level (1=highest; 9=lowest).

ORIGINAL VALUES	RECLASSIFICATION		RANKING SUSCEPTIBILITY LEVEL	
	Ushguli	Mulakhi	Ushguli	Mulakhi
12 to 16.4	1	-	9	-
8 to 12	2	-	8	-
4 to 8	3	1	7	7
1 to 4	4	2	6	6
0 to 1	5	3	5	5
-0.5 to 0	6	4	4	4
-1 to -0.5	7	5	3	3
-2 to -1	8	6	2	2
-12.6 to -2	9	7	1	1

Landcover type

The landcover layer used for the landslide analysis was considered compatible for the avalanche analysis after consulting literature sources (see section 2.2.4). Here, this layer is considered as a function of surface roughness. In Mulakhi community only three landcover classes are found. Susceptibility level values for the landcover classes were given according to the proneness of each class to avalanche initiation (Table 4.13).

Table 4.13: Land cover classes and ranking susceptibility level (1=highest; 4=lowest).

LAND COVER CLASS		SUSCEPTIBILITY LEVEL	
Ushguli	**Mulakhi**	**Ushguli**	**Mulakhi**
Forest	Forest	4	3
Grassland	Grassland	2	1
Scrubland	Scrubland	3	2
Rocky	-	2	
Glacier	-	1	

Standardization and weighting followed the same procedure as for landslide above. The consistency ratio (CR) obtained resulted in 0.06 indicating a reasonable level of consistency in the pair-wise comparison of the factors. Table 4.14 below shows an overview of the procedure.

Table 4.14: Overview of standardization and weighting for factors used (avalache).

AVALANCHE SUSCEPTIBILITY INDEX			
FACTORS	STANDARDIZATION	WEIGHTING	
		VALUE	METHOD
Slope	Ranking	0.50	Pairwise
Slope curvature		0.29	
Landcover		0.14	
Aspect (insolation)		0.06	

Finally, all the weighted factor maps were combined in turn for each community in two separate hazard trees within the ILWIS-SMCE module. For Ushguli and Mulakhi, landslide, avalanche and multi-risk hazard index maps were produced. These maps were reclassified in three classes: High, Moderate and Low hazard.

4.5.2. Sensitivity analysis

A sensitivity analysis was performed to estimate which factor has more influence on the occurrence of landslides and avalanches analysed in this study. This was done for the Ushguli study area excluding one input factor during each run within the SMCE module in ILWIS and taking into account moderate and high hazard percentage area. The results are shown in table 4.15. From table 4.15 it can be deduced that for landslides there is not much variation except for the difference when the slope parameter is not included. This implies that for landslides, slope plays an important role in their occurrence. For avalanches, it is evident that slope is the most influencing factor playing a major role in avalanche incidence.

Table 4.15: Percentage area covered with moderate and high hazard after sensitivity analysis of factors used for Ushguli (NA: Not Applicable).

INPUT FACTORS	MODERATE AND HIGH HAZARD AREA (%)	
	Landslides	**Avalanches**
All factors	94.2	94.2
No slope	**89.2**	**71.3**
No lithology	94.2	NA
No landcover	93.3	92.2
No drainage density	94.2	NA
No aspect (insolation)	NA	93.8
No slope curvature	NA	93.4

4.5.3. Elements at risk and vulnerability mapping

Vulnerability in this study is expressed by vulnerability indices based on indicators of vulnerability (mainly the state of conservation of cultural heritage objects).
Two vulnerability analyses were performed in turn for Ushguli and Mulakhi. Figure 4.3 shows the vulnerability analysis approach.

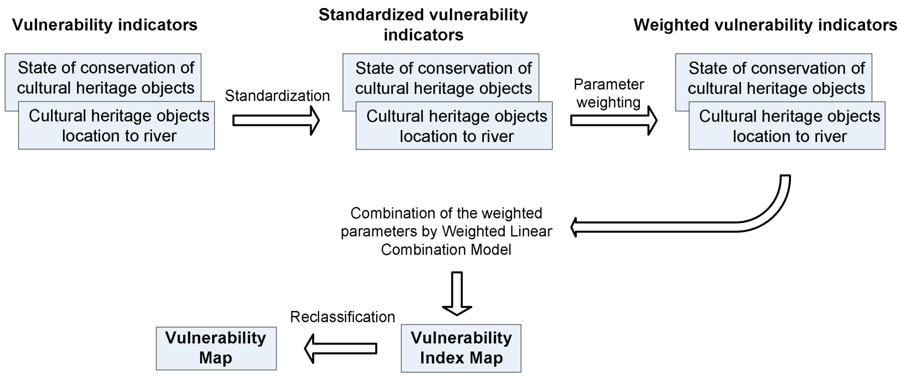

Figure 4.3: Vulnerability analysis approach (example for Ushguli).

The following vulnerability indicators were used for the analysis:

State of conservation of cultural heritage objects:
Cultural heritage features represent the element at risk in this study (see section 4.2.2). As described in section 4.2 two point layers were produced showing the state of conservation of cultural heritage objects in Ushguli and Mulakhi respectively. The layers were classified according to the state of conservation of the cultural heritage objects assessed. For the vulnerability analysis each class represents levels of exposure taking into account the fact that the worse the state of conservation of the cultural heritage object the higher its exposure (Table 4.16). Next, the layer was rasterized using a 20x20 m pixel size to match with the rest of raster layers used in the multi-risk analysis and imported into ILWIS from ArcGis10.

Table 4.16: State of conservation classes and exposure level (1=highest; 6=lowest).

STATE OF CONSERVATION CLASS	RANKING EXPOSURE LEVEL
Ruin	1
Very bad	2
Bad	3
Moderate	4
Good	5
Very good	6

Cultural heritage location with respect of riverside (Ushguli only):
Information extracted from field observations and local knowledge in Ushguli community shows that cultural heritage objects located on the left side of the river Enguri are less exposed than those located on the right side of the river. In case of landslides or avalanches the river represents a natural barrier protecting the cultural heritage features and the settlements themselves from being impacted. Consequently, in order to characterize this fact, a map was prepared showing two

classes: one class representing the right side of the river meaning more exposure, and another class representing the left side of the river meaning less exposure (Table 4.17). Next, the layer was rasterized and imported into ILWIS from ArcGis10.

Table 4.17: Classes for cultural heritage (CH) objects in respect of their location to river and exposure level (1=highest; 2=lowest).

CH LOCATION TO RIVER CLASS	RANKING EXPOSURE LEVEL
Right side	1
Left side	2

As the above indicators were already represented as class values signifying levels of exposure, the ranking method integrated in ILWIS was adopted for standardization (see tables above and Table 4.18). Finally, for Ushguli, weights were given to the two indicators maps by pair-wise comparison based on their relative importance with one another (Table 4.18). It was considered that the state of conservation of cultural heritage objects was "*moderately more important*" than the location of the objects in respect of the river.

Table 4.18: Overview of standardization and weighting for indicators used (Ushguli).

VULNERABILITY INDEX			
INDICATORS	STANDARDIZATION	WEIGHTING VALUE	WEIGHTING METHOD
State of conservation of cultural heritage objects	Ranking	0.75	Pairwise
Cultural heritage objects location related to river		0.25	

For Mulakhi community, the indicator representing cultural heritage objects location related to river was not applicable.
Finally, the two weighted indicator maps were combined for Ushguli in a vulnerability tree within the ILWIS-SMCE module. For Mulakhi, only the state of conservation indicator was used. Two vulnerability index maps were produced, one for Ushguli and one for Mulakhi. These maps were reclassified in three classes: High, Moderate and Low vulnerability.

4.5.4. Multi-hazard risk mapping

The main objective of the multi-hazard risk mapping is to provide a global view of the expected damage due to the potential landslide and avalanche hazard by identifying the most vulnerable cultural heritage objects that are threatened. Figure 4.4 shows the multi-hazard risk analysis approach adopted in this study.

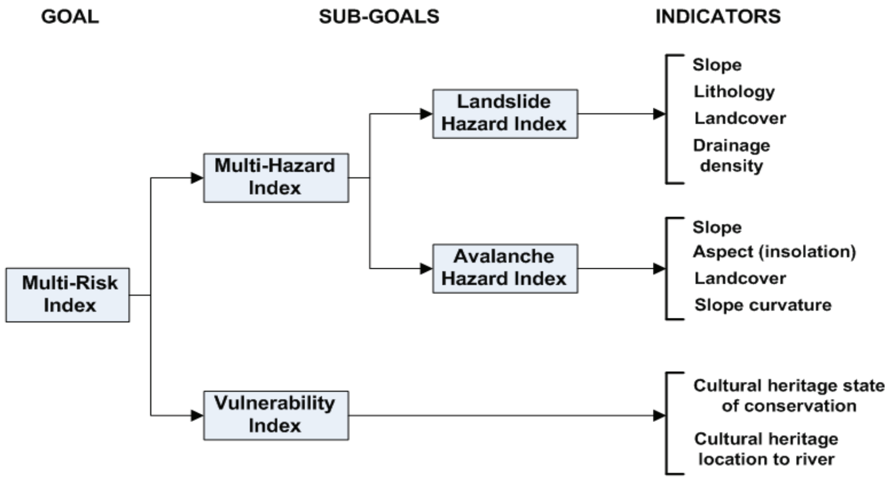

Figure 4.4: Multi-risk analysis approach in this study.

In this study two types of risk are considered: Risk for direct losses (cultural heritage objects may collapse by the direct impact of avalanches and landslides); and Risk for indirect losses (cultural heritage objects may get indirectly impacted by, for example, the loss of function of the road preventing the cultural heritage objects from being maintained as they cannot be reached). Cultural heritage is considered an intangible loss (van Westen, 2009).

Using the resulting hazard susceptibility and vulnerability maps, a matrix was developed to calculate representative risk for both landslides and avalanches as shown in table 4.19. In this matrix, a given area may have cultural heritage elements present but each with a different level of vulnerability. For example, if a cultural heritage object is found to be in a high hazard class and at the same time that object has a high vulnerability class, then the risk of such object is considered high. Below is an explanation of the matrix colours.

Red: There is a possibility of destruction of cultural heritage objects.

Orange: Damage on cultural heritage objects can be expected but not destruction.

Yellow: Minor damage may be expected to cultural heritage objects.

Table 4.19: Risk assessment matrix

	Low hazard	Moderate hazard	High hazard
Low vulnerability	Low risk	Low risk	Low risk
Moderate vulnerability	Low risk	Moderate risk	Moderate risk
High vulnerability	Low risk	High risk	High risk

Three different risk maps were produced: Landslide risk map; Avalanche risk map; and a combination of those two as a Multi-hazard risk map. To obtain the risk maps, the hazard susceptibility maps were crossed with the final vulnerability maps using ILWIS software. The final maps were reclassified in three levels of risk: High, Moderate and Low. Two approaches were used to obtain the final risk maps. In the first one, the landslide and avalanche risk maps were obtained separately (separate criteria trees for each hazard), whereas in the second approach the multi-risk analysis was performed at the same time for both types of hazards (single criteria tree for both hazards). These two approaches allowed obtaining risk information for both hazards separately and in combination.

5. Cultural Heritage State of Conservation in Upper Svaneti

In this study a total number of 60 cultural heritage objects were assessed, 30 in each community. Table 5.1 below shows a summary of the objects assessed per typology.

Table 5.1: Cultural heritage objects assessed.

Community	Measurement	Tower	Machubi	Fortified dwelling	Church	Total
USHGULI	Count	17	5	3	5	30
	% within community sample	56.7	16.7	10.0	16.7	100
	% of Total sample	28.3	8.3	5.0	8.3	50
MULAKHI	Count	20	7	0	3	30
	% within community sample	66.7	23.3	0.0	10.0	100
	% of Total sample	33.3	11.7	0.0	5.0	50
Overall %		**61.7**	**20.0**	**5.0**	**13.3**	100

5.1. Typology and Function of Cultural Heritage Objects

The next subsections give an overview in terms of typology, function and construction characteristics for the cultural heritage objects assessed in the study area. The information is based on ICOMOS (2001a), and field observations. See Appendix 2 for pictures.

5.1.1. Church

Churches are small sized (approx. 4x4m) one storey-vaulted structures. Church walls are about 50 cm thick and are built of rock rubble covered with lime mortar. Some churches keep their original slate roof whereas others have been replaced by tin plates. No windows *per se* are found on churches, just small slits for ventilation. Churches are regularly used by locals for praying and worshiping.

5.1.2. Tower

Towers are vigorous vertical structures of approximately 5x5 meters at the base and narrowing towards the top. The tower is mainly four/five stories high (12-15 m) although some towers of six floors can also be found. The floors are connected by a hole cut in the ceiling and a wooden ladder. Windows are of plain rectangular shape and very narrow in accordance with the traditional defence function of the building.

Tower walls may reach one meter thick and are also built of rock rubble (with the addition of large stones in the lower part) and covered with lime mortar. A small number of limestone and cobble are also used in the masonry. The gable roof of the tower is arrange on timber joists and traditionally covered with slate slabs although these are being recently replaced by wooden boards or tin plates. At present, towers are used as subsidiary structure for storage.

5.1.3. Machubi

Machubis are two storied rectangular structures of various dimensions. Walls may reach one meter thick and are built of 15-20 cm thick stones (with the addition of some limestone and cobbles) covered with lime mortar. Machubis have gable or pent roofs with slate slabs arrange in a system of "resting joists" which give them special strength. At present, some roofs have been replaced with tin plates.

Machubi was traditionally used as a winter dwelling for the family (first floor) and cattle shelter (ground floor). At present it is used as a subsidiary structure for cattle shelter and storage.

5.1.4. Fortified dwelling

Fortified dwellings are three or four storied structures found in Ushguli only. It is basically a typical Svanish tower with changed proportions (lower and wider, approximately 9x9 m at base). Walls and roofing are analogous to that of machubi. Fortified dwellings traditionally combined residence and defence functions, being an extremely compact and functional flexible unit. At present, they are used as a cattle shelter, storage and even as a museum (Chazhashi village).

5.2. Results of Quantitative Evaluation of Cultural Heritage State of Conservation

Information about the state of conservation of 60 cultural heritage objects was collected in Ushguli and Mulakhi communities (30 objects in each community). A total number of 116 cultural heritage objects are listed in Ushguli (GPAP, 2008). In this study, 26% of the total cultural objects in Ushguli community were surveyed. According to the same source 99 cultural heritage objects are found in the six villages assessed in Mulakhi community meaning that 30% of the total cultural heritage objects were surveyed. One object in Ushguli and five in Mulakhi were directly assessed as "Ruin". More than half (61.7%) of the objects for which information was collected were towers, followed by machubis (20%). Churches and fortified dwellings accounted for 13.3% and 5% respectively. Figure 5.1 below depicts graphically a summary of the results of the state of conservation assessment.

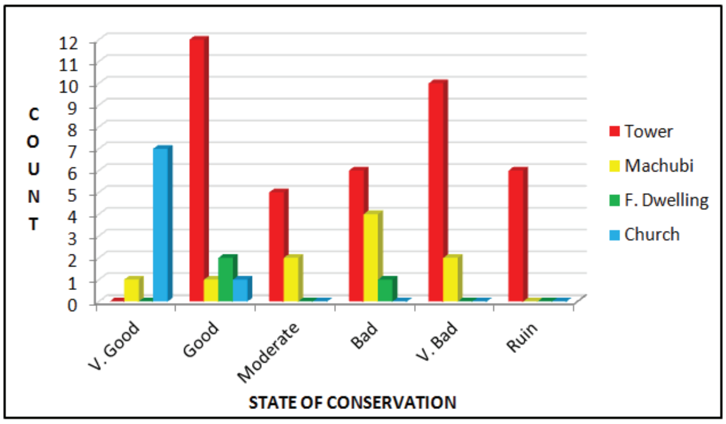

Figure 5.1: Summary results of the state of conservation assessment.

5.2.1. Damage assessment

For 54 cultural heritage objects (6 objects were directly assessed as ruined) a damage assessment was carried out for a standard set of elements (for detailed results see pictures in Appendix 2 and tables and graphs in Appendix 3):

Roof damage

Only 35.2% of the 54 objects sampled show no roof damage; low to moderate damage occurs in 22.2% of the objects; in 42.6% of the objects roof damage is (very) heavy or the roof is completely absent. 15 towers fall in this last category. When comparing the two communities Mulakhi shows a higher percentage of roof damage from heavy to the total absence of it (24.1%) than Ushguli (18.5%). Churches are the objects with less roof damage (7 out of 8 churches assessed show no roof damage at all). Figure 5.2 below shows summary results.

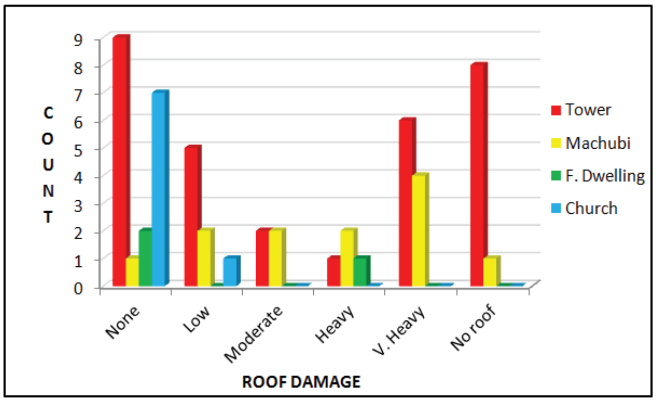

Figure 5.2: Roof damage of cultural heritage objects.

23 of the total cultural objects assessed show roof damage from heavy to no roof at all. The totality of those objects show an overall state of conservation from bad to ruin.

Structural damage (cracks)

Low presence of cracks accounts for 31.5% of the total sample; a moderate presence of cracks can be found in 33.3% of the objects. A heavy and very heavy presence of cracks accounts for 35.2% of the objects assessed. 12 towers fall in this last category. Very heavy or heavy presence of cracks is higher in Ushguli (20.4%) than in Mulakhi (14.9%). Per typology, churches are the objects with lower levels of cracks (6 out of 8).

Structural damage (partial collapses)

Only 13% of the total sample shows (very) heavy partial collapses. 18.6% of the objects account for moderate partial collapses. No partial collapses whatsoever are found in 68.5% of the objects. In Ushguli 46.3% of the objects assessed show no partial collapses compared to 22.2% in Mulakhi. Per typology, towers and machubis are the only features that present partial collapses (11 and 6 objects respectively).

Structural damage (sinking)

No sinking is found in 74.1% of the total objects assessed. Low and moderate sinking occurs in the rest of the objects 25.9%. 9 towers (6 in Mulakhi) and 5 machubis (3 in Mulakhi) fall in this category.

Structural damage (tilting)

No tilting is found in 64.8% of the total objects assessed. Low and moderate tilting occurs in 27.8% of the cultural features. Only 7.4% of the objects show heavy tilting. 4 towers fall in this category (3 in Ushguli and 1 in Mulakhi).

Damage due to moisture effects

Only 3.7% of the objects sampled show signs of heavy degradation due to humidity. Low to moderate humidity degradation occurs in 88.9% of the objects assessed and 7.4% present no humidity signs at all. Mulakhi show less levels of humidity degradation (46.4%) compared to Ushguli (53.7%). Presence of different levels of humidity degradation is found in all typologies. The highest levels of humidity degradation are found in two machubis in Ushguli.

Damage due to biological effects

Only 5.6% of the objects sampled show signs of heavy degradation due to biological effects. Low to moderate biological degradation occurs in 87.1% of the objects assessed and 7.4% present no biological degradation signs at all. Mulakhi show less levels of humidity degradation (46.4%) compared to Ushguli (53.8%). Presence of different levels of biological degradation is found in all typologies. One tower, one machubi and one church in Ushguli suffer the highest levels of biological degradation.

Damage due to misuse

Overall, 50% of the objects assessed are not used for any purpose. 27.8% of the objects are used as animal shelter and 3.7% for agricultural storage. All churches (8) are used as worship places and one object (fortified dwelling in Ushguli) as a museum. In 7 towers, 4 machubis and 1 fortified dwelling (22.2% of the total objects) in Ushguli animals are kept. In Mulakhi only 3 machubis (5.6% of total objects assessed) are used as animal shelter.

Presence/absence of restoration works

Restoration works could be observed in 51.9% (28 objects) of the cultural heritage objects assessed. Of these, 15 objects are in Ushguli and 13 in Mulakhi. Towers and churches are the objects with more presence of restoration works (15 and 7 respectively).

Slope gradient at the location of the object

59.2% of the objects assesses are located on flat or slight slope. Objects on moderate slope account for 46.3% and only 5.6% of the objects assesses are on a heavy slope. 3 towers in Mulakhi fall under this category.

5.2.2. State of conservation map

Figures 5.3 and 5.4 below represent the state of conservation of cultural heritage objects in Ushguli and Mulakhi communities respectively. The maps depict the state of conservation of the cultural heritage objects assessed from “very good” to “ruin”, as well as the typology of the objects. For example, in Murkmeli village (Ushguli) it can be observed that there are two towers in red, meaning that they are in a very bad state of conservation; a church (cross sign) in green showing a very good state of conservation; and two other towers with good and moderate level of conservation (lighter green and yellow respectively). A backdrop image of enough quality could not be found for the state of conservation map in Mulakhi community.

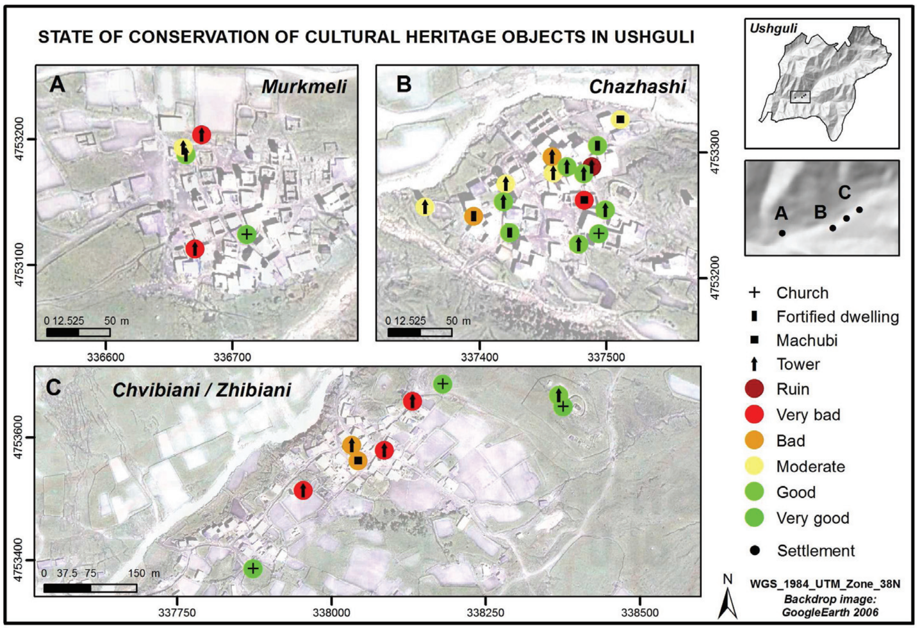

Figure 5.3: State of conservation for 30 cultural heritage objects in villages in Ushguli.

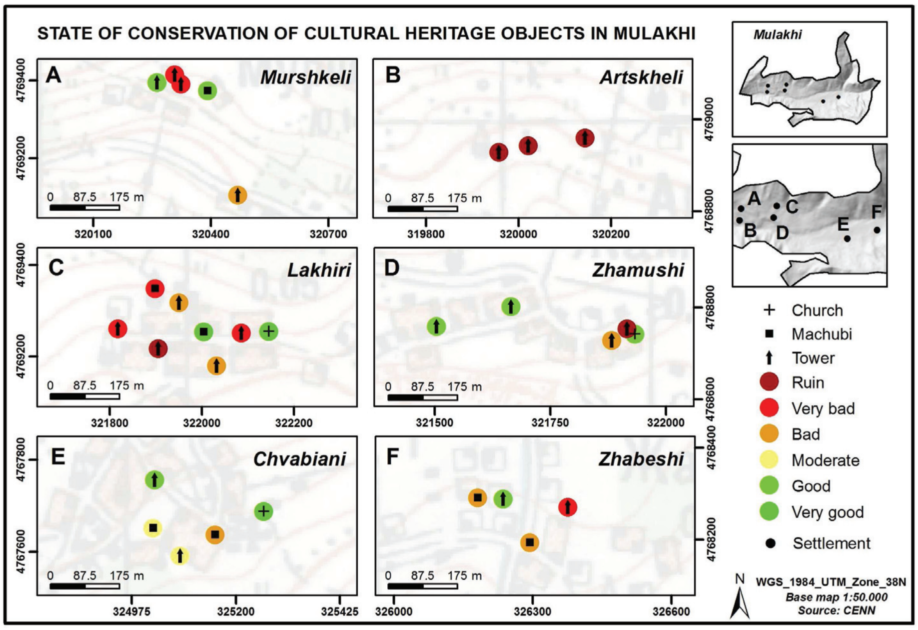

Figure 5.4: State of conservation for 30 cultural heritage objects in villages in Mulakhi.

5.3. Discussion

Assessment parameters

The damage assessed on cultural heritage objects in this study used different parameters. After examining all the data collected “Roof damage” has proved to be a significant element influencing the overall state of conservation of the buildings (see Figure 5.2 and Appendix 3: roof damage vs. state of conservation). It can be deduced that a building with bad roofing or no roof at all has a worse state of conservation than a building with good roofing. Generally, degradation starts on the roofs and spreads rapidly to the rest of the building (Sarissky, (n.d.), Lourenço et al., 2006, Gonçalves et al., 2009). This effect could be even more significant in the study area due to the harsh environment especially in winter. Considerable amounts of precipitation in the form of snow and rain are recorded every winter in Upper Svaneti (GPAP, 2008). Snow may overload already damaged roofs leading to collapse. Rain also pours inside buildings with bad roofing. Moisture may easily fill cracks present in the walls of the building, which due to the freeze-thawing effect, may slowly but severely damage the structure of the building.

Other reasons may also lead to the deterioration of the roofs of the buildings assessed in the study area. Firstly, lack of financial resources represents a burden for the maintenance of the buildings. This is clearly seen comparing the rest of settlements in the study area with Chazhashi where due to its status of World Heritage Site some resources have been in place. The result is a better overall state of conservation of the cultural heritage features in Chazhashi compared to the rest of the settlements. Secondly, the accessibility to the roofs for maintenance especially in high structures such as towers is very difficult. Also the access through the interior may be problematical due to advanced deterioration. This fact may hinder the attempt of even minor maintenance works.

Another significant parameter influencing the overall state of conservation is “crack damage” (see Appendix 3: crack damage vs. state of conservation). As mentioned earlier watering entering the building and freeze-thawing effect are significant factors influencing the expansion of cracks which may eventually lead to partial or total collapses of the building (Sarissky, (n.d.)).

For the rest of parameters, no direct significant relationship could be established between them and the overall state of conservation of the cultural heritage objects. However, it should be pointed out that the combination of those parameters it is expected to influence in various degrees of damage the overall state of conservation of the objects assessed.

Differences between communities

Comparing the results for the state of conservation of cultural heritage objects in Ushguli and Mulakhi some differences can be observed. Within Ushguli the buildings assessed in Chazhashi present a better conservation status compared to the rest of the settlements in the community. As mentioned earlier more resources have been allocated to Chazhashi. Within Mulakhi the buildings assessed in the settlements of Artskheli and Lakhiri (see also Figure 5.4) show a worrying state of conservation especially in the former where all three buildings assessed were ruined. Comparing between communities, Ushguli shows an overall better state of conservation of its cultural heritage objects. This is due to a great extent to the overall moderate to good state of conservation of the buildings assessed in Chazhashi village.

Differences between typologies

Among the typologies assessed, churches clearly stand out from the rest. All the churches assessed resulted in a good or very good state of conservation. It is apparent that more resources have been put for repairing and maintenance of churches in the study area. All the churches assessed had been provided for the last years with new roofing improving substantially the overall state of these structures. The more effort put into the maintenance of churches can be easily understood as these buildings are frequently used for praying and worshipping as well as guarding precious icons, murals and paintings.

Comparison of results

In an earlier survey (ICOMOS, 2001a) in the village of Chazhashi in Ushguli community the physical conditions of 39 objects (Table 5.2) were assessed and classified in four categories: Very bad; Bad; Moderate; and Good.

Table 5.2: Cultural heritage objects assessed in Chazhashi village by ICOMOS.

CULTURAL HERITAGE OBJECTS	
Typology	**Count**
Tower	14
Machubi	21
Fortified dwelling	3
Church	1

This survey was carried out by a group of specialists including architects and cultural heritage experts. Table 5.3 below shows the comparison of results between the same objects assessed in the present study (see Figure 5.3: Chazhashi) and in the mentioned ICOMOS survey.

Although no major discrepancies are found, from this comparison it can be deduced that the present study slightly overestimates the physical conditions of the buildings assessed. It is unknown with detail what was the process followed by ICOMOS to assess the physical conditions of the buildings. Consequently, comparisons in that respect could not be fully concluded.

Table 5.3: Cultural heritage state of conservation comparison of results.

ID	FEATURE	PRESENT STUDY	ICOMOS
1	Tower	Moderate	Bad
2	Fortified dwelling	Bad	Bad
3	Tower	Moderate	Bad
4	Tower	Good	Moderate
5	Tower	Bad	Bad
6	Fortified dwelling	Good	Bad
7	Machubi	Moderate	Moderate
8	Tower	Ruin	Very bad
9	Tower	Good	Moderate
10	Tower	Moderate	Moderate
11	Machubi	Very bad	Bad
12	Tower	Good	Bad
13	Fortified dwelling	Good	Good
14	Tower	Good	Good
15	Tower	Good	Moderate
16	Church	Very good	Good

However, it is considered that the results for the state of conservation of cultural heritage objects in Chazhashi performed in the present study and based on a non-expert approach are quite approximate to the results from the ICOMOS study originated by specialists.

Advantages / Disadvantages

The approach developed in this study to assess the state of conservation of cultural heritage objects has advantages and disadvantages.

On the positive side, this approach allows for a non-expert assessment of simple architectonical features. As seen earlier, this approach does not get too distant results compared to those obtained by experts. Moreover, it allows in a relatively quick and straight-forward way to deliver valuable information which authorities can use to address economic budgets aimed to the repairing and even recovery of cultural heritage buildings. This approach also allows for a rapid integration of the information into digital format which can be used in a GIS-based environment for further geographical analysis.

On the disadvantageous side, the approach proposed may have certain degree of subjectivity as all parameters are assessed based on visual inspection. To improve this more detailed examination should be included especially in the assessment of significant parameters (roof, cracks) such as measuring the cracks of the buildings, measuring the amount of moisture present on foundations and walls and analysing the wood frame condition in roofs. For example, Sarisski (n.d.) identifies some key features to consider for the assessment of a roof structure: large dead knots leading to partial failure of the member; fungus and insect attack especially affecting joints; and aggressive excrements of animals living in under roof spaces (these excrements cause slow chemical changes in the wood and weaken the members). As far as the assessment of cracks is concerned, Şeker et al. (1998) for example, use digital cameras to record cracks in earthquakes induced building damages. Then, they use a GIS to storage, administrate and analyse the data recorded to finally construct an automated damage analysis system. This approach, although considered very interesting for this work could not be applied due to the high level of photogrammetric expertise required.

Another problem may be the difficulty in assessing cultural heritage objects which are difficult to reach to due to the complexity of the terrain. In this case some other approaches based on remote sensing techniques could be useful.

For example, Gonçalves et al. (2009) use very high spatial resolution (VHSR) multispectral aerial images to assess the state of conservation of roofs in the historic city centre of Coimbra, Portugal. Their results are validated with the data obtained from a field study conducted during 2 years that included over 800 buildings and showed an accuracy of 78%. Their study proves that the state of conservation of roofs can be obtained from VHSR multi-spectral images when appropriate data and resources are available.

This approach, although considered very interesting for this work could not be applied due to unavailability of data, especially high resolution aerial images of the area of study.

6. Risk Assessment using SMCE

6.1. Multi-hazard Assessment

6.1.1. Expert interview / Local interviews

Expert interview

Tchichico Djanelidze (CENN) was interviewed the 13th September 2010. Mr. Djanelidze is a well recognised authority in Georgia in the field of geology and geography. The information extracted from the interview is summarized as follows:
The main natural hazards in Upper Svaneti that may affect cultural heritage are avalanches and landslides. Floods do not represent a risk for cultural heritage objects as they were built on purpose in non-flooded areas. Earthquakes do not represent a menace in Upper Svaneti. It is in the neighbouring region of Racha where earthquakes occur more frequently. The main causes of the incidence of avalanches and landslides are deforestation and building of infrastructure (especially roads).

Local interviews

A total number of 29 people participated in the interviews (see also section 4.3.1): 11 in Ushguli (4 interviews) and 18 in Mulakhi (5 interviews). Information extracted from local interviews in the study areas is summarized as follows:

Hazard information

The main hazards recognised are avalanches and landslides. These may occur from once to several times per year but mainly in spring (April/May) and coinciding with maximum load of melting snow and water combined with raising of temperatures. Avalanches and landslides are not reported to impact on buildings with the exception of the 1987 avalanche. Earthquakes are not reported in the area. A 65 year old interviewee who has spent all his live in the area did not remember any earthquake at all.

Hazard exposure information

In Ushguli no risk for cultural heritage objects is considered. In Mulakhi only two specific objects are recognised as being at risk (see also Figure 6.5). In both communities roads are regularly affected (blocked) by minor avalanches and landslides especially in winter and spring.

Hazard perception information

The main cause of avalanches and landslides is excessive precipitation in the form of snow and rain. The slopes at both sides of the river Enguri in Ushguli are perceived as prone to avalanches and landslides (Figure 6.1). In four villages in Mulakhi danger is perceived to come from the slopes directly above the settlements (Figure 6.1). In the other two villages in Mulakhi (Zhabeshi and Chvabiani) the main threat is perceived from the south slopes (Figure 6.1). Local people recognise planting trees and building stone walls (gabions) as main protection measures to put in place against avalanches and landslides.

6.1.2. Field observations / sketch maps

An area of landslide development was perceived by locals to be located in the south facing slopes of Ushguli between two avalanche pathways (also pointed by locals) (see Figure 6.1b). This area was examined with the aim of finding terrain features related to landslide development such as cracks and scars in vegetation. No evidence was found in this area that pointed to landslide development. In the north facing slopes in Ushguli where locals had located landslides (see Figure 6.1b) displaced rocks and stones were found showing evidence of past mass movements. In Mulakhi clear evidence of past avalanches was found especially in the village of Zhamusi (building debris and vegetation scars) (see Figure 6.1a and Figure 6.3).
Sketchs maps were drawn together with locals (see also section 4.3.3). An example of sketch maps produced can be found at the end of Appendix 1. This sketch map relates to the area around Zhamushi and Lakhiri settlements in Mualkhi community (see also Figure 6.1a). It illustrates avalanche pathways and especially the one that hit Zhamushi in 1987. It shows also how the forest protects Lakhiri but how a major avalanche can even destroy the forest and progress further down the slope causing damage to people and buildings.

As concluded from information extracted from local knowledge as well as expert knowledge and field observations, the two major natural hazards identified in the study area are avalanches and landslides. Figure 6.1 below shows the location and pathways of landslides and avalanches according to local knowledge (interviews) in the study areas.

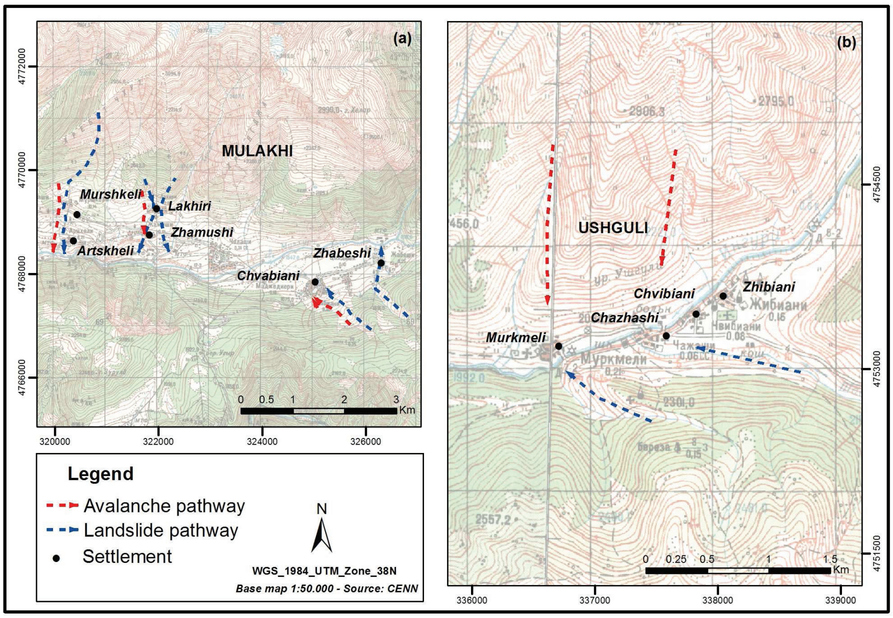

Figure 6.1: Location and pathways of landslides and avalanches according to local knowledge in the study area: (a) Mulakhi; (b) Ushguli.

6.1.3. Hazard factor maps

A number of hazard factor maps were produced to model, using spatial multi-criteria evaluation, the susceptibility of the study areas to landslides and avalanches (see also section 4.5.1). For landslide four factor maps were produced: 1. Slope gradient; 2. Lithology; 3. Landcover; and Drainage density. For avalanche four factor maps were produced: 1. Slope gradient; 2. Aspect (insolation); 3. Slope curvature; and 4. Landcover. These factor maps can be found in Appendix 1.

6.1.4. Multi-hazard mapping and analysis

A multi-hazard susceptibility analysis was performed using the spatial multi-criteria evaluation module within ILWIS. Three maps for each community resulted from the analysis: landslide susceptibility map; avalanche susceptibility map; and multi-hazard susceptibility map (combining landslide and avalanche susceptibility) (Figure 6.2 A, B and C for Mulakhi; D, E and F for Ushguli). Table 6.1 below shows also the percentage of the total area with low, moderate and high hazard susceptibility per each type of hazard and for both hazards combined (multi-hazard) in the study areas. Figure 6.2 and Table 6.1 will be discussed in the next section.

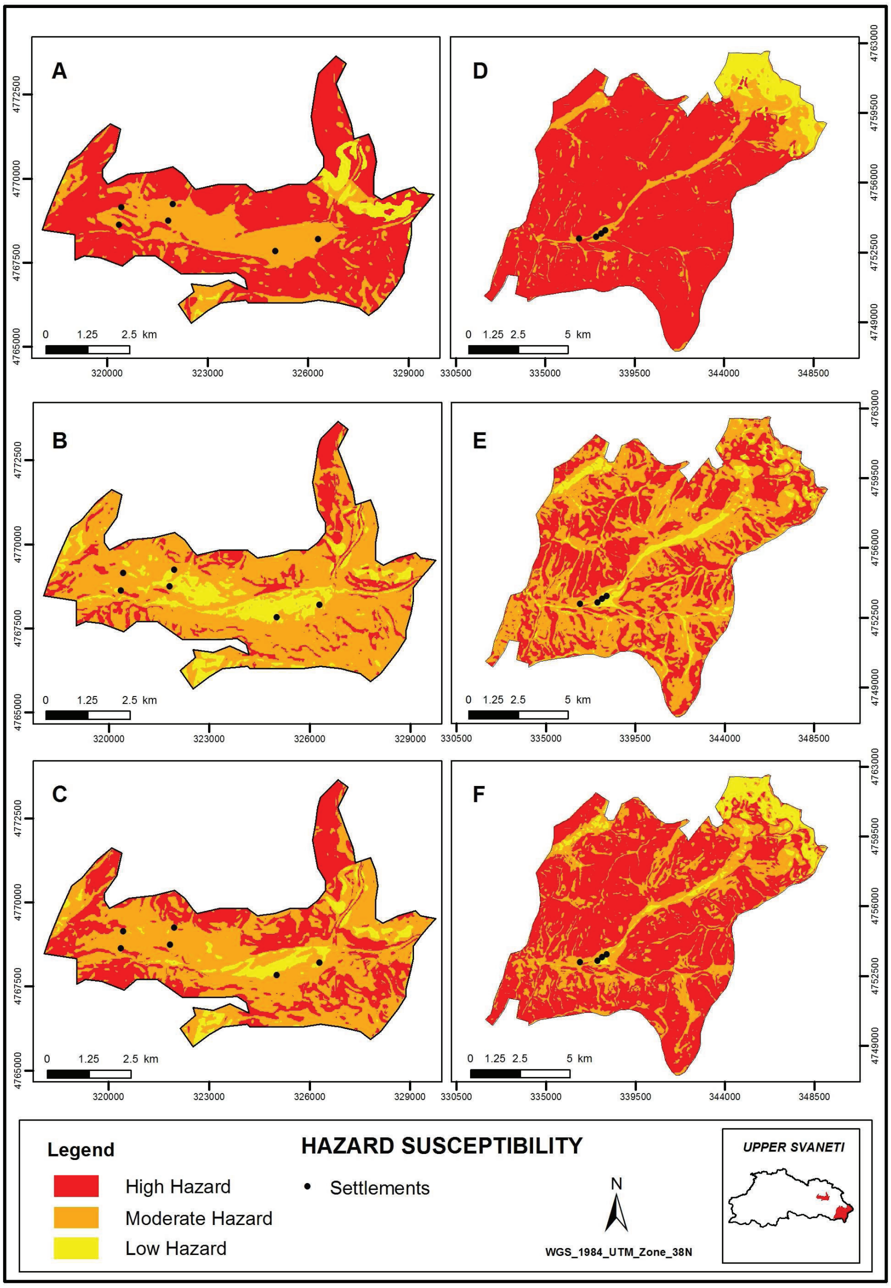

Figure 6.2: Hazard susceptibility in the study area. Mulakhi: Landslide, avalanche and multi-hazard (A, B and C respectively). Ushguli: Landslide, avalanche and multi-hazard (D, E and F respectively).

Table 6.1: Hazard percentage area in both communities.

COMMUNITY	HAZARD	AREA (%)		
		Low Hazard	Moderate Hazard	High Hazard
Ushguli	Landslide	5.8	15	79.2
	Avalanche	5.8	55.9	38.2
	Multi-hazard	5.5	30.8	63.6
Mulakhi	Landslide	4.9	33	62.1
	Avalanche	13	72.6	14.4
	Multi-hazard	6.2	60.6	33.2

6.1.5. Discussion

Interviews

Not many interviews were carried out in both communities. This was due to various reasons. First, the study areas are as a matter of fact scarcely populated (not many people could actually be found and be approached for interviewing). Moreover, the period when the fieldwork was conducted (mid September to mid October) was a time of fodder harvesting and storage before the arrival of winter. That meant that all men force in the area was working since very early in the morning until late at night while women were busy with domestic duties. Nonetheless, some locals did kindly consent to be interviewed at night after a hard day's work. Furthermore, for logistic reasons, group discussions and formal gatherings with locals and local authorities could not be established beforehand, hence and once in the field, a significant degree of improvisation was required and people were generally approached for interviewing in a spontaneous way.

By and large, the 29 locals that participated in the interviews gave similar answers to the questions enquired. The main message extracted was that the most important natural hazards in the study area were avalanches and landslides. Also there was a general consent about cultural heritage not being especially affected by those natural hazards. The information from locals coincided to a large extent to that provided by the senior geologist and cultural heritage expert (see also section 6.2.1) interviewed some days before in Tbilisi. In relation to landslides, it should be pointed out that locals understand this phenomenon as any kind of mass movement down the slope apart from avalanches.

Field observations / sketch maps

The information provided by locals was always intended to be contrasted on the field based on expert judgement. However, this probed to be a difficult task as not many major events have occurred in the area for years, hence not many signs in the terrain could be found. Consequently, not all information provided by locals indicating avalanches and landslides pathways could be confirmed. Some however, could be recognised as, for example, minor recent events that left scars on some buildings and, above all, a major avalanche event that occurred in 1987 in the community of Mulakhi resulting in the destruction of several buildings and 27 people dead. The avalanche had a volume of 1500000 m^3 and a height of 80-100 cm (Irakli Megrelidze, personal communication, 13^{th} January, 2010). Figure 6.3 below shows the avalanche event of 1987: (A) avalanche pathway as indicated by locals (red arrow); (B) avalanche destruction soon after it happened; (C) present signs of the avalanche (ruins, debris).

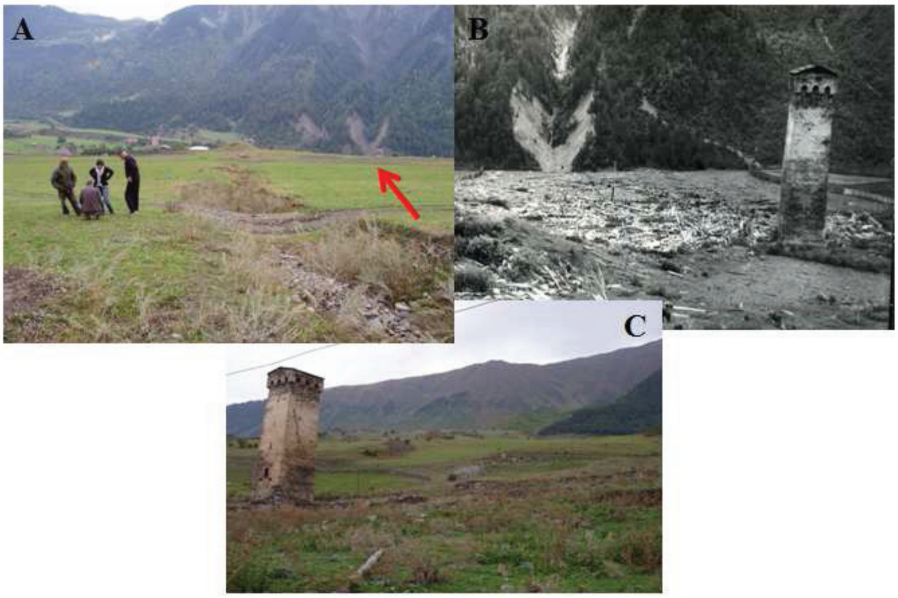

Figure 6.3: 1987 avalanche event in Zhamushi (image B courtesy of Irakli Megrelidze).

Sketch maps proved to be useful after field work in helping locating in digital format features recorded in the field.

Multi-hazard susceptibility

The results of the multi-hazard analysis show that the study areas have a significant level of hazard susceptibility (Figure 6.2 and Table 6.1). According to the analysis performed, 79.2% of the area in Ushguli has a high susceptibility to landslides. Such a high percentage resulted because Ushguli is an area with prominent slopes, covered to a large extent by grassland and its lithology is composed mainly of clay, shales, sandstone, limestone and marls (see also section 4.5.1 and Appendix 1 for factor maps). In Mulakhi, high landslide susceptibility was less compared to Ushguli (62.1%) resulting from slightly more gentle slopes and the presence of more forested areas within the community. Avalanches represent mainly a moderate hazard for both communities. In Mulakhi the percentage in this class is higher compared to Ushguli mainly because the slopes in Mulakhi present less curvature and also due to the more abundance of forested areas in Mulakhi offering some degree of protection. Overall, the multi-hazard analysis shows that Ushguli have a higher level of hazard susceptibility compared to Mulakhi. These results were visually compared overlaying them with the hazards pathways indicated by locals (Figure 6.4). From this comparison it can be observed that the location of the avalanche and landslides pathways indicated by the people interviewed matches to a large extent with the areas of higher level of avalanche and landslide susceptibility extracted from the analysis. Consequently, it could be affirmed that the hazard factor maps used in the SMCE proved to be a good choice as well as the weights given to the different factors.

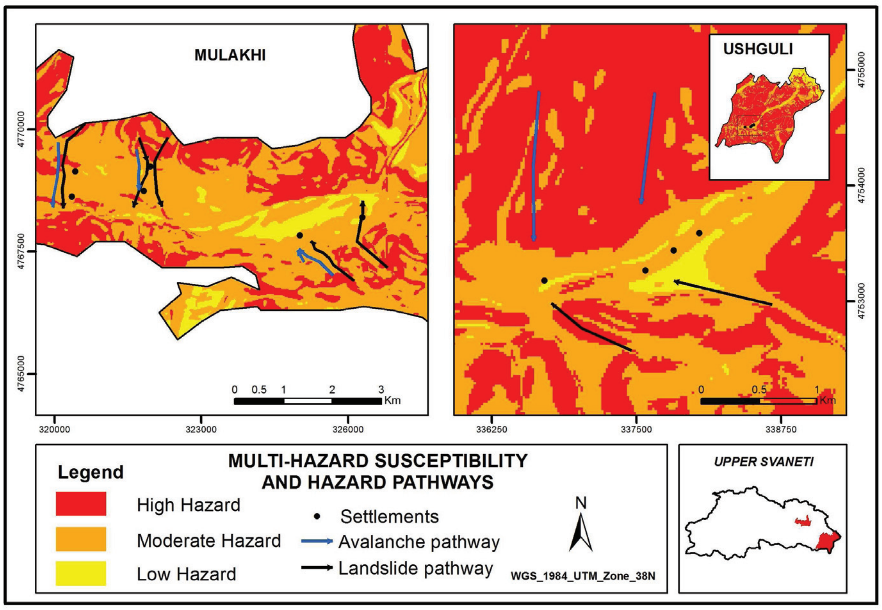

Figure 6.4: Avalanche and landslide pathways extracted from local knowledge overlaid on top of the multi-hazard analysis result.

6.2. Vulnerability Assessment

6.2.1. Expert interview / Local interviews

Expert interview

Senior cultural heritage expert Marina Khenia (ICOMOS-Georgia) was interviewed the 14th of September 2010 with the aim to obtain general information about cultural heritage in Upper Svaneti. The main message extracted from the interview was that cultural heritage is not particularly affected by natural hazards in the study area. Rather, the main threats to cultural heritage according to Marina have a human origin largely as lack of resources for maintenance. Also climatic factors such as precipitation (snow/rain) and freeze/taw effect were mentioned in the interview as influencing to some extent the state of conservation of cultural heritage assets.

Local interviews

Once in the study area, the message from the local community was similar. In Ushguli, no cultural heritage objects were identified by the local community as being at risk of avalanches and landslides. In Mulakhi however, some objects were identified as being at risk (Figure 6.5): Object Id 17 and Object Id 29. The latter object is the tower that survived the 1987 avalanche mentioned earlier. Objects 6, 7 and 8 are towers in a ruined state. These objects are in the very middle of avalanche and landslides pathways.

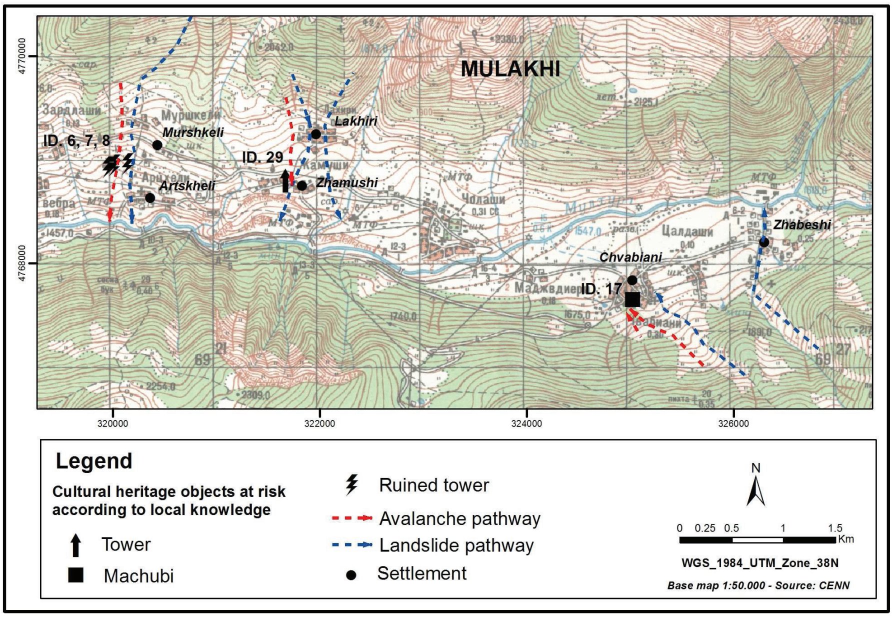

Figure 6.5: Cultural heritage objects at risk according to locals (Mulakhi).

6.2.2. Indirect risk due to blockage of main road

The road connecting the main town of Mestia to Ushguli community was visually examined with the aim of finding evidence of natural hazards which may induce to road blockage. Due to time constraints and the complexity of the terrain no examination could be done on the roads leading to the different settlements in

Mulakhi community. Figure 6.6 below shows 61 *hot spots* identified during the field work (see also Figure 6.7) along the road from Mestia to Ushguli that could cause blockages and hence indirectly influencing the integrity of cultural heritage (see also section 3.7 and 4.4.1).

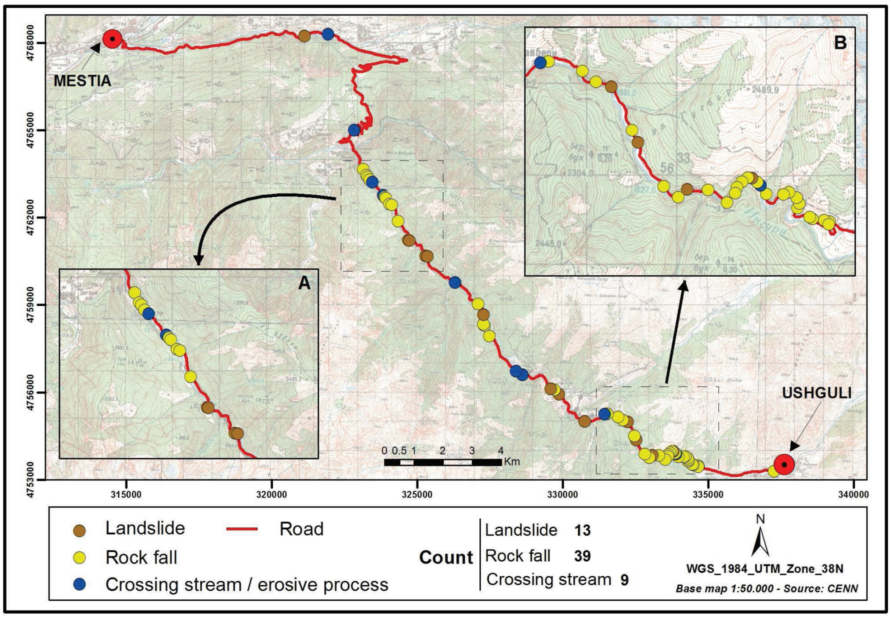

Figure 6.6: 61 identified road *hot spots* along the road from Mestia to Ushguli.

Figure 6.7: Hotspots examples of: (A) Rockfall; (B) Stream crossing road; (C) Landslide.

6.2.3. Vulnerability mapping and analysis

Figures 6.8 and 6.9 show landslide and avalanche vulnerability of cultural heritage objects in Ushguli and Mulakhi respectively.

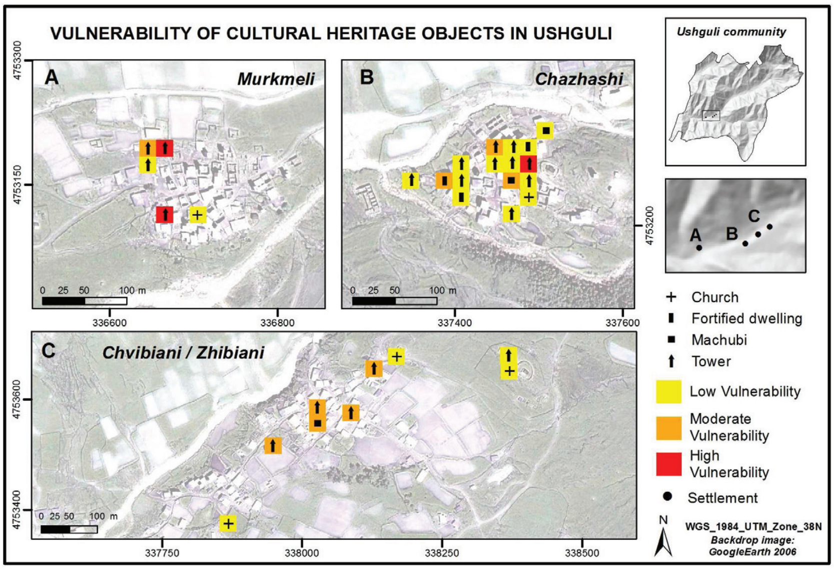

Figure 6.8: Landslide and avalanche vulnerability of cultural heritage objects in Ushguli.

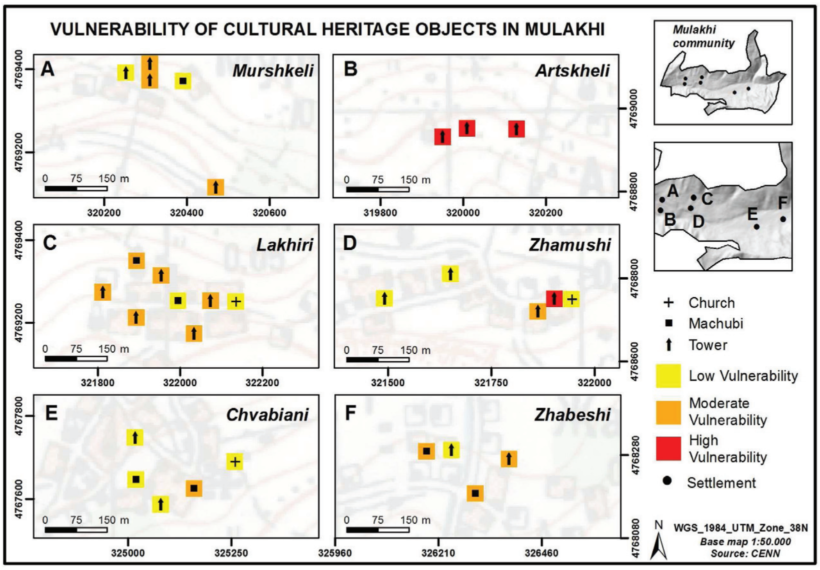

Figure 6.9: Landslide and avalanche vulnerability of cultural heritage objects in Mulakhi.

In Ushguli community vulnerability was calculated based on the state of conservation of cultural heritage objects and on the location of the objects in relation the river. 19 out of 30 objects show low vulnerability and only 3 objects have high level of vulnerability due to their especially advance state of deterioration. Two of those high vulnerability objects are located in the right side of the river Enguri in Murkmeli hence having an additional degree of vulnerability. The overall vulnerability of the cultural heritage objects in Ushguli is quite favourable as many of these objects (especially in Chazhashi village) have benefited in the last years of recovery and maintenance works. In Mulakhi 12 out of 30 objects have low vulnerability whereas 4 are high vulnerable. Churches are globally the cultural heritage object less vulnerable.

6.2.4. Discussion

Interviews

The information extracted from the expert interview and the locals interviews coincided to a large extent in pointing cultural heritage objects as not being at risk from natural hazards in the study areas. For example, the same tower that survived the 1987 avalanche was mention by Marina Khenia in Tbilisi and the locals in Mulakhi when describing how strong these structures are. It could not be established if the towers found in a ruined state and in the middle of avalanche and landslide pathways (Figure 6.5) were indeed destroyed by natural hazards. There was no consent among the people interviewed about the cause of destruction of these towers. Some locals said it was because of past avalanches events and some simply did not know.

Despite the evidence gathered in the field, the possible risk to cultural heritage objects by natural hazards in the study areas was assessed (see section 6.3) in order to contrast and discuss the information provided by cultural heritage expert Marina Khenia and the local community.

Road Mestia - Ushguli

There was a unanimous consent among the local community when identifying the roads as elements at risk. Roads become regularly blocked by minor avalanches and landslides especially in winter influencing in a negative manner many aspects of the community. Consequently, cultural heritage objects may also suffer indirectly from road blockages as no resources may be able to reach the community for inspection and/or maintenance.

Examining the type of soils along the road (see map in Appendix 1) it can be observed that most of the transportation facility was built on alluvial and colluvial sediments (sands, pebbles and clays). Due to its loose structure nature, this type of soil is especially prone to mass movement particularly in soaked terrain conditions.

It should be pointed out that the soil map does not offer very accurate detail information due to its small scale (1:500000). Consequently, more accurate mapping and field studies would be required to give more precise information on soil type along the road.

Vulnerability mapping and analysis

Cultural heritage objects are the pre-defined elements at risk in this study. In this study the physical vulnerability of cultural heritage objects has been established using spatial multi-criteria evaluation based on their state of conservation which determines the level of exposure to landslides and avalanches. Vulnerability is analyzed in this context as the potential for physical impact on the cultural heritage assets with basically the same structural type, hence having similar damage performance. Introducing economic and social value of these cultural heritage objects into the vulnerability assessment would have been valuable. However, lack of data and time constraints to construct these data prevented this study from including those parameters.

Moreover, vulnerability in this study assumes susceptibility areas for landslides and avalanches based on a set of factor parameters indicating areas prone to the initiation of those natural hazards. Run-out or travel distance area calculation for avalanches and landslides would have been useful for effective vulnerability assessment with the aim of analysing whether landslides and avalanches could physically impact the cultural heritage objects. This, however, was considered out of the scope of this work due to lack of data availability and time constraints.

6.3. Risk Assessment

6.3.1. Risk mapping and analysis

For each community, three maps were produced using spatial multi-criteria evaluation showing the risk of cultural heritage objects to landslides, avalanches and both hazards combined (multi-hazard).

Figures 6.10 and 6.11 below show the risk of cultural heritage objects to landslides and avalanches combined (multi-risk) (see Appendix 1 for maps of cultural heritage objects risk to landslides and avalanches separately for each community).

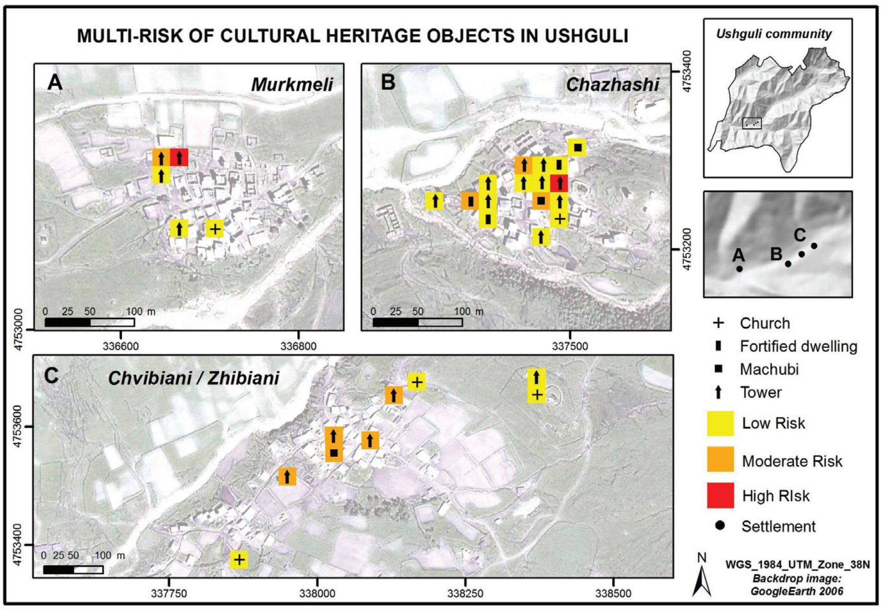

Figure 6.10: Multi-risk (landslide and avalanche) of cultural heritage objects in Ushguli.

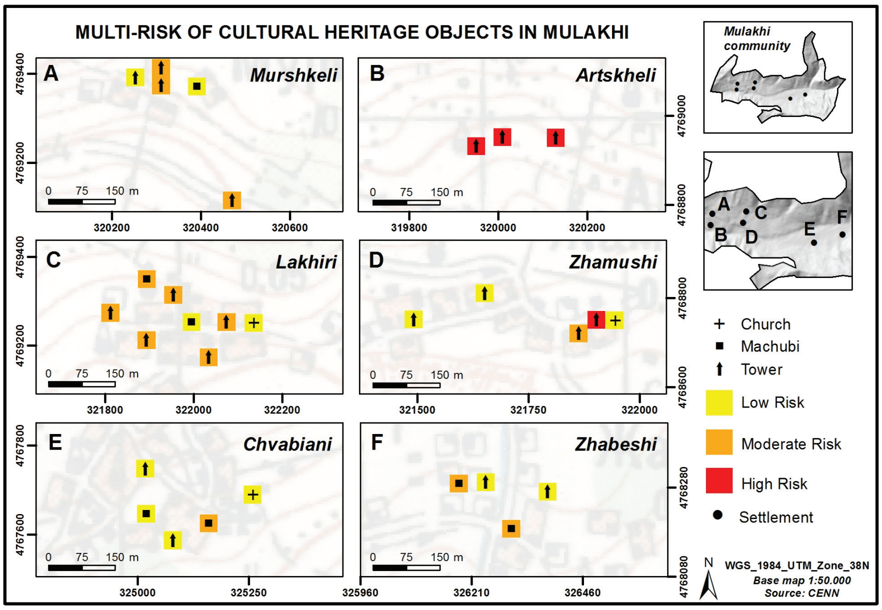

Figure 6.11: Multi-risk (landslide and avalanche) of cultural heritage objects in Mulakhi.

6.3.2. Discussion

The results from the risk analysis show a very similar picture compared to those from the vulnerability analysis. For example, when comparing the multi-risk and vulnerability results for both communities in 58 out of 60 cases cultural heritage objects show the same level of vulnerability and risk. Two objects are the exception: the tower in the south of Murkmeli (Ushguli) which has high vulnerability and low risk; and the tower in the east of Zhabeshi (Mulakhi) which has moderate vulnerability and low risk. This is because both objects are located in a low hazard pixel in the SMCE analysis. This fact demonstrates that the risk to cultural heritage objects in the study areas is highly dependent on their vulnerability and hence on their state of conservation. Consequently, within the spatial multi-criteria analysis vulnerability seems to contribute more that hazard susceptibility in the overall risk analysis.

The results obtained cohere with the local community and cultural heritage expert Marina Khenia assertion that cultural heritage objects are not particularly affected by natural hazards in the study area.

This study shows that cultural heritage features are located in moderate to low susceptibility areas for landslides and avalanches. An object may be situated in an a priori “safe” place but can still be hit by a landslide or avalanche that initiated somewhere else up the hill. For example, the 1987 avalanche (see also section 6.1.5) did indeed reach some objects. Consequently, run-out or travel distance for landslide and avalanches would be a fundamental parameter to estimate risk of cultural heritage objects more accurately. With run-out information included in the analysis the susceptibility of the area would probably change significantly.

Moreover, to add accuracy in the risk analysis more accurate information would be needed on the real capacity of these structures to withstand land masses impacts. There is at least one example of a tower withstanding the impact of an avalanche (1987 event). It seems very likely that many natural events may have happened in the area since these structures were built about one millennia ago. The fact that many of these structures are still standing seems to prove that they were constructed purposely to withstand severe forces.

Risk mapping and visualization is considered an important issue in hazard risk assessment (Castellanos Abella, 2008a). For this study it was considered that the use of a simple classification with three classes using yellow, orange and red would be appropriate to show the different levels of susceptibility, vulnerability and risk. This form of visualization is conceived as being well suited for non-experts end users such as civil defence and local authorities (Castellanos Abella, 2008a).

7. Management Planning

This chapter looks into existing management plans and reports as well as means of integrating hazard risk elements into cultural management plans. Protective measures against natural hazards and for cultural heritage conservation are also put forward.

7.1. Existing Management Plans and Reports

In this section a number of relevant management plans and reports for Upper Svaneti are examined. The focal point is on exploring the presence/absence of hazard risk management elements related to cultural heritage conservation.

Village Chazhashi - *Conservation Plan*
This conservation plan carried out by ICOMOS Georgia (ICOMOS, 2001a) gives a general overview of Chazhashi (Ushguli) focusing on the state of conservation of the buildings in the settlement. The essence of the plan is to encourage maximal use of the cultural heritage potential for the economic and cultural revitalisation of the community as well as the region. This conservation plan was carried out by architects and cultural heritage experts. Natural hazards risk elements as possible threats to cultural heritage are not taken into consideration in this study.

Village Chazhashi – *Strategic Objectives for Site Development*
Parallel to the conservation plan above, ICOMOS Georgia (ICOMOS, 2001b) developed a multi-disciplinary study in Ushguli community focusing in the village of Chazhashi with the aim of giving guidelines for the revitalization of the site based on conservation strategies. In this study risk preparedness is considered as an "immediate" conservation priority. The inclusion of geologists in the development of the planning process is also mentioned. Consequently, it could be alleged that natural processes (which may have an impact on the settlement in general and on cultural heritage in particular) may be taken into account.

Upper Svaneti Protected Areas Management Plan
The management plan for protected areas in Upper Svaneti (GPAP, 2008) was developed with the aim to conserve the natural and cultural characteristics of these areas. In this management plan natural hazards are mentioned as possible threat to the conservation of historical cultural monuments. However, when presenting guidelines for inventory, documentation and conservation of historical cultural

monuments no hazard risk elements are mentioned. The authors of this plan propose the creation of a specialist team to carry out culture conservation programs. The proposed team includes architects and fine arts specialists disregarding any natural hazard, geologist or natural science experts.

Strategic options towards sustainable development in mountainous regions: a case study on Upper Svaneti

A consulting project was carried out (Engel et al., 2006) with the aim of building strategies to stimulate sustainable development in Upper Svaneti. In this report natural hazards are taken as an important issue as they are considered to have a significant impact on many aspects in the region. According to this study no detailed expert studies such as risk mappings have been undertaken in the region. Cultural heritage is barely mentioned in this report nor hazard risk elements related to the conservation of cultural heritage.

7.2. Integrating Hazard Risk into Cultural Management Plans

7.2.1. Overview

Examination of the literature (Taboroff, 2000, Taboroff, 2003, Spennemann, 2005, Lazzari et al., 2006, Mitsakaki and Laoupi, 2009, Abhas, 2010) confirms that hazard risk is not normally included in cultural heritage management plans. This is even more the case in countries such as Georgia where tight national budgets prevent cultural heritage from receiving sufficient resources as it is not considered a priority. However, heritage places have a unique nature that makes them irreplaceable in case of damage. Consequently, cultural heritage sites should be managed in a way that prevents, or at least minimises the possible adverse effects of natural hazards (Spennemann, 2005). National cultural heritage management plans should represent a key instrument for the preservation and conservation of cultural assets. One of the main objectives of these national plans should be the creation of guidelines for the application of monitoring and diagnostic methods, for both decaying and hazard problems of cultural assets (Mitsakaki and Laoupi, 2009).

Taboroff (2000) recommends to use a series of systems in order to identify and minimize potential damage and liabilities to cultural heritage assets:

Risk Mapping

Risk mapping provides the geographical component to risk evaluation enabling to establish better predictions.

National Inventories

National inventories of historic places are paramount for heritage management simply because knowing what one's resources are is a central requirement for effective preservation. Geographical Information Systems (GIS) and remote sensing has opened the possibility of large, fast and efficient national inventories. A GIS database can provide precise location information portraying historic features and susceptible areas. Moreover, GIS can aid disaster response to identify resources, create accurate maps showing both natural and cultural resources, and establish databases to enhance maintenance of facilities.

Object ID

Object ID is an international documentation standard for the information needed to identify art and antiques. Its applicability for disaster mitigation is considered high as loss of art such as ancient icons and paintings in churches particularly impoverishes developing countries.

Emergency Works and Advice Services

Emergency works and advice services aim to help owners deal with sudden catastrophes and unforeseeable circumstances and to prevent dramatic deterioration in a building or monument. It includes advice and site visits, and covers work that is necessary immediately to protect the overall stability or integrity of an historic building or to preserve specific features.

Individual Disaster Plans

The risk to cultural heritage is highly location dependent, which reduces the efficient implementation of national and international directives. Individual disaster plans at local scale are thus essential.

A change in orientation is needed from the focus on individual monuments to heritage in its wider physical and social context. Table 7.1 below lists a series of principles to follow for an effective integration of hazard risk elements into cultural heritage management plans.

Table 7.1: Principles for risk management of cultural heritage (Taboroff, 2000).

PRINCIPLE	DESCRIPTION
1	Disaster planning for a cultural heritage site should be conceived for the whole site including its buildings, structures and contents, and landscapes.
2	This planning should integrate relevant heritage considerations within a site's overall disaster preparedness and mitigation strategy.
3	Preparedness requirements should be met in heritage sites by means that will have least negative impact on heritage values.
4	Documentation of heritage sites, their significant attributes and any history of disaster response is the basis for appropriate disaster planning.
5	Maintenance programs for historic sites should take into account a cultural heritage at risk perspective.
6	Property occupants and users should be directly involved in the development of emergency response plans.
7	During emergencies, securing heritage features should be a high priority.
8	Following a disaster, every effort should be made to ensure the retention and repair of structures or features that have suffered damage or loss.
9	Conservation principles should be integrated where appropriate in all phases of disaster planning and mitigation.

Furthermore, government policies should be redesigned in order to prevent further loss of cultural heritage and ensure adequate level of conservation. Table 7.2 below shows the steps proposed by Mitsakaki and Laoupi (2009) that government policy should follow to achieve that goal.

Table 7.2: Government policy steps to follow for effective cultural heritage management (Mitsakaki and Laoupi, 2009).

STEP	DESCRIPTION
1	Integration of the Cultural Heritage Management (CHM) into the Environmental Management so that long-term interactions between living and past populations and their environments could be clarified.
2	Development of a more efficient and internationally accepted policy and legislation on CHM.
3	Budget provisions for CHM from national fiscal programs.
4	Dissemination of information on CHM topics and the activation of public awareness as well as involvement of local communities in all stagesof CHM.
5	Coordination with respect to the international community in order to secure necesary funding and ensure agreement with global guidelines and legislation, as well as professional standards.

7.2.2. Management plan integration in Upper Svaneti

Based on literature sources (Taboroff, 2000, ICOMOS, 2001b, Spennemann, 2005, Abhas, 2010) and the knowledge acquired of the area during this study a number of guiding principles are proposed for the creation/improvement of management plans and the integration of hazard risk elements in Upper Svaneti:

- Identification of the main actors at national, regional and local level responsible for the creation of a cultural heritage management process.
- Creation of multi-disciplinary teams for the elaboration of cultural management plans that includes among others experts in disaster management.
- Give priority to the elaboration of complete census of cultural heritage assets as well as natural hazards inventories.
- Promotion of GIS and remote sensing techniques in various processes within the management plan such as hazard mapping, analysis and creation of databases.
- Inclusion of the landscape as a part of the cultural management plan.
- Involvement of the local community in the management process.
- Promotion of training activities in the region that involves regular maintenance of the sites and tourism management.
- Promote cultural heritage to the youngest through education programs within the schools in the region.

- Promote natural hazard awareness to the youngest also through education.

7.3. Protective Measures

In this section risk mitigation options generally not included in existing management plans in the context of natural hazards (landslides and avalanches), and cultural heritage are suggested.

7.3.1. Protective measures against natural hazards

Structural measures refer to any physical construction to reduce or avoid possible impacts of hazards, which include engineering measures and construction of hazard-resistant and protective structures and infrastructure. The strategy is to modify or reduced the hazard (UNISDR, 2004). Protective measures could include (van Westen, 2009):

Landslides:

- Retaining walls that put a load against the toe of the slope to prevent movement.
- Anchoring, rock bolting and soil nailing to add strength to rock or soil.
- Drainage in the slope.
- Terracing of slopes.

Avalanches:

- Snow galleries to protect transportation lines from avalanches
- Snow fences / snow nets
- Reforestation

In the study area no structural measures were observed with the exception of some gabions located in the village of Chvabiani (Mulakhi) (see Figure 6.1) aimed to divert potential landslides. In the context of this study slope drainage and terracing (landslide protection) and wooden snow fences and reforestation (avalanche protection) are considered the most cost-effective measures for implementation as they do not require expensive resources and a high level of expertise.

Non-structural measures refer to policies, awareness, knowledge development, public commitment, and methods and operating practices, including participatory mechanisms and the provision of information, which can reduce risk and related impacts. The aim is to modify the susceptibility of hazard damage and disruption and/or modifying the impact of hazards on individuals and the community (UNISDR, 2004). In the context of this study non-structural measures should focus on developing physical plans that identify land use zones which are developable and not hazard-prone; designing standards and building codes for infrastructure (buildings, roads); overgrazing control; deforestation; and community education.

7.3.2. Protective measures for cultural heritage

Cultural heritage represents an essential element for the economic development of the communities analysed in this study. In this context, preserving and conserving the cultural heritage assets included in these areas is fundamental. Based on literature sources (Taboroff, 2000, ICOMOS, 2001b, Lazzari et al., 2006, Gonçalves et al., 2009, Mitsakaki and Laoupi, 2009, Abhas, 2010) the following protective measures may be considered:

Cattle movement control: Due to uncontrolled roving of the cattle many historic buildings are turned into cattle shelter. As a result, accumulated waste does chemically disintegrate the foundations and walls damaging the buildings.

Vegetation control: Uncontrolled growth of vegetation is a serious risk factor for the abandoned structures. Regular cleaning would be needed.

Improvement of infrastructure: Especially transportation facilities that would allow a more efficient access to the sites for maintenance purposes as well as encouraging tourism bringing more economic resources to the community.

Regular technical inspection and maintenance: Aimed to avoid irreversible decay.

Use of adequate materials for restoration: Traditional/natural materials should be used in restoration works to keep the essence of the historic fabric.

Roof maintenance/restoration: Resources should focus especially on the maintenance and restoration of roofs as this element has proved to be vital for the general state of conservation of cultural heritage objects.

Preventive maintenance policies: These should be design at all levels from national to local.

Community participation: Encouraging community participation and awareness in the preservation and conservation of their cultural heritage would bring benefits to all parties.

8. Conclusions and Recommendations

8.1. Conclusions

This study was carried out in the communities of Ushguli and Mulakhi within the Upper Svaneti region of Georgia. It involved addressing the following objectives:

1. **Identification and differentiation of cultural heritage as physical elements at risk**

- This study has focused on medieval buildings as pre-established possible elements at risk.
- The road linking the main town of Mestia to Ushguli community is recognised as an important element at risk.
- In Mulakhi community 60% of the objects assessed have a bad, very bad or ruin state of conservation. In Ushguli, 36.6% of the objects fall in that category.
- The state of the roof in the buildings is considered a key parameter in the overall state of conservation of the object.
- It is considered that the state of conservation of the cultural heritage objects assessed is deteriorating over time especially the objects with bad or no roof.
- Lack of proper protective measures and policies are the main reason for this deterioration.
- The conservation index method adopted is a useful tool to perform a non-expert, rapid and consistent evaluation allowing for prioritization of resources.

2. **Hazard identification and hazard susceptibility evaluation**

- The most prevalent natural hazards in the study area are landslides and avalanches.
- Landslides are prone to initiate mainly in areas with slopes between 20-40º; on soils composed of clay, shale, sandstone and marls; and in areas with scarce vegetation (grassland).
- Avalanches are prone to initiate mainly in areas with slopes between 28-45º; slopes facing north, northeast and east; ridges; and areas with scarce vegetation.
- 63.6% of the area in Ushguli and 33.2% of the area in Mulakhi shows high multi-hazard susceptibility.

- Cultural heritage features in the study areas are not particularly affected by natural hazards, rather is the lack of maintenance that is driven cultural heritage objects to decay.
- Transportation facilities especially the road linking Mestia to Ushguli are regularly affected by rock falls, avalanches and aggressive erosive processes as a result of streams crossing the road.
- The use of a combined community-based and knowledge-based approach is a useful tool to acquire rapid, adequate and low-cost hazard information.
- More local interviews/group discussion may be needed to add reliability and accuracy to the hazard information obtained.

3. Evaluation, using SMCE, of the vulnerability of cultural heritage objects to natural hazards

- 54 out of the 60 cultural heritage objects assessed show either low or moderate levels of risk to landslide and avalanches.
- Vulnerability of cultural heritage objects is directly related to their state of conservation.
- The cultural heritage site most vulnerable to hazard risk is Mulakhi as the state of conservation in this community is worse compared to Ushguli.
- Within the cultural heritage objects assessed priorities for action should focus on those that show high and moderate vulnerability (30 objects).
- SMCE is a useful tool for estimating potential landslide and avalanche initiation areas in situations of scarce resources. However, in order to produce more accurate assessments at local scale more parameters with further fine-tuning weighting would be needed.
- SMCE used at a very local scale may give oversimplified results. Many more factors should be included, especially parameters dealing with geomorphology and historical events.

4. Incorporation of risk management elements into cultural heritage conservation and management plans

- The approach adopted in this study allows for a basic and rapid assessment meant to allocate economic budgets oriented to recovery and maintenance interventions in a more efficient way. This method gives an approximate idea of the overall state of conservation of cultural heritage sites.
- This method also combines state of conservation of cultural heritage objects with hazard information in a spatial multi-criteria evaluation environment which could be easily integrated in a cultural management plan.

- Heritage management as process that aims at protecting properties and places which have historical and cultural significance should take into account the threat posed by natural hazards. The inclusion of a section on hazard risk in cultural heritage conservation plans should be mandated.
- Most plans consulted do not consider natural hazards, only slow-decay of the cultural heritage due to other causes such as climate and general neglectfulness.
- Once general plans are in place focus should be on developing site-specific cultural heritage plans that integrate site-specific risk assessments.

8.2. Recommendations

- To include community-based hazard inventory and monitoring (including run-out information) as well as risk assessment as a standard element of heritage conservation.
- Execution of a detailed and complete census of cultural heritage objects. Remote sensing offers the possibility of carrying out this type of task (see section 7.2.1).
- Calculation of the economic value of the cultural heritage objects assessed would be very useful to estimate vulnerability more accurately.
- To consider, given the scale of this study, other methodological methods apart from SMCE such as direct mapping based on geomorphology and historical events; or modelling.
- To carry out a complete hazard inventory of the region using affordable resources (GIS and remote sensing techniques should be considered).
- To consider the use of SMCE also for the calculation of the state of conservation of cultural heritage objects so more conclusions could be drawn from the method used in this study.

8.3. Limitations of the study

- Limited data availability and limited accessibility due to the complex geography of Upper Svaneti prevented this study from expanding to a regional scale.
- Direct communication with interviewees was not possible so interpreters had to be used. This may have lead to some loss of information during translation.
- Some of the secondary data used had to be corrected for topology anomalies so a certain amount of time was used for correction.
- A considerable amount of time was spent on the application of ILWIS for SMCE as several software bugs were found that prevented the program from running properly.

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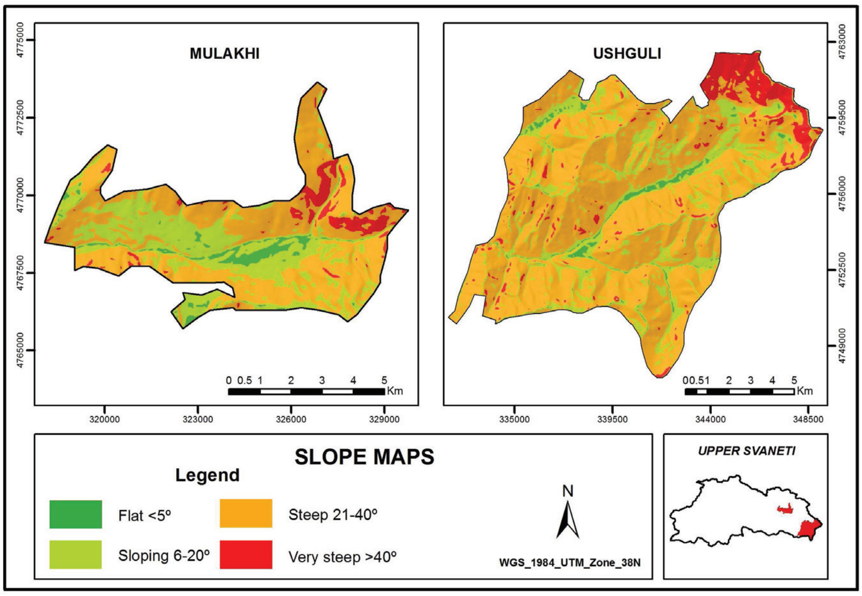
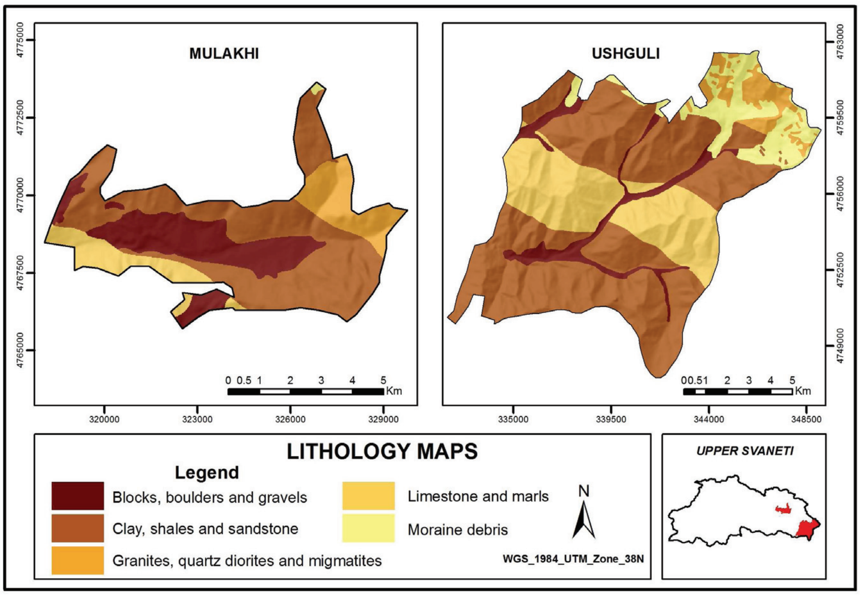
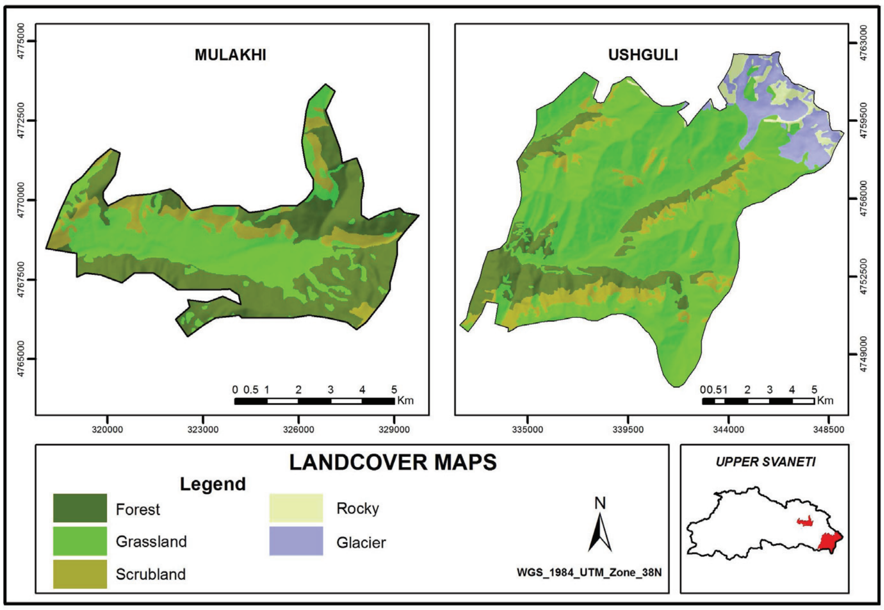
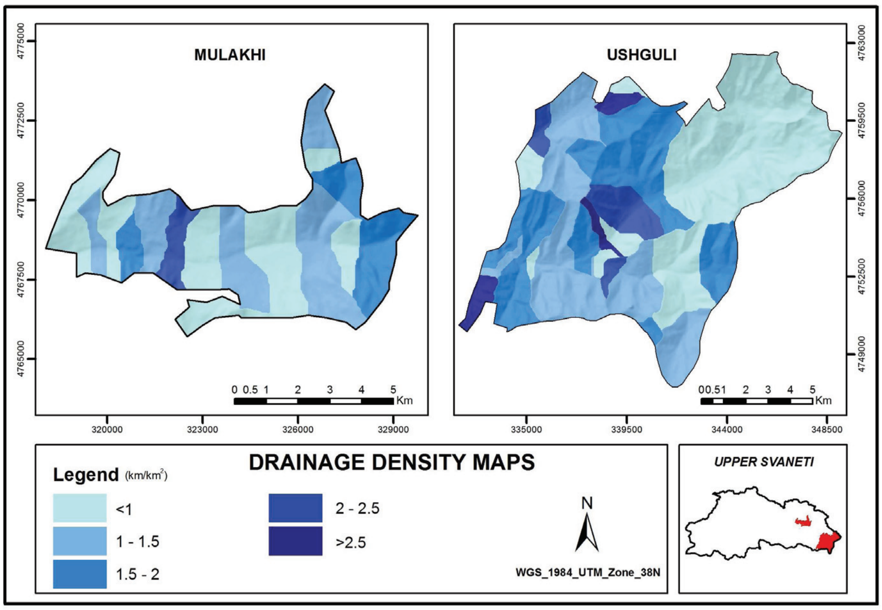
Appendix 1

LANDSLIDE FACTOR MAPS:

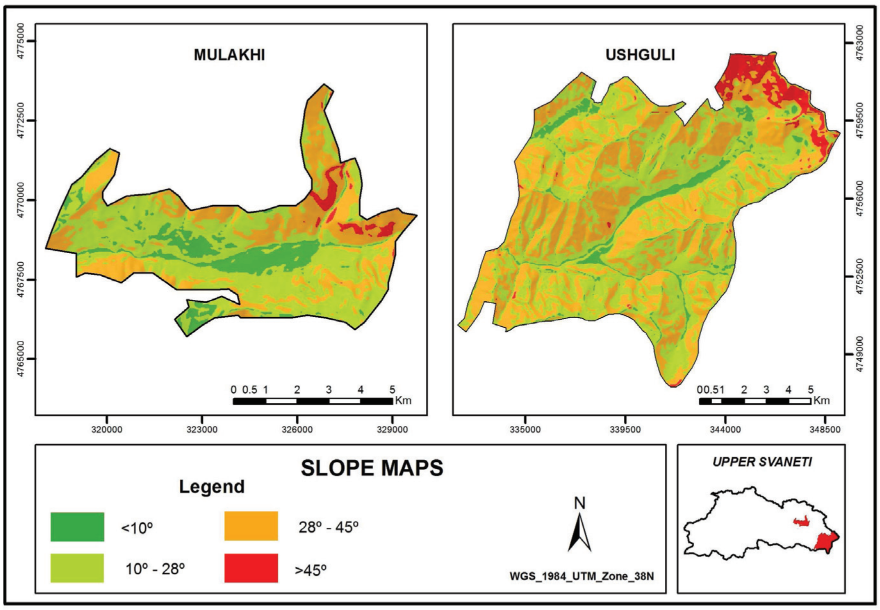


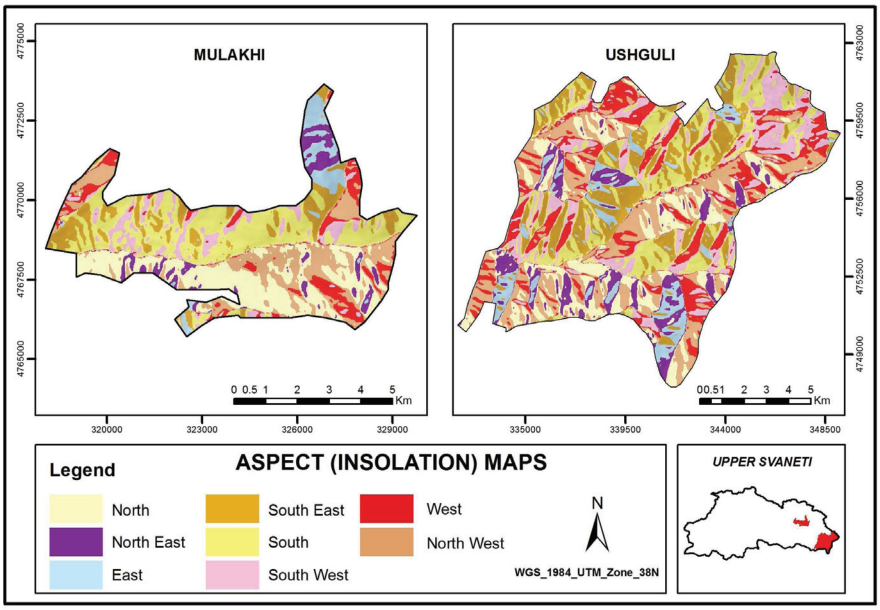


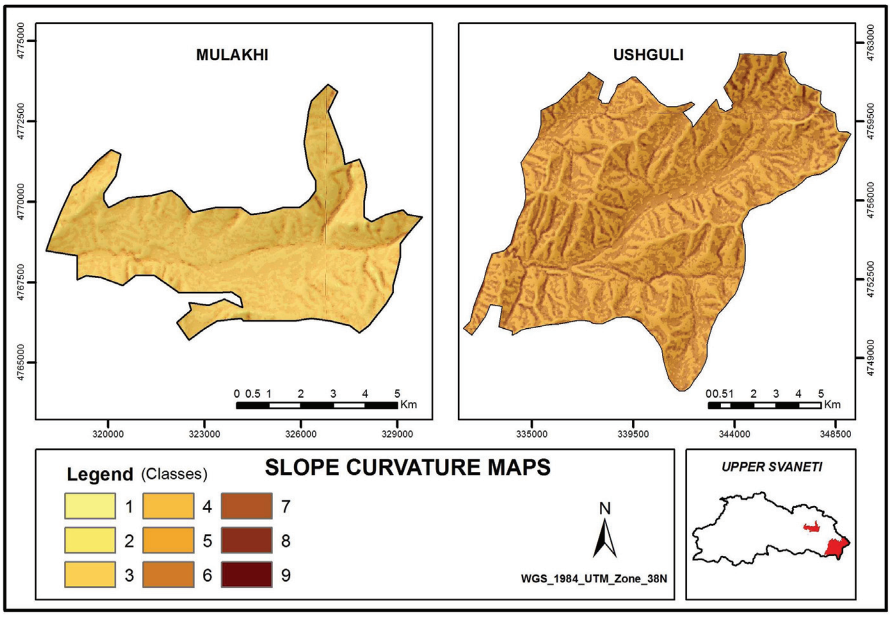

MULAKHI
USHGULI
LANDCOVER MAPS
Legend
Forest
Grassland
Scrubland
Rocky
Glacier
UPPER SVANETI
N
WGS_1984_UTM_Zone_38N
Km


MULAKHI
USHGULI
DRAINAGE DENSITY MAPS
Legend (km/km²)
<1
1 - 1.5
1.5 - 2
2 - 2.5
>2.5
UPPER SVANETI
N
WGS_1984_UTM_Zone_38N
Km

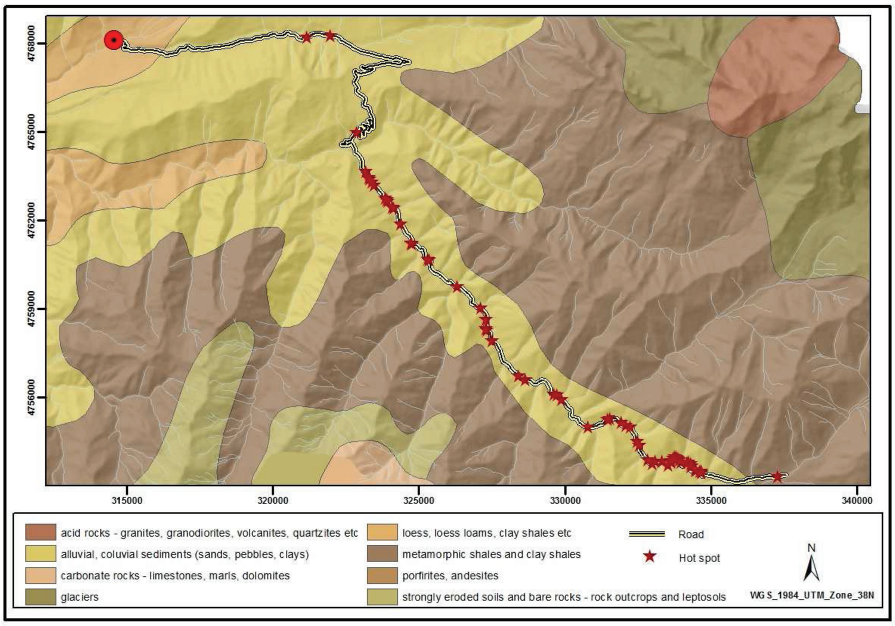
AVALANCHE FACTOR MAPS:



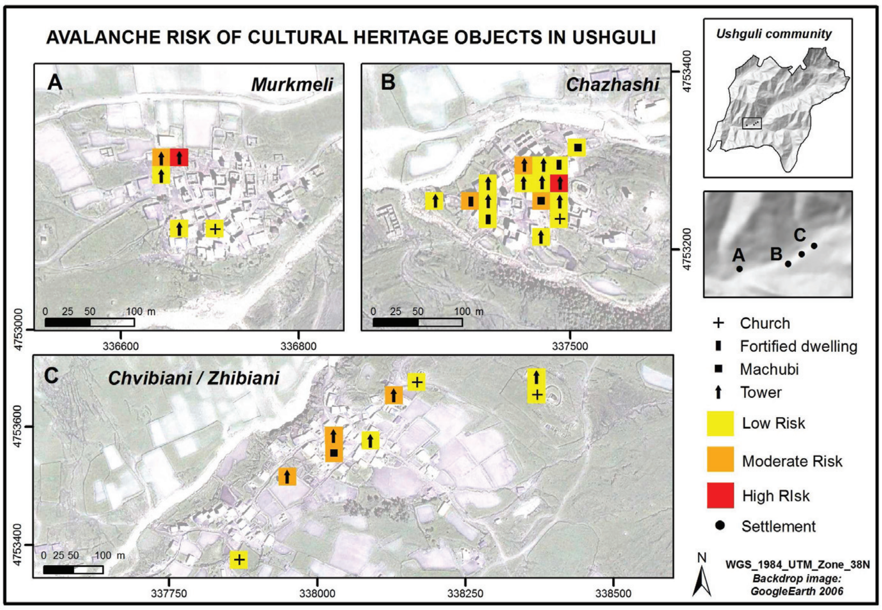


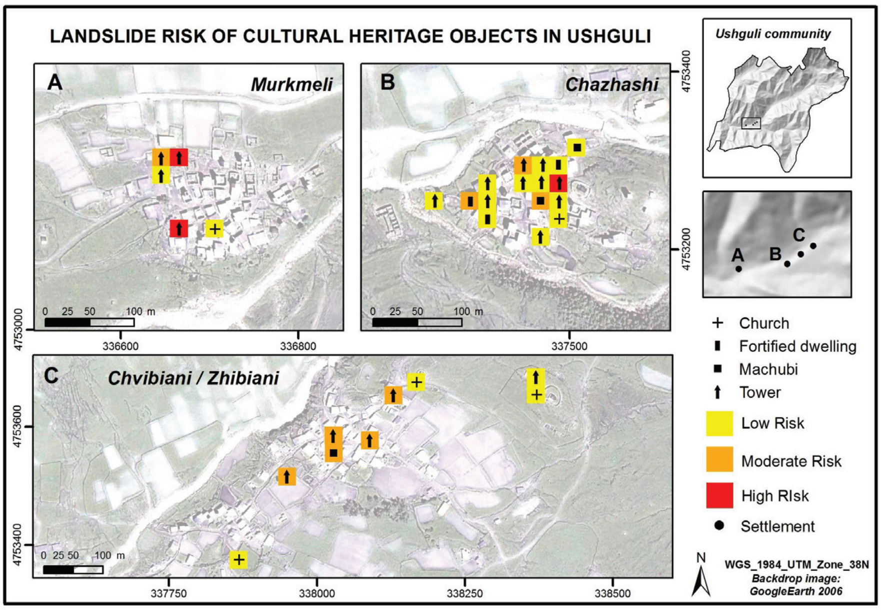


SOIL TYPE ALONG THE ROAD FROM MESTIA TO USHGULI:

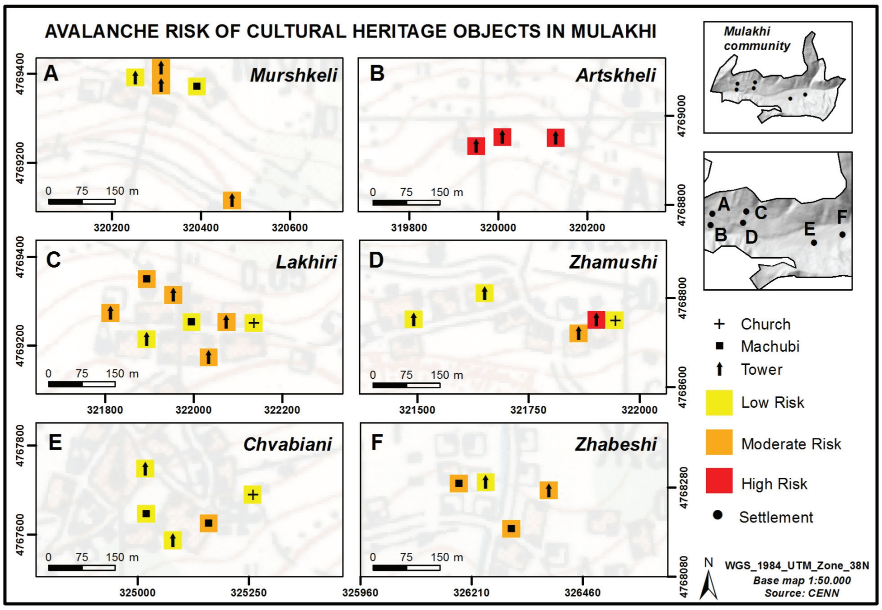


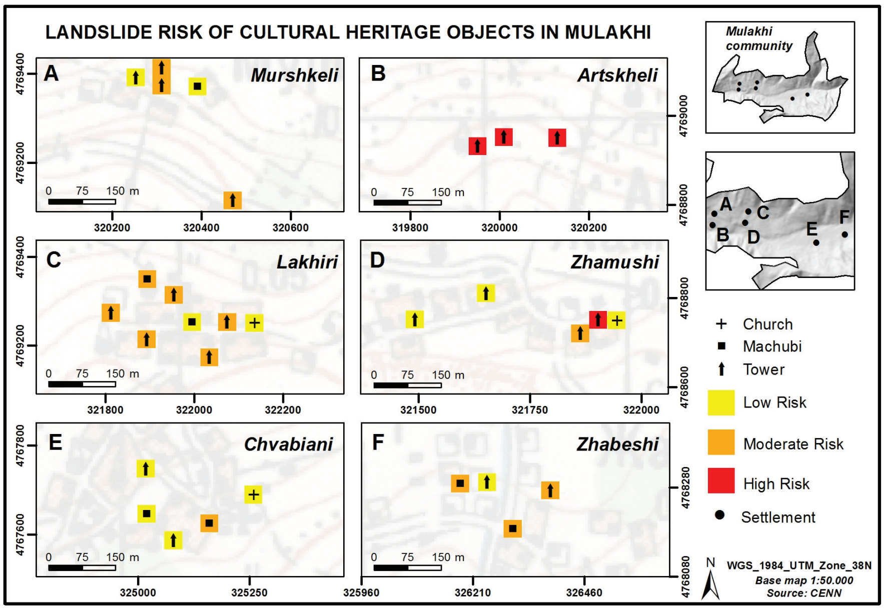
AVALANCHE AND LANDSLIDE RISK FOR CULTURAL HERITAGE OBJECTS IN USHGULI:



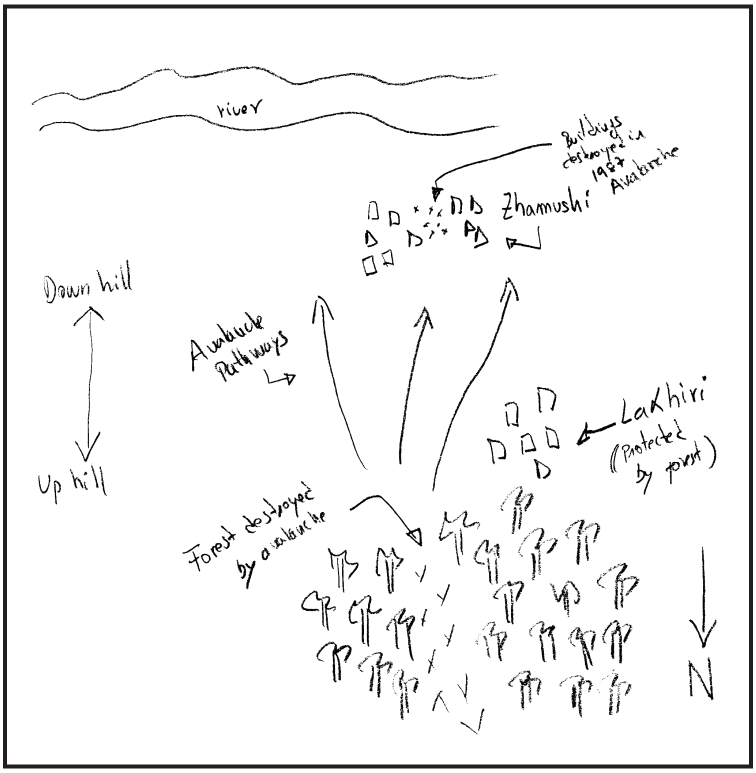


AVALANCHE AND LANDSLIDE RISK FOR CULTURAL HERITAGE OBJECTS IN MULAKHI:





EXAMPLE OF SKETCH MAP PRODUCED IN THIS STUDY



Appendix 2

TYPOLOGIES

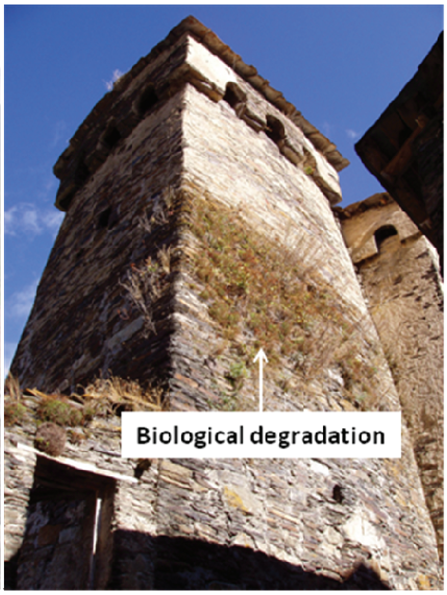
Church

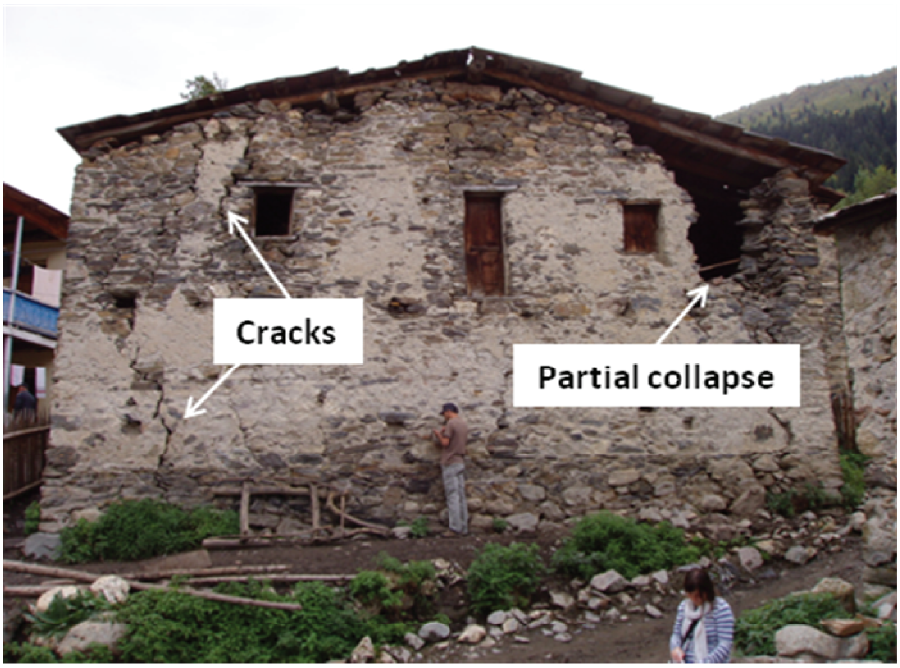
Tower

Machubi

Fortified dwelling

EXAMPLES OF DAMAGE ELEMENTS






Humidity degradation

Absence of roof

Appendix 3

WORKING SHEET USED FOR THE ASSESSMENT OF STATE OF CONSERVATION OF CULTURAL HERITAGE OBJECTS

MULAKHI		Village:					Overall Impression:
CH Feature ID:		STATE OF CONSERVATION - DAMAGE - INDIVIDUAL OBJECTS					
		NOTES					
GENERAL INFO	Tipology						
	No. Floors						
	Location (GPS) ID No.						
	Presence of restoration works (Yes / No). Type; Where; Quality (+/- impact)						
	Human use (residential, storage, animal shelter,						
	Topographic position (slope, flat)						
			Very Heavy	Heavy	Moderate	Low	NOTES
DAMAGE	Structural Damage	Cracks					
		Partial collapses					
		Sinking					
		Tilting					
	Other Damage	Roof					
		Humidity degradation					
		Biological degradation					

INTERVIEWS SHEET AND QUESTIONS

Interview no.	Date	Place	Interview		
			At CH object	At/near house	In field

Hazard information

1. What hazards do occur in the area? (landslide, avalanche, mudflow, flood, earthquake)
2. Where do they occur? (general geographical indication)
3. How often do they occur?
4. What time of the year do they occur?
5. In case of flood: for how long?
6. How and where do they develop \ start?
7. What is their typical pathway?
8. Until where to they arrive (runout area)?
9. Or can you show the example of one particular hazard that has occurred?

Hazard exposure information

10. What are the risks for CH objects?
11. Which do you think is the NH that impacts CH the most?
12. Is\are there specific CH objects at risk?
13. Can you identify that object?
14. What are risks for houses in village?
15. Has your house been hit by a hazard?
    - yes\no
    - If yes: when?
    - Was damage: none little much other
16. Are roads affected by NH?
    - yes\no
    - If yes what is the extent of the damage?

Hazard perception

17. What do you think are main causes of hazards in the area?

(excessive) rainfall
snowmelt, melting ice
deforestation
seismic activity
climate change
construction works
farming \ cattle breeding activities \ overgrazing
Spontaneous failure

18. What are dangerous parts\sections in the surrounding terrain?

Steep slopes
River\stream beds
Gullies
Other

19. Which protection measures do you think there should be in place against NH?

DAMAGE ASSESSMENT

Roof damage

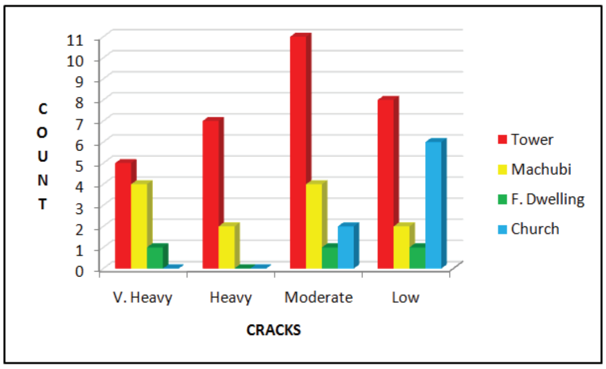
Community	Typology	No Roof		Very Heavy		Heavy		Moderate		Low		None	
		Count	% of Total sample	Count	% of Total sample	Count	% of Total sample	Count	% of Total sample	Count	% of Total sample	Count	% of Total sample
U S H	Tower	3	5.6	3	5.6	0	0.0	1	1.9	3	5.6	6	11.1
	Machubi	1	1.9	1	1.9	1	1.9	1	1.9	1	1.9	0	0.0
	Fortified dwelling	0	0.0	0	0.0	1	1.9	0	0.0	0	0.0	2	3.7
	Church	0	0.0	0	0.0	0	0.0	0	0.0	1	1.9	4	7.4
Total Ushguli		4	**7.4**	4	**7.4**	2	**3.7**	2	**3.7**	5	**9.3**	12	**22.2**
M U L	Tower	5	9.3	3	5.6	1	1.9	1	1.9	2	3.7	3	5.6
	Machubi	0	0.0	3	5.6	1	1.9	1	1.9	1	1.9	1	1.9
	Fortified dwelling	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Church	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	5.6
Total Mulakhi		5	**9.3**	6	**11.1**	2	**3.7**	2	**3.7**	3	**5.6**	7	**13.0**
OVERALL		9	**16.7**	10	**18.5**	4	**7.4**	4	**7.4**	8	**14.8**	19	**35.2**

Roof damage vs. state of conservation

FEATURE ID	OBJECT	STATE OF CONSERVATION	ROOF DAMAGE
4	Tower	Very bad	Very heavy
5	Tower	Very bad	Very heavy
6	Machubi	Bad	Very heavy
7	Tower	Bad	Very heavy
8	Tower	Very bad	No roof
14	Machubi	Very bad	No roof
18	Tower	Bad	Heavy
21	Fortified dwelling	Bad	Heavy
26	Tower	Very bad	No roof
29	Tower	Very bad	No roof
32	Tower	Very bad	Very heavy
33	Tower	Very bad	No roof
35	Tower	Bad	Heavy
39	Tower	Very bad	No roof
40	Machubi	Bad	Very heavy
42	Machubi	Bad	Very heavy
43	Machubi	Bad	Heavy
48	Machubi	Very bad	Very heavy
49	Tower	Bad	Very heavy
51	Tower	Bad	Very heavy
52	Tower	Very bad	No roof
54	Tower	Very bad	No roof
58	Tower	Bad	No roof

Structural damage (cracks)

Community	Typology	Very Heavy		Heavy		Moderate		Low	
		Count	% of Total sample	Count	% of Total sample	Count	% of Total sample	Count	% of Total sample
U S H	Tower	3	5.6	4	7.4	5	9.3	4	7.4
	Machubi	3	5.6	0	0.0	2	3.7	0	0.0
	Fortified dwelling	1	1.9	0	0.0	1	1.9	1	1.9
	Church	0	0.0	0	0.0	1	1.9	4	7.4
Total Ushguli		7	**13.0**	4	**7.4**	9	**16.7**	9	**16.7**
M U L	Tower	2	3.7	3	5.6	6	11.1	4	7.4
	Machubi	1	1.9	2	3.7	2	3.7	2	3.7
	Fortified dwelling	0	0.0	0	0.0	0	0.0	0	0.0
	Church	0	0.0	0	0.0	1	1.9	2	3.7
Total Mulakhi		3	**5.6**	5	**9.3**	9	**16.7**	8	**14.8**
OVERALL		10	**18.5**	9	**16.7**	18	**33.3**	17	**31.5**

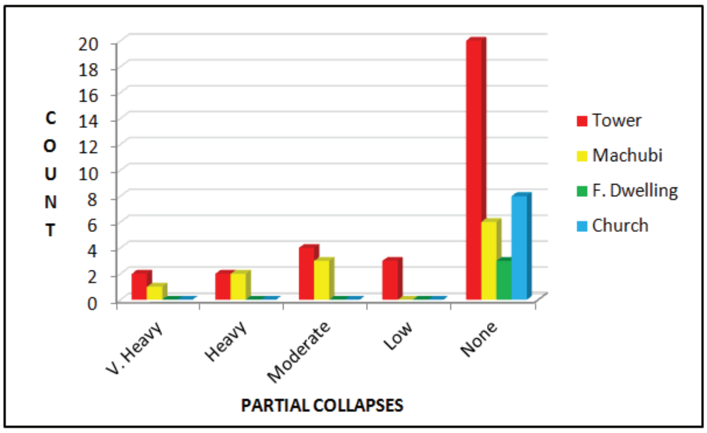


Crack damage vs. state of conservation

FEATURE ID	OBJECT	STATE OF CONSERVATION	CRACK DAMAGE
4	Tower	Very bad	Very heavy
5	Tower	Very bad	Heavy
6	Machubi	Bad	Very heavy
7	Tower	Bad	Heavy
8	Tower	Very bad	Heavy
14	Machubi	Very bad	Very heavy
18	Tower	Bad	Very heavy
21	Fortified dwelling	Bad	Very heavy
26	Tower	Very bad	Very heavy
27	Tower	Moderate	Heavy
29	Tower	Very bad	Very heavy
32	Tower	Very bad	Heavy
39	Tower	Very bad	Very Heavy
40	Machubi	Bad	Heavy
42	Machubi	Bad	Heavy
43	Machubi	Bad	Very Heavy
51	Tower	Bad	Very Heavy
52	Tower	Very bad	Heavy
54	Tower	Very bad	Heavy

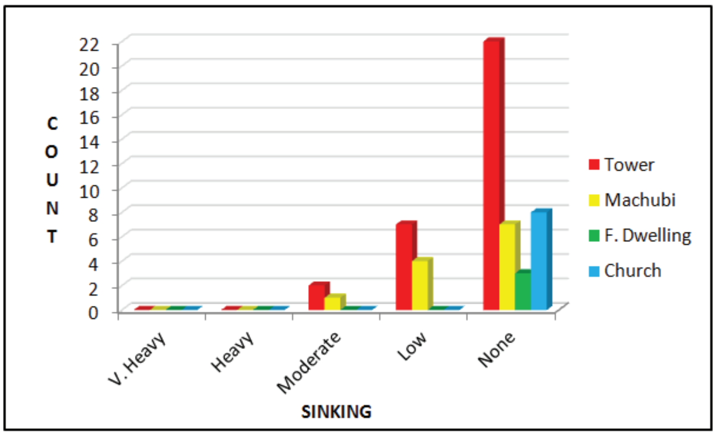
Structural damage (partial collapses)

		Very Heavy		Heavy		Moderate		Low		None	
Community	**Typology**	**Count**	**% of Total sample**	**Count**	**% of Total sample**	**Count**	**% of Total sample**	**Count**	**% of Total sample**	**Count**	**% of Total sample**
U	Tower	1	1.9	1	1.9	1	1.9	0	0.0	13	24.1
S	Machubi	1	1.9	0	0.0	0	0.0	0	0.0	4	7.4
H	Fortified dwelling	0	0.0	0	0.0	0	0.0	0	0.0	3	5.6
	Church	0	0.0	0	0.0	0	0.0	0	0.0	5	9.3
Total Ushguli		2	**3.7**	1	**1.9**	1	**1.9**	0	**0.0**	25	**46.3**
M	Tower	1	1.9	1	1.9	3	5.6	3	5.6	7	13.0
U	Machubi	0	0.0	2	3.7	3	5.6	0	0.0	2	3.7
L	Fortified dwelling	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Church	0	0.0	0	0.0	0	0.0	0	0.0	3	5.6
Total Mulakhi		1	**1.9**	3	**5.6**	6	**11.1**	3	**5.6**	12	**22.2**
OVERALL		3	**5.6**	4	**7.4**	7	**13.0**	3	**5.6**	37	**68.5**



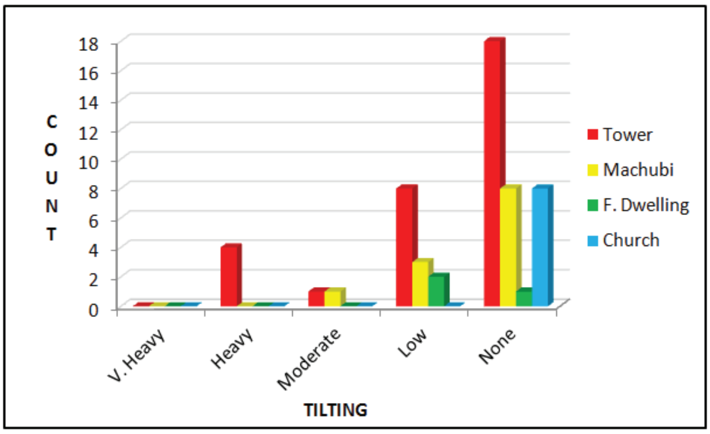
Structural damage (sinking)

Community	Typology	Very Heavy Count	Very Heavy % of Total sample	Heavy Count	Heavy % of Total sample	Moderate Count	Moderate % of Total sample	Low Count	Low % of Total sample	None Count	None % of Total sample
USH	Tower	0	0.0	0	0.0	0	0.0	3	5.6	13	24.1
	Machubi	0	0.0	0	0.0	0	0.0	2	3.7	3	5.6
	Fortified dwelling	0	0.0	0	0.0	0	0.0	0	0.0	3	5.6
	Church	0	0.0	0	0.0	0	0.0	0	0.0	5	9.3
Total Ushguli		0	**0.0**	0	**0.0**	0	**0.0**	5	**9.3**	24	**44.4**
MUL	Tower	0	0.0	0	0.0	2	3.7	4	7.4	9	16.7
	Machubi	0	0.0	0	0.0	1	1.9	2	3.7	4	7.4
	Fortified dwelling	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Church	0	0.0	0	0.0	0	0.0	0	0.0	3	5.6
Total Mulakhi		0	**0.0**	0	**0.0**	3	**5.6**	6	**11.1**	16	**29.6**
OVERALL		0	**0.0**	0	**0.0**	3	**5.6**	11	**20.4**	40	**74.1**



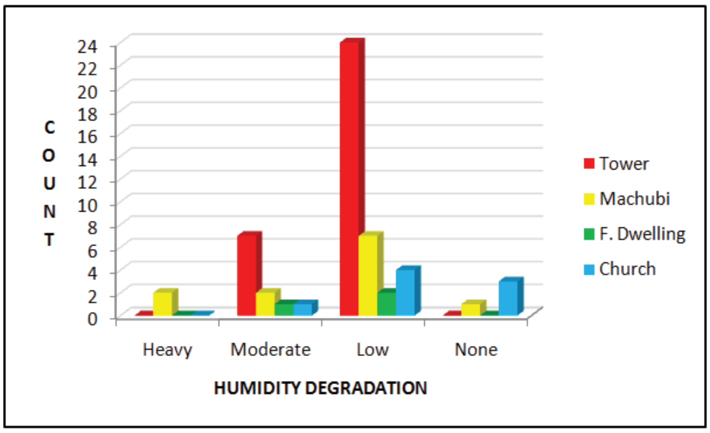
Structural damage (tilting)

Community	Typology	Very Heavy		Heavy		Moderate		Low		None	
		Count	% of Total sample	Count	% of Total sample	Count	% of Total sample	Count	% of Total sample	Count	% of Total sample
USH	Tower	0	0.0	3	5.6	1	1.9	5	9.3	7	13.0
	Machubi	0	0.0	0	0.0	1	1.9	1	1.9	3	5.6
	Fortified dwelling	0	0.0	0	0.0	0	0.0	2	3.7	1	1.9
	Church	0	0.0	0	0.0	0	0.0	0	0.0	5	9.3
Total Ushguli		0	**0.0**	3	**5.6**	2	**3.7**	8	**14.8**	16	**29.6**
MUL	Tower	0	0.0	1	1.9	0	0.0	3	5.6	11	20.4
	Machubi	0	0.0	0	0.0	0	0.0	2	3.7	5	9.3
	Fortified dwelling	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Church	0	0.0	0	0.0	0	0.0	0	0.0	3	5.6
Total Mulakhi		0	**0.0**	1	**1.9**	0	**0.0**	5	**9.3**	19	**35.2**
OVERALL		0	**0.0**	4	**7.4**	2	**3.7**	13	**24.1**	35	**64.8**



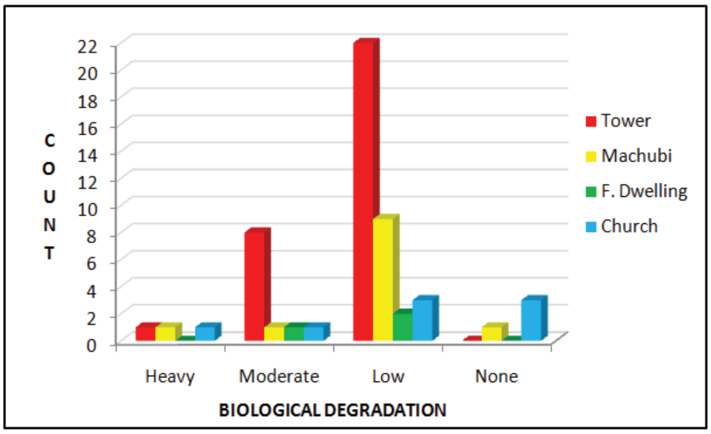
Damage for humidity degradation

Community	Typology	Heavy		Moderate		Low		None	
		Count	% of Total sample	Count	% of Total sample	Count	% of Total sample	Count	% of Total sample
USH	Tower	0	0.0	2	3.7	14	25.9	0	0.0
	Machubi	2	3.7	1	1.9	1	1.9	1	1.9
	Fortified dwelling	0	0.0	1	1.9	2	3.7	0	0.0
	Church	0	0.0	0	0.0	3	5.6	2	3.7
Total Ushguli		2	**3.7**	4	**7.4**	20	**37.0**	3	**5.6**
MUL	Tower	0	0.0	5	9.3	10	18.5	0	0.0
	Machubi	0	0.0	1	1.9	6	11.1	0	0.0
	Fortified dwelling	0	0.0	0	0.0	0	0.0	0	0.0
	Church	0	0.0	1	1.9	1	1.9	1	1.9
Total Mulakhi		0	**0.0**	7	**13.0**	17	**31.5**	1	**1.9**
OVERALL		2	**3.7**	11	**20.4**	37	**68.5**	4	**7.4**



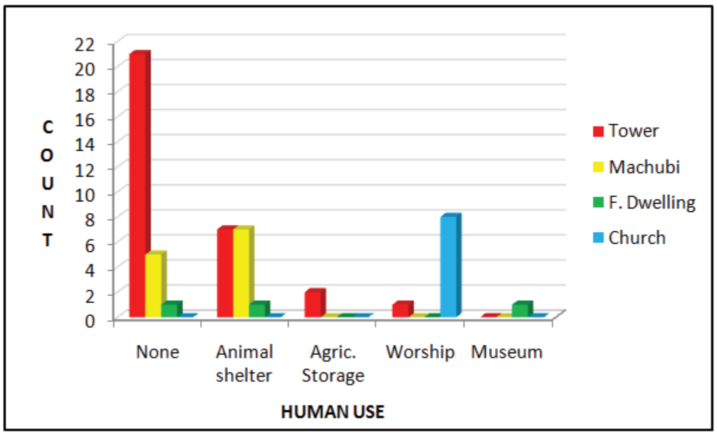
Damage for biological degradation

Community	Typology	Heavy Count	Heavy % of Total sample	Moderate Count	Moderate % of Total sample	Low Count	Low % of Total sample	None Count	None % of Total sample
USH	Tower	1	1.9	3	5.6	12	22.2	0	0.0
	Machubi	1	1.9	0	0.0	3	5.6	1	1.9
	Fortified dwelling	0	0.0	1	1.9	2	3.7	0	0.0
	Church	1	1.9	0	0.0	2	3.7	2	3.7
Total Ushguli		3	**5.6**	4	**7.4**	19	**35.2**	3	**5.6**
MUL	Tower	0	0.0	5	9.3	10	18.5	0	0.0
	Machubi	0	0.0	1	1.9	6	11.1	0	0.0
	Fortified dwelling	0	0.0	0	0.0	0	0.0	0	0.0
	Church	0	0.0	1	1.9	1	1.9	1	1.9
Total Mulakhi		0	**0.0**	7	**13.0**	17	**31.5**	1	**1.9**
OVERALL		3	**5.6**	11	**20.4**	36	**66.7**	4	**7.4**



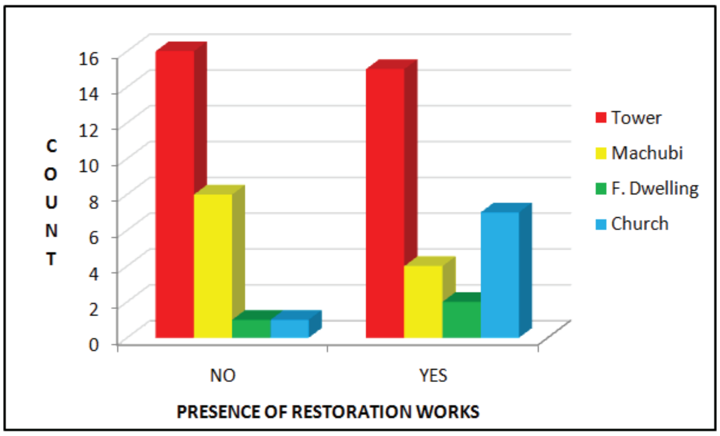
Damage due to human use

		None		Animal shelter		Agric. Storage		Worship		Museum	
Community	Typology	Count	% of Total sample	Count	% of Total sample	Count	% of Total sample	Count	% of Total sample	Count	% of Total sample
USH	Tower	8	14.8	7	13.0	1	1.9	0	0.0	0	0.0
	Machubi	1	1.9	4	7.4	0	0.0	0	0.0	0	0.0
	Fortified dwelling	1	1.9	1	1.9	0	0.0	0	0.0	1	1.9
	Church	0	0.0	0	0.0	0	0.0	5	9.3	0	0.0
Total Ushguli		10	**18.5**	12	**22.2**	1	**1.9**	5	**9.3**	1	**1.9**
MUL	Tower	13	24.1	0	0.0	1	1.9	1	1.9	0	0.0
	Machubi	4	7.4	3	5.6	0	0.0	0	0.0	0	0.0
	Fortified dwelling	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Church	0	0.0	0	0.0	0	0.0	3	5.6	0	0.0
Total Mulakhi		17	**31.5**	3	**5.6**	1	**1.9**	4	**7.4**	0	**0.0**
OVERALL		27	**50.0**	15	**27.8**	2	**3.7**	9	**16.7**	1	**1.9**



Presence/absence of restoration works

		YES		NO	
Community	Typology	Count	% of Total sample	Count	% of Total sample
USHGULI	Tower	8	14.8	8	14.8
	Machubi	1	1.9	4	7.4
	Fortified dwelling	2	3.7	1	1.9
	Church	4	7.4	1	1.9
Total Ushguli		15	**27.8**	14	**25.9**
MULAKHI	Tower	7	13.0	8	14.8
	Machubi	3	5.6	4	7.4
	Fortified dwelling	0	0.0	0	0.0
	Church	3	5.6	0	0.0
Total Mulakhi		13	**24.1**	12	**22.2**
OVERALL		28	**51.9**	26	**48.1**



Cultural heritage objects vs. slope gradient (visual estimation)

Community	Typology	Flat Count	Flat % of Total sample	Slight slope Count	Slight slope % of Total sample	Moderate slope Count	Moderate slope % of Total sample	Heavy slope Count	Heavy slope % of Total sample
USH	Tower	4	7.4	6	11.1	7	13.0	0	0.0
	Machubi	1	1.9	2	3.7	2	3.7	0	0.0
	Fortified dwelling	1	1.9	2	3.7	0	0.0	0	0.0
	Church	2	3.7	0	0.0	3	5.6	0	0.0
Total Ushguli		8	**14.8**	10	**18.5**	12	**22.2**	0	**0.0**
MUL	Tower	1	1.9	9	16.7	7	13.0	3	5.6
	Machubi	0	0.0	3	5.6	4	7.4	0	0.0
	Fortified dwelling	0	0.0	0	0.0	0	0.0	0	0.0
	Church	1	1.9	0	0.0	2	3.7	0	0.0
Total Mulakhi		2	**3.7**	12	**22.2**	13	**24.1**	3	**5.6**
OVERALL		10	**18.5**	22	**40.7**	25	**46.3**	3	**5.6**