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Landslide risk perception and communication for disaster risk management in mountain areas of developing countries: a Mexican foretaste

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Abstract: The increasing impact of disasters at local, national, regional and global scales in recent decades has provided enough evidence to urgently direct attention towards the necessity of disaster risk reduction and management, and this requires knowledge. Knowledge without communication is barren, and to communicate the risk of disaster it is necessary to understand the perception of the people at risk. In particular, this paper deals with the necessity to delineate strategies of risk communication in pursuance of risk knowledge as a core of disaster risk reduction and management, especially in mountain areas of developing countries. To portray this issue, an analysis of landslide risk perception in terms of experience, landslide risk awareness, exposure, preparedness, and risk communication and trust was undertaken in the municipality of Teziutlán, Puebla, Mexico, an area that has been affected for several decades by episodes of mass movement. Analysis of the responses to a risk perception questionnaire has offered valuable insights in terms of the information and knowledge most required by the people living in the area of interest, in order to devise a realistic and functional strategy to communicate the risk of a landslide disaster. This includes better understanding of controlling factors and drivers of this risk, and the establishment of potential trusted sources of risk communication. Beyond considering practical matters of risk assessment and management, risk perception and communication can increase the resilience of vulnerable people, and can enhance capacity building for present and future generations.

Keywords: Risk perception; Risk communication; Landslides; Disaster risk; Mountain areas

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Introduction

Disaster prevention is moving from being a scientific perspective -based mainly on natural sciences- that paid little attention to a wide recognition of the need for sustainable development and climate change mitigation and adaptation to reduce disaster risk (Cutter et al. 2015). Coordinated efforts at the global scale became more visible with the establishment in 1971 of the United Nations Disaster Relief Office (UNDRO) and, during the 1990s, the International Decade for Natural Disaster Reduction (IDNDR). These were followed by the Yokohama Strategy (1994), the Hyogo Framework for Action (HFA)

(2005-2015), and the Sendai Framework for Disaster Risk Reduction (SFDRR) (2015-2030). However, in spite of those global strategies, new risks have been created particularly in recent decades, and they have accumulated more rapidly than others have reduced (UNISDR 2015a, b).

The mounting impact of disasters has been shaped by several inter-related components including population growth, urbanization, increasing global inequality, unsustainable practices and growing exposure to hazards (Alcántara-Ayala et al. 2015; UNISDR 2015a). Therefore, in this new era of the international agenda, managing disaster risks as opposed to managing disasters has become a significant challenge for the entire community of stakeholders. Disaster Risk Management (DRM) should be directed towards anticipating future disaster risk, reducing existing exposure, vulnerability or hazard, and strengthening resilience (UNISDR 2015a).

From this perspective, awareness and understanding of risk, and preparedness for disaster, are essential for the management of risk at all levels. Accordingly, there is a fundamental need to move from information to understanding (UNISDR 2015a). Nevertheless, availability of information does not guarantee that it will be capitalised as knowledge. Furthermore, knowledge by itself is not good enough; it should be mobilised into action anchored in a shared understanding of risk.

It is a matter of moving from information to knowledge and back; information is an essential medium or material for extracting and creating knowledge (Hey 2004), whereas knowledge "is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information" (Davenport and Prusak 1998). The population living at risk is usually the most knowledgeable about their land and their environment. Therefore, one source of important information and knowledge is precisely that provided by the people at risk. The incorporation of indigenous, local and scientific knowledge in order to reduce risk more effectively would improve awareness, preparedness, response and recovery, and adaptation in the long term, in accordance with the culture, perception and interests of the population.

The emphasis on strengthening synergies among science, society and Disaster Risk Reduction (DRR) and DRM should involve the commitment of governments to the use of scientific capabilities and knowledge in an integrated manner to be translated into policy-making (Cutter et al. 2015). In the words of Boaz and Haydn (2002), recently used by Southgate et al. (2013): despite the challenges frequently faced to provide "the right information, at the right time, for the right people" scientific research must be "useful, usable and used".

Deep commitment in the realm of risk awareness, preparedness and policy making to attain management must rely on socialising and capitalising risk knowledge. From this arises the necessity to move towards risk communication. Since risk perception involves “people’s beliefs, attitudes, judgments and feelings, as well as the wider social or cultural values and dispositions that people adopt, towards hazards and their benefits” (Pidgeon et al. 1992), all the complex and challenging tasks of creating better risk communication strategies are still before us.

This paper deals with the necessity to delineate strategies of risk communication in pursuance of risk knowledge as a core of Disaster Risk Reduction, Management and Governance, particularly in mountain areas of developing countries, where exposure to landslides and other hazards is a key ingredient of the social construction of disaster risk. It presents an analysis of landslide risk perception in terms of experience, awareness, exposure, preparedness, and risk communication and trust. This was carried out in Teziutlán, Puebla, one of the municipalities in Mexico historically affected by landslides.

1 Risk Perception and Risk Communication

1.1 Perception of risk of natural hazards

The perception of risk is a set of psychological processes that occur when interacting and / or understanding a hazard from either a natural or a built environment (Clavel 2006). These processes may originate from direct observation (i.e. to be present at a landslide) or information obtained

from other people, media or social networks (e.g.to read about an earthquake). Individuals or groups differ in their perception of psychological, cultural and social factors. From perception, reality is built in order to make the world more meaningful and to respond according to that meaning.

Society tends to be particularly resistant to the idea of living under disaster risk conditions. Most people think that they are exposed to a lower risk than the average individual. This unreal optimism is based on the information available and on a reasoning that suggests that the danger is not a real threat, even though it affects known people (Weinstein 1980). All these issues influence the way risk is confronted and responded to and are part of the perception.

While a specific context or location may generate some risk, it is also true that the same context can provide benefits. Numerous studies have documented how the balance between risks and benefits estimated by an individual can influence risk perception (Fischoff et al. 1981).

When people have more experience with disasters, that experience shapes their perceptions to a greater extent, and when there is a lack of experience or it is considered as remote, it is more likely that judgements will be based on information obtained through the media, their own intuition (Wachinger and Renn 2010) and immediate social networks. Information from the media regarding natural hazards can also affect the perception of the severity of an event. Although the media information may not accurately reflect the severity or frequency of natural hazards, it can change the way these events are considered (Wachinger and Renn 2010).

There is little knowledge about the public perception of landslide risks. This is a weakness, because knowledge and comprehension of perception is essential for the successful implementation of risk communication plans, as part of risk reduction strategies and adaptation measures.

Examples include (Table 1) landslide information and knowledge (Green 1992; Ahmad and Lateh 2011; Kitutu et al. 2011; Calvello et al. 2016); hazard awareness (Green 1992; Solana and Kilburn 2003; Ahmad and Lateh 2011; Salvati et al. 2014; Calvello et al. 2016; Hernández-Moreno and Alcántara-Ayala on line); perceived magnitude and frequency (Bjønness 1986); attitudes (Alexander 1992); the perception of different stakeholders (Gurung 1989; Nathan 2008; Kitutu et al. 2011; Damm et al. 2013); influencing factors, such as previous experience (Bjønness 1986; Kitutu et al. 2011; Damm et al. 2013; Calvello et al. 2016; Landeros et al. 2016; Roder et al. 2016), gender, age, education (Aucote et al. 2010; Roder et al. 2016); and response, mitigation measures and disaster risk reduction (Gurung 1989; Green 1992; Alexander 1992; Finaly and Fell 1997; Wagner 2007; Ahmad and Lateh 2011; Damm et al. 2013; Misanya and Øyhus 2014; Landeros et al. 2016).

1.2 Risk communication

When a population is severely affected by environmental changes, the crisis is generally followed almost immediately by criticisms from diverse sectors, including the media. The immediate accusation is that information is hidden or that the responses serve vested interests (e.g. economic, political and industrial) and that, ultimately, the authorities do not work primarily on security or in the interests of citizens. Risk communication can be regarded then as a process to help citizens to understand disaster risk associated with environmental hazards (Moreno et al. 2016).

The perception of risk is an important element contributing to development and implementation of a risk communication plan aimed at promoting awareness, preparedness and disaster risk management focused on decision makers, authorities, society, including people in charge of disaster emergency response, and other stakeholders. Understanding risk perception is a precondition for implementing risk communication. Carney (1993) for instance put forward the idea that the best risk communication strategies should be developed by considering a contingency model on which the actual risk and the perceived risk are included.

Risk communication also strengthens knowledge. The participation of populations in risk areas can lead to greater familiarity with the risk, bringing benefits and encouragement in addressing and solving environmental problems; the community changes from object to subject, promoting discussion between community and

Table 1 Investigations into landslide risk perception

Location	Risk perception issues and influencing factors	References
Nepal	Location, perceived magnitude and frequency of hazards, previous experience.	Bjønness 1986
Nepal	Landslide risk perception by farmers and socio-economic constraints to take action	Gurung 1989
USA	Lack of hazard awareness and information/knowledge of the mitigation measures.	Green 1992
Peru and Italy	Landslide risk perception is not a significant issue to reduce vulnerability. Attitudes.	Alexander1992
Australia	Cognitive factors, levels of responsibility for mitigation measures, and contrasting perception of mass movement processes to that of other hazards	Finlay and Fell 1997
Hong Kong, China	Landslide risk as unintentional and caused by both natural and human factors. Accountability of the public and private sectors for the safety of slopes.	University of Hong Kong 1998
Spain	Perception of potential landslide risk and identification of the need to implement landslide awareness programs	Solana and Kilburn 2003
Bavarian Alps	Landslide risk perception studies through mental models	Wagner 2007
Bolivia	Landslide risk perception of different stakeholders: community leaders, local authorities. Underestimation or risk denial.	Nathan 2008
Australia	The perception of landslide risk in areas of high exposure to rockfalls: attitudes and beliefs according to gender.	Aucote et al. 2010
Malaysia	Landslide awareness in terms of knowledge, attitudes and willingness to be involved in slope control activities.	Ahmad and Lateh 2011
Uganda	Landslide risk perception and knowledge by farmers based on experience. Anthropogenic and natural causes of landslides.	Kitutu et al. 2011
Austria	Diachronic survey of perception of rainfall-induced landslide risk in terms of personal experience, responsibility, and effectiveness of mitigating measures. Experts vs. Non-experts	Damm et al. 2013
Uganda	Landslide risk perception and response.	Misanya and Øyhus 2014
Italy	Lack of public awareness and knowledge of communities (national scale)	Salvati et al. 2014
Italy	Lack of solid public programs on awareness and knowledge even in areas seriously affected by landslide disasters	Calvello et al. 2015
Mexico	Landslide risk perception as a function of hazard exposure, experiences and commitment to disaster risk reduction.	Landeros et al. 2016
Taiwan, China	Risk perception of an indigenous community in terms of landslide causes and preparedness. Gender, age education and experience.	Roder et al. 2016
Mexico	Landslide risk perception associated with experience, public awareness and knowledge.	Hernández-Moreno and Alcántara Ayala on line

those responsible for risk management (Moreno et al. 2016). Through participation and discussion of the risks, it is easier to remember an event. Participatory approaches are not easy; they have limitations as well as the benefits. The community should take responsibility for protection against risk, but they may also create a risk of disaster through inadequate use of the territory and exploitation of resources. If individuals are given no responsibility or command, they are not real participants in the process; it is important to participate in prevention and management in order to be successful (Petts and Leach 2000).

When dealing with natural hazards, decision makers have to be concerned about risk and uncertainty. Confidence levels to reduce uncertainty and the complexity of people are challenges for facing future events. In dealing with infrequent natural hazards, the information to be transmitted by risk communication should be evaluated in terms of the widespread beliefs of the people regarding trust in social institutions (Paton 2008).

The mixture of ways to obtain knowledge is of great importance for reducing vulnerability. Without experience, people tend to underestimate the probability of a disaster and are not aware of the need to understand risk and take protective actions. This is a challenge to risk communication, particularly in climate-related hazards. For

example, the message "this includes you" is more difficult to communicate that "many will die" (PAHO 2012).

The development of landslide inventories, susceptibility and hazard maps, and instrumentation, monitoring and modelling is essential in order to establish slope instability scenarios and undertake landslide risk assessments and landslide disaster risk management. All this information should be available to the community as a significant input to the understanding of risk communication messages. The more people understand disaster risk, the more confident they are in their own personal judgment and not only on the advice of the authorities. This has to be taken into account when the competent and transparent risk communication is undertaken by experts or authorities (Wachinger and Renn 2010).

More than a decade ago, O'Neill (2004) had already emphasized the need for an integrated model of risk communication that should include the risk perceptions of the community, their self-sufficiency and the limitations of this perspective. However, this was depicted as a merely protective behaviour. In this regard, we consider that there is still a need to move ahead and to envisage risk communication not only in terms of response, but as a key element for understanding the social construction of risk (Oliver-Smith et al. 2016) and hence to reduce disaster risk through management. To do so, the first step is to recognise that disaster risk involves the potential impact of hazards on vulnerable people, who are exposed to that particular hazard or series of hazards in time and space (Blaikie et al. 1994).

2 Material and Methods

2.1 Study site

The municipality of Teziutlán (19°49′N, 97°22′W) is situated in the Sierra Norte de Puebla, in the transition between the Sierra Madre Oriental and the Trans-Mexican Volcanic Belt, in the north-eastern sector of the state of Puebla in Mexico (Figure 1). Climate conditions are humid temperate in the north, and warm humid in the south; precipitation takes place all year long, and especially during summer, May to September (INEGI 2015). Notwithstanding high rates of deforestation, cloud forest and evergreen forest can still be found, particularly in the north of the region.

The total population of the municipality in 2010 was 92,246 inhabitants: 43,462 male and 48,784 female, i.e. a sex ratio of 89. Also in 2010, the total population of the city of Teziutlán was 58,699, being 27,126 male and 31,573 female: sex ratio was 85.9. Illiteracy affected 4365 inhabitants of the municipality and 1696 of the city, i.e. 6.8% and 2.6%, respectively, of those older than 15 years.

Owing to the mountainous geological complexity of the area, Teziutlán, along with other municipalities of the Sierra Norte de Puebla, has been historically affected by hillslope instability (Alcántara-Ayala 2004). Landslide episodes linked to hurricanes *Florence*, *Hilda* and *Janet* have been dated back to 1954 and 1955. Most recently, of particular significance was the landslide disaster triggered by precipitation that took place in Teziutlán in October 1999. In a single landslide in La Aurora neighbourhood, 109 human lives were lost. The aftermath at regional level included 263 casualties, 1.5 million people affected, equivalent to one-third of the total population of the state, and

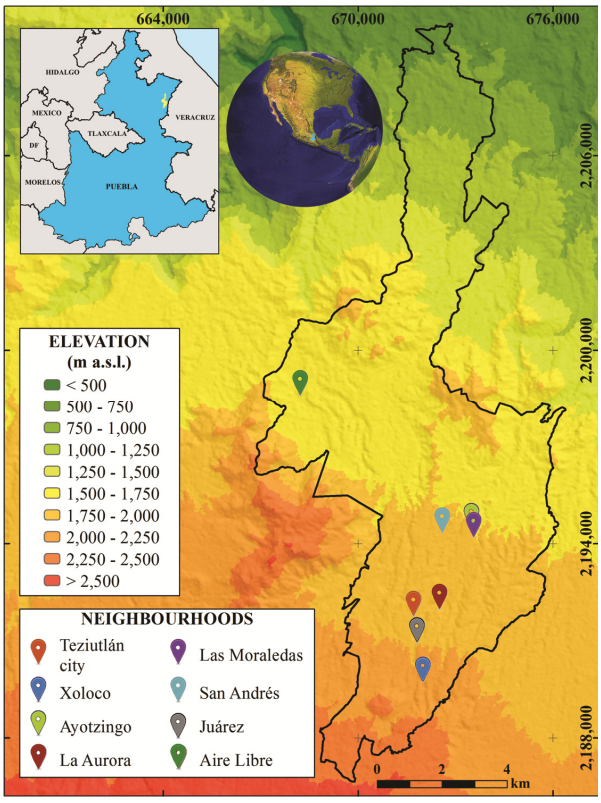

Figure 1 Location of Teziutlán, in Puebla State, Mexico.

economic damage in the order of US450 million (Bitrán and Reyes 2000). Moreover, derived from the presence of Hurricanes *Stan* (2005), *Dean* (2007) and *Ingrid* (2013), further landslides have occurred in Teziutlán during the past decade.

Geology plays a key role in determining landslide occurrence in Teziutlán. The geological basement is of metamorphic origin, and formed mainly by shales and andesitic metalaves of Permian age (Ferriz and Yañez 1981; Ferriz and Mahood 1986). Volcanic deposits of the Trans-Mexican Volcanic Belt overlay the sedimentary sequence of the Sierra Madre Oriental. The former comprise andesite, basaltic andesite and rarely basalt, and some andesitic tuff horizons of Pliocene ages that belong to the Teziutlán Andesite, along with ignimbrite materials, including rhyolitic tuff, rhyolite, rhyodacitic pumice and andesitic scoria generated by the activity of the Los Húmeros caldera (Ferriz and Mahood 1984; SGM 2011). Shales and limestones of Jurassic age are the main sedimentary rocks outcropping in the area (SGM 2011).

Susceptibility to landslides is associated with the presence of low-resistance hillslope-forming materials, and is particularly due to the availability of deposits of ignimbrite type, which under conditions of intense or cumulative rainfall can easily be mobilised. From an anthropogenic point of view, intensive land use inherent in population growth and urbanization, lack of planning and the increasing expansion of human settlements in areas exposed to mass movement have also contributed considerably to the configuration of landslide risk in the region (Figure 2).

2.2 Sampling procedure and measures

The present study is within a major research project that aims to investigate the diverse dimensions of landslide risk perception in the municipality of Teziutlán, Puebla. A risk perception questionnaire was prepared as follows: (1) in-depth interviews; (2) application of a pilot study derived from in-depth interviews; (3) preparation of the final version of the questionnaire accordingly.

In-depth semi-structured interviews were designed to examine the local context, and to recognise key elements linked to the psychosocial essentials of landslide risk perception. They were conducted with 10 key persons living in five localities of Teziutlán where landslides had previously been experienced. First contact with key people was arranged through the authorities and by some participants in the project who had already established a relationship with the population. Meetings took place in venues agreed by the interviewees. On the basis of the results, a specific questionnaire was prepared with consideration of vulnerability, responsibility, preparedness and prevention, risk communication, and social and psychological characteristics. Validation of this first version of the questionnaire involved its application to 206 people as a pilot study. Statistical analyses assessed the psychometric validation of content, scales and reliability of questions; after revision of some questions, the final version of the questionnaire was developed. The final sample comprised 600 adults >18 years of age, from eight neighbourhoods of Teziutlán (Figure 1, Tables 2, 3 and 4).

Figure 2 Socio-environmental context and landslide-related factors in neighbourhoods of the municipality of Teziutlán: (1) Transition between the municipal cemetery and the high-density housing area in the city of Teziutlán; (2) Exposure and vulnerability of people living at risk; (3) and (4) Series of dwellings at risk situated along the river channels and hillslope formed by low-resistance pyroclastic materials, which are very susceptible to landsliding; (5) House situated above a deficient drainage on landfill in El Paraíso neighbourhood before and (6) after collapse triggered by rainfall on 10 August 2015.

Table 2 General attributes of 600 inhabitants of Teziutlán municipality interviewed in April 2014

		Fre.	%			Fre.	%
Gender	Female	391	65.2	Employment status	Public sector or government employee	41	6.8
	Male	209	34.8		Private sector employee	78	13.0
Age (years old)	18 to 20	76	12.7		Business owner	45	7.5
	21 to 30	137	22.8		Self-employed (taxi driver, labourer, peasant)	89	14.8
	31 to 40	139	23.2		Sole practitioner (dentist, accountant, lawyer, etc.)	18	3.0
	41 to 50	90	15.0		Professor or teacher	12	2.0
	51 to 60	83	13.8		Retired or pensioner	13	2.2
	>61	75	12.5		Housewife	219	36.5
Level of education	No education	25	4.2		Student	66	11.0
	Basic education	142	23.7		Unemployed	19	3.2
	Secondary education	152	25.3	Years living in the community	0 to 5	138	23.0
	High school	135	22.5		6 to 10	130	21.7
	University education	98	16.3		11 to 20	153	25.5
	Commercial or technical education	43	7.2		21 to 30	60	10.0
					31 to 45	71	11.8
	Postgraduate studies	5	0.8		>46	48	8.0

Note: Fre. = Frequency.

Table 3 Description of the questionnaire sections

Section	Concept	No.	Responses	Observations
General Information	Sex	1	Dichotomy	N/A
	Age	1	Open	N/A
	Education	1	Multiple choice	N/A
	Employment status	1	Multiple choice	N/A
	Years living in the community	1	Open: Years	N/A
	Neighbourhood they live in	1	Open: Teziutlán city or San Andrés neighbourhood	N/A
Experience	Personal experience of landslide disasters	1	Multiple choice	N/A
LRA	Main causes of landslides	1	Multiple choice (select the three main causes)	Natural or anthropogenic
Exposure	Levels of perception of exposure to landslide risk, based on location of dwellings and nature of properties	11	4-point scale: 1 = Very low risk to 4 = High risk	Final scale for graphic representation Low, Moderate and High Exposure
Preparedness	Frequency of information regarding landslide preventive measures	9	4-point scale: 1 = never, 4 = frequently	Final scale for graphic representation: never, very few times, sometimes and frequently.
	Main types of mass media providers or activities concerning landslide risk	10	Multiple choice: (select communication media types)	N/A
	Preventive measures already undertaken to cope with landslide disaster events	9	Multiple choice: (select specific actions)	N/A
	Prioritising preventive measures to be undertaken to cope with landslide disaster events	11	6-point scale: 0 = Nothing necessary to 5 = Highly necessary	Final scale for graphic representation from nothing to highly necessary.
Trust	Prioritising preferred communication method(s) to obtain information in case of landslides	10	Multiple choice: (select communication media types)	N/A
	Level of people's confidence to be informed about disaster preparedness and response by different social actors	11	4-point scale: 1 = Never trust, 4 = Always trust	Final scale for graphic representation No Trust, Some Trust, Trust

Notes: No.= Number of items; *N/A: not applicable; LRA = Landslide risk awareness.

Table 4 Detailed overview of questionnaire structure

Experience			
Q. *From the following sentences tell me please, what is the one that indicates best your experience with landslides?* • You have experienced landslides in this neighbourhood • You have experienced landslides in another neighbourhood • You have not personally experienced landslides, but a relative or close friend has • You have never suffered from the impact of landslides, nor has a relative or a close friend • You have only heard, read or seen information related to landslides on the news			
Landslide risk awareness			
Q. *I'm going to read a series of situations that are on this card. What are the three that in your view are the main causes of landslides?*			
• Drought • The existence of a river close to slopes • Moderate rains for several days • Presence of loose or soft soil • Earthquakes • Heavy rains		• Presence of drainage channels • Terracing • Negligence of the authorities • Tree removal • Houses built on slopes	
Exposure. Levels of perception of risk of exposure to a landslide, based on location and nature of dwelling			
Q. *Could you please indicate to me the degree of risk the following properties have of being affected by a landslide? Response options are: very low risk, low risk moderate risk and high risk*			
• Houses built on areas affected by landslides • Houses built at the top of a slope • Houses built at the foot of a slope • Houses built on the edge of a slope • Houses built very close to a river • Houses built by the government for relocation of affected settlements		• Houses built of precarious materials • Houses built at the side of a road • Houses built by the government (social housing) • Houses built on reinforced slopes • Houses in the city centre	
Preparedness			
Q. *How often have you seen or heard about the following… Response options are never, very few times, sometimes and frequently*			
• Information about emergency routes • Best practices for protecting belongings during an emergency • Location of shelters • The need to have a radio with batteries • Existence of a warning system in case of emergency		• Areas at risk that need to be evacuated • Ways people need to organise and participate in community activities • Preparation of food and water supplies • People in charge of providing an alert in case of emergency	
Q. *Where have you Heard or seen information on landslide risk?*			
• TV • Radio • Talks	• Leaflets • Digital social networks	• Newsletters • Textbooks • Short courses	• Signalling • Evacuation drills
Q. *Which of the following recommendations have you undertaken to cope with landslides?*			
• Protecting important documents • Protecting personal belongings • Being aware of a hazard warning • Knowing the location of shelters • Identification of safe exit routes		• Ensuring a provision of water and food supplies • Participating in community activities • Ensuring the availability of radio with batteries • Participating in the establishment of a warning mechanism	
Q. *How necessary are these actions for the safety of inhabitants of Teziutlán?*			
• Implementing a warning system for communities at risk • Promoting programmes for community preparedness • Providing health programmes for people affected by disasters • Involving people in programmes for communicating landslide risk • Providing information on the best practices for protecting belongings during an emergency		• Promoting evacuation drills in areas at risk • Guaranteeing equality for the attention of affected people • Relocating people who live in areas at risk • Landslide instrumentation and monitoring • Prohibiting the construction of dwellings in areas at risk • Establishment of shelters	
Risk communication and trust			
Q. *What would be your preferred communication method to receive information in case of landslides*			
• Leaflets • Textbooks • Talks	• Internet and social networks (Facebook/Twitter) • Radio	• TV • Newspaper • Emergency telephone number	• Strategically placed emergency alert siren system • Mobile loudspeakers (in a vehicle)
Q. *To obtain information on how to prevent or respond to a landslide, how much do you trust the following? No trust, some trust, regular trust, always trust.*			
• Federal Government • State Government • Municipal Government	• Civil Protection • Local Police • People from other communities • Scientists	• Health institutions • The Red Cross • The neighbourhood elder • Lions Clubs International	

Intentional random sampling by quotas considered as inclusion criteria landslide susceptibility level of the zone they lived in and previous disaster experience. Interviews were conducted in April 2014, on a voluntary and anonymous basis.

Questionnaires included over 200 questions and were conducted in Spanish by experienced interviewers using a mobile tablet computer. Time to complete interviews ranged between 40 and 90 minutes (see Landeros et al. 2016; Hernández-Moreno and Alcántara-Ayala on line).

Five aspects expressed through nine thematic questions were taken into account from the whole questionnaire to analyse potential landslide risk communication initiatives based on risk perception: (1) Experience (preceding direct or indirect experience of landslide occurrence); (2) Landslide risk awareness (level of acquaintance regarding the main causes of landslides); (3) Exposure (perception of risk of exposure to a landslide, as a function of location and nature of the dwelling); (4) Preparedness (information, recommendations and actions to cope with landslide disasters); and (5) Risk communication and trust (preferred communication methods and level of confidence to be informed about disaster preparedness and response by different social actors) (Tables 3 and 4).

3 Results

3.1 Landslide experience

Landsliding is a frequent hazard in Teziutlán. It is common for the inhabitants to have experienced either a landslide disaster or mass movements that have affected to a lesser extent housing or infrastructure: 22% had experienced landslides in their neighbourhood, and 22% had experienced landslides in another neighbourhood; 12% had not experienced a landslide, but a relative or close friend had. However, 12 % had never suffered from the effects of a landslide, nor had a relative or close friend, and 32% had only heard or seen information related to landslides.

3.2 Landslide risk awareness

Both natural and anthropogenic related causes of mass movement processes were listed. Heavy rains and earthquakes were perceived as the main causes of landslides by 70% and 55% of the interviewees, respectively, building houses on slopes (48%) and the presence of loose or soft soil by 45% as one of the main causes (Figure 3).

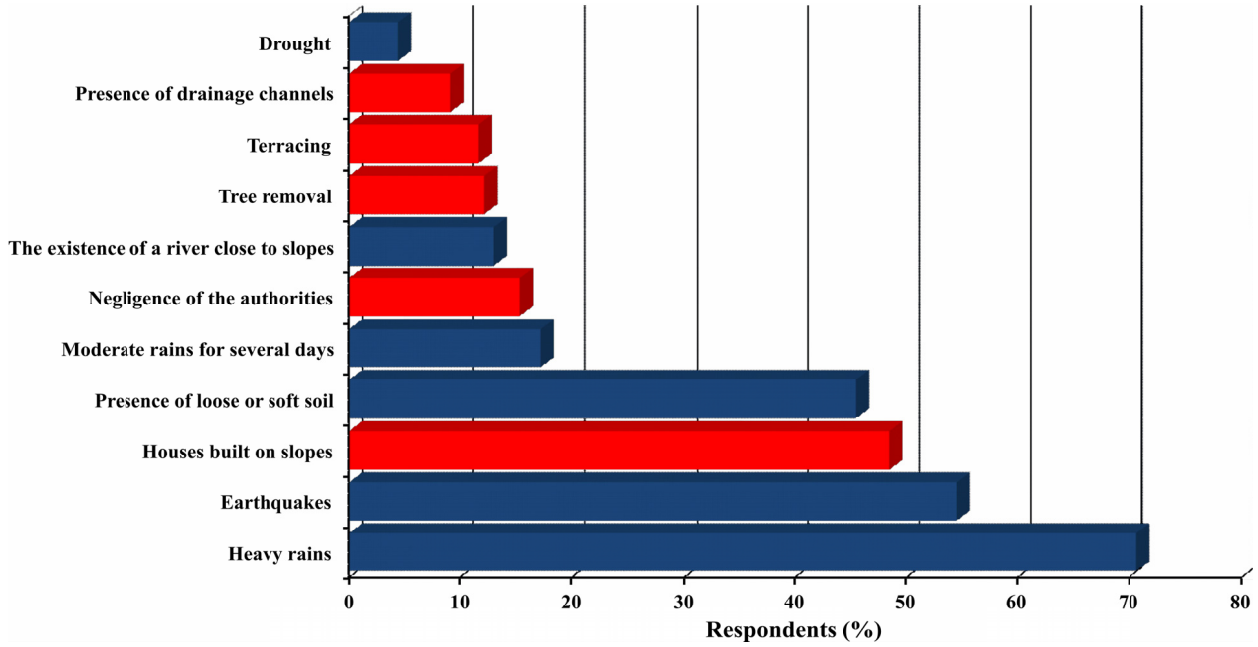

Figure 3 Landslide risk awareness: natural (blue) and human related (red) causes of landslides.

3.3 Landslide exposure

Location of properties was perceived as the most important factor in the risk of exposure to a landslide. Houses built on the edge, at the foot and at the top of a slope were regarded as of high risk by 74%, 69% and 64% of the interviewees respectively. They were also thought to be of moderate risk by a further 16%, 19% and 25%, respectively. Houses built on areas previously affected by landslides were placed in the fourth rank, 62% and 26% of respondents regarding them as of high and moderate risk, respectively. Houses situated in the city centre were considered the safest, with 30% and 47% of the respondents perceiving them to be a very low or low risk (Figure 4).

3.4 Landslide preparedness

The information most frequently received by 36% of respondents was about emergency routes. If the responses "sometimes" and "frequently" are summed, location of shelters was regarded as the most common answer by 82%, followed by information about the need to have a radio with batteries (81%), the best practices for protecting personal belongings during an emergency (79%), and information on emergency routes (78%). In contrast, 27%, 26% and 25% indicated that they had never or seldom received information on how to prepare food and water supplies, on the existence of a warning system in case of emergency and on the identification of areas at risk that need to be evacuated, respectively (Figure 5).

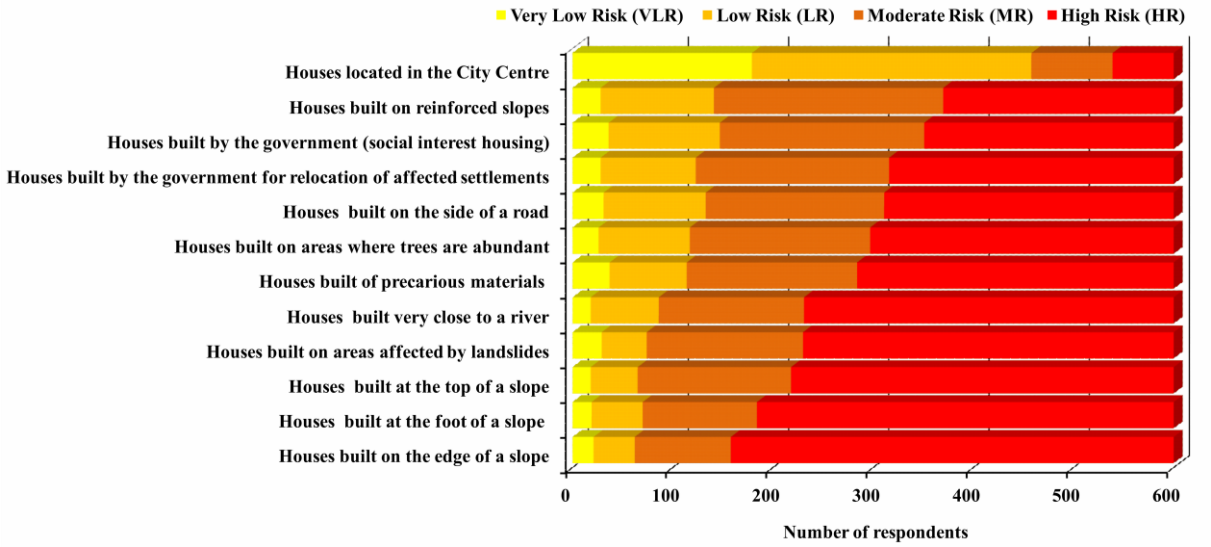

Figure 4 Perception of risk of landslide exposure based on location and nature of dwellings.

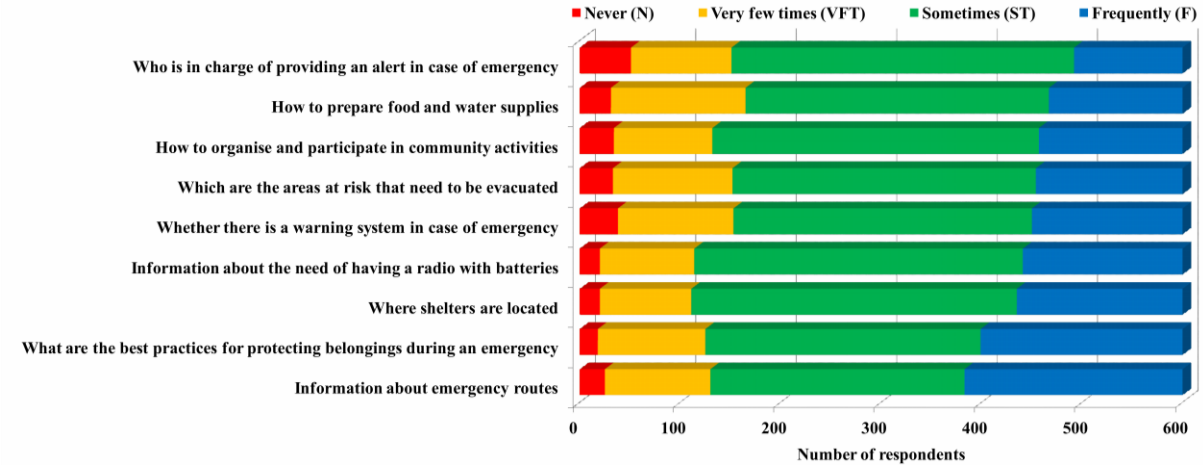

Figure 5 Landslide preparedness based on frequency of provided information.

The second question concerned the type of media or activities that had supplied information on landslide risk.TV, radio and talks were placed top, whereas evacuation drills, and signalling and short courses were conspicuously at the bottom (Figure 6).

Of recommendations already followed, documents and personal belongings had been protected by 81% and 72% of respondents, respectively. 71% were aware of hazard warnings, 68% knew the location of shelters, and 65% were able to identify the safe exit routes. Only 45% had participated in the establishment of a warning mechanism in the community.

The perception of the relative importance of the eleven measures to prepare for landslides gave generally high ranks to all (Figure 7). Implementation of a warning system for communities at risk was regarded as highly necessary by 77%. Promoting programmes for community preparedness by 75% and providing health programmes for people affected by disasters by 72%.

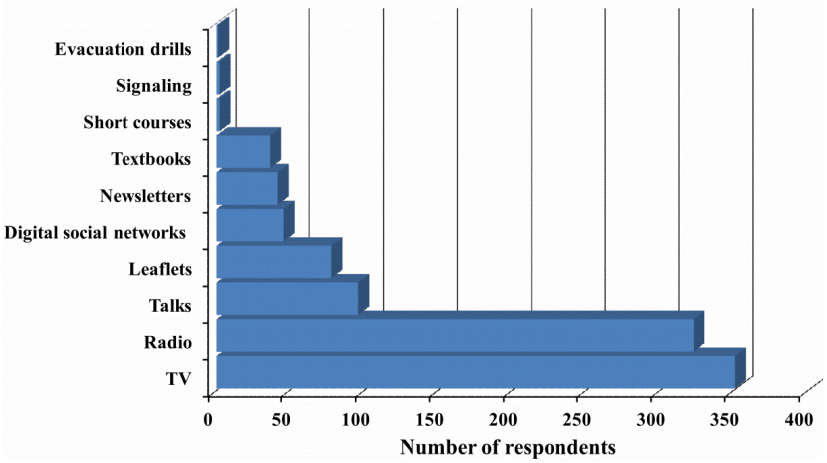

Figure 6 Hierarchical classification of media as providers of landslide preparedness.

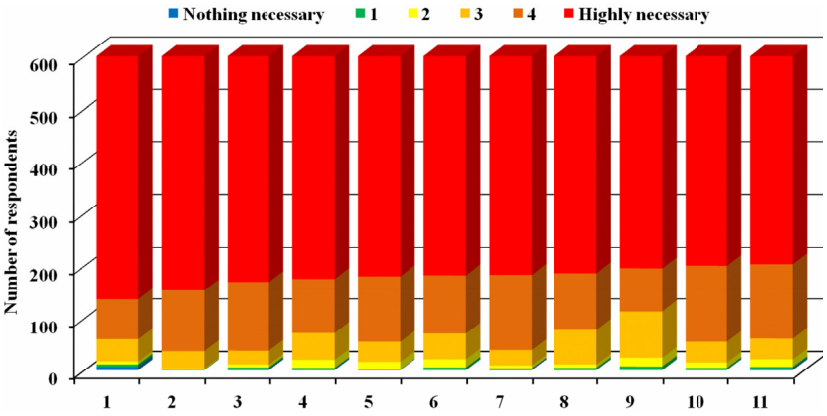

Figure 7 Landslide preparedness perceived as a function of prioritization of actions: (1) Implementing a warning system for communities at risk; (2) Promoting programmes for community preparedness, (3) Providing health programmes for people affected by disasters; (4) Involving people in landslide risk communication programmes (5) Providing information on the best practices for protecting belongings during an emergency; (6) Promoting evacuation drills in areas at risk; (7) Guaranteeing equality in attending to affected people; (8) Relocating people who live in areas at risk; (9) Landslide instrumentation and monitoring; (10) Prohibiting the construction of dwellings in areas at risk; (11) Establishment of shelters.

3.5 Risk communication and trust

In terms of communication, radio was the first choice of 25% of respondents; TV was selected by17% and talks by 15%. Only 1% preferred newspapers, 3% an emergency telephone number and 5% textbooks. The second choice was radio for 21% of the interviewees, TV for 21% and talks for 15%, while the third choice was leaflets for 15%, radio for 14%, talks for 13% and

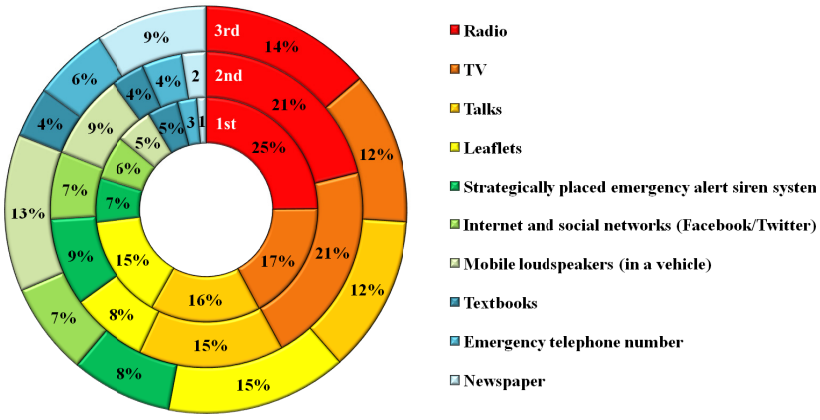

Figure 8 Preferred methods to get information about landslide risk.

mobile loudspeakers in a vehicle for 13% (Figure 8).

Responses describing sources of information as "regularly" trusted or "always" trusted were grouped into a single category of "trust" (Figure 9). Scientists were perceived as the most trust worthy by 22% of the respondents, followed by the Red Cross (21%), and Civil Protection (18%). Some trust was afforded to people from other communities by 86%, to the state government by 82%, and to the federal government by 81%. However, 8% expressed their complete lack of trust in the neighbourhood elder, 8% in the state government, 7% in people from other communities and 7% in the federal government.

4 Discussion

Awareness was related to previous experience of the people living in Teziutlán. Rainfall has been documented as the main triggering mechanism of landslides in recent decades, but the respondents also considered earthquakes to be an important cause since seismic activity is common at regional level. Experience derived particularly from the 1999 event identified among the main causes of landslides the presence of loose or soft soil and the construction of houses on slopes. Major attention will have to be paid, however, to emphasis of the deleterious effect of tree removal, since deforestation influences mass movement processes. Warnings are also required regarding the contribution to landslide risk represented by changes in slopes, particularly the role of terracing, inadequate drainage channels and precarious sewers.

The perception of susceptibility to landslides matched the actual vulnerability of the terrain, which is determined to a great extent by the geological-geomorphological conditions, with the level of landslide hazard being lowest in Teziutlán city centre. However, the impact of a landslide will also be influenced, in terms of mobility, accessibility and response, by the configuration of the settlements and the socio-economic activities that are concentrated in the heart of the municipality. Hence, efforts to increase awareness and preparedness must also be directed to people living in the city centre.

Moreover, as landslides are very frequently reactivated, special emphasis must be given to the information provided on the exposure of those dwellings built on areas previously affected by landslides. Unfortunately, the growth of the city has augmented the use of areas exposed to landsliding for construction of dwellings and other types of infrastructures. Consequently, land-use changes also need to be understood as one of the main risk drivers, and what is more, to be considered as a critical issue for risk management.

Preparedness is usually associated with the knowledge of the people to take some actions to respond to a disaster situation. Quite commonly, people living in areas susceptible to landslides have some information regarding emergency alerts,

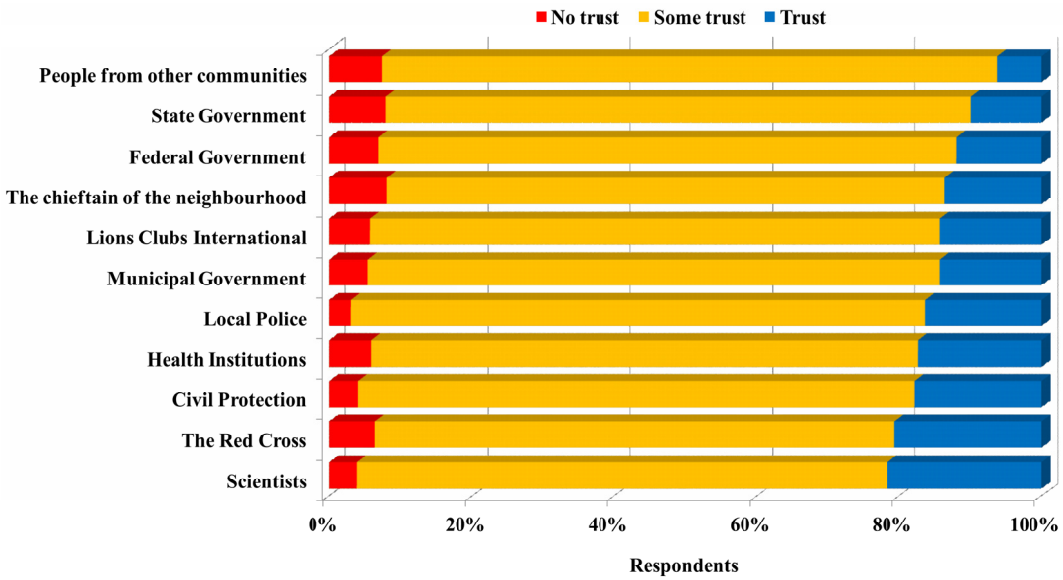

Figure 9 Trust in sources of information regarding preparedness for a landslide disaster.

evacuation routes, location of shelters, preparation and provisions of water, food and basic medicine supplies, and best practices to protect belongings. In addition to that background knowledge, the most common source of information on landslide risk for the respondents of Teziutlán was TV, although radio was the most trusted. Consequently, it would be important to develop a strategy of communication in which radio can be regarded as a key element. Major attention must also be paid to increasing the interest of people in the establishment of instrumentation, monitoring and an early warning system. Lack of interest in these strategies may partly reflect the present focus on provision of the information to schools and teachers rather than within the whole community. In addition, monitoring, instrumentation and early warning are usually viewed as an external initiative developed by scientists and/or authorities, in which local inhabitants do not play an active role, because they are usually only told what to do (e.g. "if you hear the bell, run…").

Trust is a requirement for all the stakeholders involved in DRR. In particular, when communicating the risk of disaster, not only the message to be delivered but the source of information must be reliable. The most trusted bodies were scientists, the Red Cross and Civil Protection. They represent a wide spectrum of opportunity to enhance awareness and preparedness of the community according to their individual field of experience. Information regarding hazard, vulnerability, and exposure can be provided by scientists and it should of course comprise a non-technical but robust message on the necessity of instrumentation and warning mechanisms or systems. Elements to identify exposure conditions and risk drivers as a function of the particular social context of Teziutlán can be given by Civil Protection. Insights from both the scientific community and the Civil Protection authorities can help the citizens to understand the diverse ingredients of the social construction of disaster risk, and most importantly, to understand the necessity to avoid the reproduction or new construction of conditions of risk. Last, but not least, the historical and natural experience of the Red Cross during and after disasters could facilitate better ways to confront, respond to, and recover from disasters.

Specific guidelines for the communication of landslide risk should take into account the above-mentioned in addition to other factors that may influence risk perception such as gender, age, level of education, employment status and duration of residence in the community.

5 Conclusions

It is difficult to conceive the establishment of reliable strategies of risk communication without analyses of risk perception. In spite of the lasting effects of previous mass movement processes in Teziutlán, not all the people have directly or indirectly experienced landslides. This is strongly related to the structure of the community in terms of age and population mobility. As Teziutlán is a regional centre of attraction for economic activities within the Sierra Norte de Puebla region, communication should be directed not only towards the local inhabitants but also towards a wider range of people including the floating population.

The respondents had received insufficient information regarding strategies for coping with landslides, and the lack of urban planning has reduced accessibility: narrow, steep and crowded streets usually restrict mobility of vehicles. Effects of a landslide in any part of the municipality can be potentially exacerbated under these conditions.

There is also a deficiency of coordinated action. TV, radio and talks are the common sources of information, but communication should also include evacuation drills, signalling and short courses. Protection of documents and personal belongings is a common strategy, but it is imperative that the inhabitants also be made aware of hazard warnings, and the location of shelters and safe exit routes; they should also understand the significance of, and participate in, the establishment of a landslide warning mechanism.

Implementation of a landslide warning system for the Teziutlán community (Garnica-Peña et al. 2014) must integrate new technology with traditional mass media and social networks. It would be desirable therefore to develop an Early Warning Articulated System (Alcántara-Ayala and Oliver-Smith, 2017) founded on the participation of communities, scientists, authorities, decision makers, and other stakeholders. This does not

follow the traditional notion of response, but centres on the comprehension of the underlying causes of disasters, the perception of risk, and the multi-spheres of vulnerability, resilience and adaptation. It targets individual and collective preparedness, and favours the integration of legal frameworks and ethical codes into disaster risk governance.

Communication can promote community participation that will facilitate the reconciliation of local knowledge based on accumulated experience with scientific and technical development, decision making and practice in areas susceptible to landslides. This could address one of the greatest obstacles for disaster risk governance: lack of integration of the diverse knowledge and different interests of all groups of stakeholders involved in DRR and DRM.

Risk perception and communication could increase the resilience of vulnerable people, and enhance capacity building to avoid the creation of new risks for tomorrow. This should include consideration of the potential impact of climate change on disaster risk.

In the fortified enclaves of disaster risk governance, gates must be opened to welcome the co-production of integrated knowledge, and boundaries must not be delineated to prevent communities from gaining preparedness and action. Knowledge of risk must be inclusive and extensive in order to be integrated into development planning and practice from local to global scales. This requires realistic, influential, science-based and sustainable strategies of communication.

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