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Natural hazards and risk mitigation in El Salvador: An introduction

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ABSTRACT

This volume brings together papers on current research into natural hazards in El Salvador and efforts to mitigate their impact on the society. It recognizes the need and potential for such work around the world and especially in many developing countries. In El Salvador, researchers on geological hazards obtain very frequent experience with real hazards and, through their work, aim to help develop strategies to mitigate the terrible suffering and monetary cost that is associated with their impact.

Keywords: natural hazards, El Salvador, risk mitigation, earthquakes, volcanoes, landslides

INTRODUCTION

Much of the work in this volume is collaborations of foreign scientists with local counterparts, with the aim of providing training and exchanging experiences. The volume is likely to be widely read in El Salvador, and also we hope by scientists and engineers from outside El Salvador—people who are doing similar work in other countries or people who might consider working in El Salvador itself. In this brief introduction we provide a thumbnail sketch of El Salvador and its environment, plus an overview of the natural hazards to which it is subjected and the social factors that both exacerbate the impact of natural hazards and present obstacles to effective risk mitigation programs.

THE COUNTRY OF EL SALVADOR

El Salvador is the smallest country of Central America, with just 21,040 km^2. Its population is 6.4 million (2001) resulting in an average density of ~304 per km^2, the region's highest. According to the World Bank, the country has a per capita income of just over $2000, higher than Guatemala, Honduras, and Nicaragua (http://www.worldbank.org/data). However, this income level masks a stark inequality between a small wealthy elite and a large and very poor majority (Barry, 1991).

Population density is amplified in the southwestern third of El Salvador, where 3/4 of the population are now settled in the area west of Lake Ilopango and south of the city of Santa Ana (Rosa and Barry, 1995). The people live on a rugged topography made up of young volcanoes and eroded older ones. Settlement patterns were originally dictated by fertility and water availability on the volcanic slopes in the Great Interior Valley. Coffee cultivation in the end of the nineteenth century changed land use and ownership when productive land was put in control of a few families, and left most of the people without their own land. During the last two decades the migration from the northern and eastern parts of the country has been driven by persistent rural poverty and by the fratricidal war from 1980 to 1992. The last two decades has also seen a huge exodus from El Salvador with more than a million Salvadorans having moved abroad, primarily to the United States. The mass emigrations have also had a marked effect on the national economy, giving rise to a situation where U.S. dollars, sent back by Salvadorans living in the United States, reached a level of U.S.$1751 million in the year 2000. This is six times greater than the value of coffee exports and almost three

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times greater than the net foreign exchange generated by the garment assembly industry, which has mushroomed in recent years. The U.S. dollar is now the official currency of El Salvador.

The topography and geology of El Salvador provides many advantages, including significant hydrological and geothermal power, scenic landscapes for tourism, and rich tropical soils. El Salvador borders the Middle America Trench, the active subduction boundary and seismic zone between the Cocos and Caribbean plates (Dewey et al., this volume, Chapter 27). As a consequence of plate subduction, El Salvador is bisected by the volcanic front, a linear belt of active volcanoes and accompanying seismic zone. Thus, El Salvador faces high rates of both subduction zone and upper-crustal earthquakes (White et al., this volume, Chapter 28), explosive eruptions, and landslides—three of the most destructive geological hazards. Floods are also important. The affirmation by the historian William Durant, that civilization exists by geological consent subject to changes without prior notice, is definitely applicable to this tiny country. The shadowy ambiguity of a volcano—beauty, fertility, energy, and its inevitable danger—is an important symbol for El Salvador, and it colors everyone's hazard perception.

RECENT EVENTS

Recent history has reminded Salvadorians of many of the natural hazards in their otherwise delightful natural surroundings. In addition to geological hazards, El Salvador is located in the subtropical hurricane zone and is visited by both Atlantic and Pacific cyclones. In November 1998, Hurricane Mitch killed 240 people, displaced 85,000, and cost the country an estimated $388 million, equivalent to 3% of the gross domestic product (GDP) (Mowforth, 2001; Gonzalez, this volume, Chapter 34). In early 2001, a series of earthquakes and associated landslides killed 1259 people, destroyed or damaged more than 300,000 houses, and caused about $1.6 billion in damages (Bommer et al., 2002). This was the fifth large earthquake in 50 yr, consistent with the pattern of El Salvador being hit by a destructive earthquake once per decade on average. The last earthquake before this was the upper-crustal event that struck San Salvador in October 1986, leaving 1500 dead and causing damages equivalent to 31% of the GDP in the same year. Similarly destructive earthquakes occurred in 1951 and 1965.

Volcanoes have been kinder in recent years, although landslides triggered in loose deposits on their slopes have had a terrible impact. A notorious example was the mudslide triggered on the slopes of the San Salvador volcano by heavy rainfall in September 1982, burying 500 people and leaving another 2400 homeless (CEPRODE, 1994). Although the morphology of the volcanic front resembles both Guatemala and Nicaragua, historic volcanic activity in El Salvador is sparse, compared to either of its neighbors. Prehistory was markedly different however (Sheets, this volume, Chapter 8), and this longer time perspective integrates more information and more accurately portrays volcanic risk. The three largest cities (San Salvador, Santa Ana, San Miguel) are each located on the flanks of potentially active volcanoes (with the same names). In the center of El Salvador is Ilopango Caldera, an active volcano (Mann et al., Chapter 12; Richer et al., Chapter 13; López et al., Chapter 14: all this volume) masquerading as a beautiful lake, which has devastated El Salvador four times in the past 56,000 yr, the last at ~A.D. 429 (Dull, this volume, Chapter 18). The country's major seaport, Acajutla, through which 45% of the external trade passes, is located on a huge debris avalanche from Santa Ana volcano (Siebert et al., this volume, Chapter 2). San Salvador is on top of thick deposits of the Tierra Blanca Joven tephra of Ilopango (10 km east; Rolo et al., this volume, Chapter 5) and intercalated mudflows and fall deposits of San Salvador volcano (7 km west; Sofield, this volume, Chapter 11). Both of these volcanoes are likely to be active again. Although the impact on the population was limited, the most recent eruption of San Salvador volcano, in 1917, covered part of the northern side of the volcano with lava, creating a rough area that remains unpopulated.

As if it were not enough for this small country to have the geographical misfortune to be prone to the full spectrum of natural hazards, its recent history has been severely marked by disaster from human conflict. The hugely uneven distribution of the country's wealth led to a civil war from 1980 to 1992 that left 75,000 people dead, the vast majority of them noncombatants, and cost more than $2 billion. The decade of peace that has followed the signing of agreements between the guerrillas of the Farabundo Marti para la Liberacion Nacional (FMLN) and the El Salvadorian government has not brought the stability and prosperity that was expected (Europa World Yearbook, 2000). Poverty, particularly in rural areas, has not been eliminated, and most Salvadorians feel that their economic situation is precarious or worse. United Nations statistics on human development paint a worrying picture (http://www.deasrrollohumano.org.sv). A particular problem that has arisen in the postwar period is a massive increase in crime, particularly violent crime, which has created a situation of great insecurity for most of the population. A Gallup poll taken in February 2002 (http://www.cidgallup.com), just one year after the earthquakes, reveals that the two overriding preoccupations of Salvadorians were unemployment and delinquency. Environmental degradation is another very serious problem and a concern for Salvadorians (PRISMA, 1995).

RISK MITIGATION EFFORTS

Until recently, El Salvador's government has not made a large commitment to natural hazards mitigation. International researchers did not study the geology of El Salvador much, because of war and an environment perceived as unsafe. During the 1980s, the war was the obvious obstacle to any risk mitigation programs. In the last decade, the relative lack of concerted efforts in hazards mitigation likely reflects the severity of more immediately demanding problems such as water quality, sanitation, various health issues, etc. This is despite the fact that 50% of the population reported, in the Gallup poll mentioned previously,

that they or a family member had been adversely affected by the earthquakes in 2001.

The combined effect of Mitch and the 2001 earthquakes, however, has had an impact. In response to these, the Salvadorian government has taken the bold step in the past two years to establish a new government agency Servicio Nacional de Estudios Territoriales (SNET) in the Ministerio de Ambiente and Recursos Naturales. The new agency aims to deal with the mitigation of natural hazards, and it will try to consolidate and strengthen infrastructure. Work on hazard characterization involves technical aspects such as monitoring of earthquakes, volcanoes, meteorology/hydrology, and slopes. But education of the public about risk is also badly needed. Geoscience education in El Salvador is minimal—the only university degree program in the whole country is one in physics with an option in geophysics. Training in earthquake-resistant structural design is also limited (Lopez et al., this volume, Chapter 23). Although no studies document this, there seems to be an unusual sophistication amongst Salvadorians about risk perception. This comes from the continual experience with war and natural hazards in recent years. Few in the population are without friends and relatives that were impacted. This has taught them to compare low-level risks with some sophistication. As we know from our experience in developed countries, the public, government officials, and even insurance companies are quite ignorant about low-level risk and there can be difficulty in discussing these issues rationally. The cultural, social and historical context of each country makes education about natural hazards challenging. It is not enough to know the technical aspects.

There are many questions to consider when thinking about mitigating the risks from natural hazards in a developing country. The poorest Salvadorans live in the areas with highest risk (on steep slopes and along rivers). Most of these natural events cannot be prevented or even significantly modified by man's effort. Recent history has made Salvadorans more aware of seismic hazards than volcanic ones, but this may well be misleading. How can education effectively address this? How does a mitigation effort produce value added from expenditures that are very badly needed for other purposes as well? What should be the goal of a risk mitigation effort? How are low-probability but apocalyptic hazards addressed? How can the work by foreign scientists and engineers in El Salvador best reinforce local infrastructure? What kinds of technology transfer are most effective? How can local administrative authorities in El Salvador be strengthened in order to enable them to impose land use control and building regulations that can control the impact of future events?

CONCLUSION

The first volume devoted to geological studies in El Salvador is now published. It puts together information that can be used by Salvadorans for many purposes, such as land use, risk management, and education. We hope that this volume will also increase interest in international intercultural communications and science about natural hazards. The volume is complementary to studies that have looked at natural hazards and local capacities for dealing with their impact in the region (Ordoñez et al., 1999; Trujillo et al., 2000), providing a specific focus on El Salvador and adding more detailed and up-to-date technical information. We hope that others may be inspired to produce similar compilations for other countries in Central and South America that share similar problems in terms of natural hazards and developing economies.

We believe that the high and growing costs of natural hazards can be cut by working together in a way that benefits everyone—giving scientists from abroad access to the most dramatic and current natural events and providing a vehicle for strengthening local knowledge and capability.

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