Landslides in the squatter settlements of Caracas; towards a better understanding of causative factors

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I. INTRODUCTION

HOUSING THE URBAN poor in the cities of Latin America is already a complex task without the demands caused by so-called "natural disasters". When these occur, the loss of life and the level of disruption reveal the lack of preparedness in each country to deal with problems of this magnitude. This might also be the case for countries in the North but the much higher number of people at risk often found in countries in the South makes the overall effect worse.

This article examines the vulnerability of squatter settlements to landslides in Caracas, Venezuela. The paper is divided into three main sections. In the first, the incidence and effects of earthquake and rainfall induced landslides in Latin America are considered. The second and third sections provide an overview of the causes and effects of slope instability in the *barrios* (squatter settlements) of Caracas; the causes range from the rapid growth of the *barrios* and the attitudes of the government, to the impact of rainfall and the slope modifications caused by the settlement process. A final section presents some conclusions.

II. HAZARDS IN LATIN AMERICA

IN THE MEXICO City earthquake of September 1985 (with a magnitude of 7.8 on the Richter scale), approximately 10,000 people were killed. In October 1989, an earthquake of comparable intensity in San Francisco (7.1 on the Richter scale) killed 63 people, "...many in the San Francisco Bay area where parts of the Interstate 880 bridge collapsed".[1] Although the estimated material loss in terms of million US$ was higher for San Francisco, what must be emphasized is that

1. Degg, M.R. (1992), "Natural disasters: recent trends and future prospects" in *Geography*, Vol. 77, No. 3, in press.

the damage was also overwhelming to the properties of the urban inhabitants in Mexico, and it had a major impact on people's lives. As Cannon states, in the literature, there is "...a perception of disasters as having little impact in terms of deaths in industrialized countries but much material damage (in physical and value terms), while in the Third World the situation is seen as the opposite. This is based on a crude and ill-informed understanding of the value of a great deal of property in Third World countries for the actual users."[2]

Sudden events such as earthquakes can obviously cause major disruptions and many have led to disasters; Box 1 presents some recent examples from Latin America. Although landslides are not considered to be as severe, they have also endangered the lives and properties of the inhabitants on many different occasions. It is important to recognize that "...the extent and economic impact of landslides in the world are considerable, though not well known".[3] Part of the difficulty in assessing the scope and scale of the problem is that much landslide damage is masked by its association with other events.

As well as being triggered by earthquakes, landslides have also occurred as a result of more frequent events such as rainfall. They can be considered "small dimension" disasters, mainly (but not only) affecting communities located on the slopes. In many cases they are an annual occurrence but even so, many cities still do not have the level of preparedness required to cope with such events. Similar events to those described in Box 1 have been documented in other Latin American cities including Medellin, Colombia where, in the squatter settlement of Villa Tina, approximately 120 people were killed in a landslide that followed heavy rain in the area; and in Veracruz, Mexico, in October 1991, a landslide caused by torrential rain killed 13 people, destroyed several homes and left 10 people missing.[4]

The United Nations has declared the 1990s to be the "International Decade for Natural Disaster Reduction". Special attention is being focused on the Third World and, as stated in the UN resolution, the aim is, through concerted international action, to reduce the loss of life, property damage and social and economic disruption caused by "natural disasters". This is not an easy task in the already densely populated and still expanding cities of Latin America. Cities have often expanded into the worst locations in terms of physical stability, such as hillsides prone to landslides and land subject to flooding. Without changed policies "...cities will increasingly be made up of settlements built on dangerous sites, continuing the long established trends...."[5] One consequence of human induced modifications to the natural environment is that naturally occurring changes in the landscape have also become a risk to communities. As has been said about Los Angeles: "Directly, urban growth is responsible for transforming geomorphological processes into community hazards."[6]

III. ON A DOWNWARD SLOPE: SQUATTER SETTLEMENTS AND LANDSLIDES IN CARACAS

IN CARACAS, LANDSLIDES have become an increasing problem, frequently associated with the rainy season and the creation of more vulnerable sites by the expansion of the urbanized area. Their effects

2. Cannon, T. (1992), "A hazard need not a disaster make: vulnerability and the causes of 'natural' disasters" in Varley, A. (editor), *Disasters, Development and Environment*, Belhaven (forthcoming).

3. Brabb, E. and B. Harrod (1989), *Landslides: Extent and Economic Significance*, proceedings of the 28th International Geological Congress, Balkema, Rotterdam.

4. Reported in *The Guardian*, 29 September, 1987 and 4 October 1991.

5. Hardoy, J. and D. Satterthwaite (1990), "The future city" in *The Poor Die Young*, Hardoy, J., Cairncross, S. and Satterthwaite D. (editors), Earthscan, London.

6. Cooke, R.U. (1984), *Geomorphological Hazards in Los Angeles*, The London Research Series in Geography 7, Allen and Unwin, London.

Box 1: Recent Earthquakes and Landslides in Latin America

SAN SALVADOR: The October 1986 earthquake with an intensity of 5.4 on the Richter scale caused 2,000 deaths and injured 10,000 people; total damage was estimated at US $2 billion. ".. a large percentage of the victims were squatters who, prior to the earthquake, were residing on marginal sites, such as the banks of steep ravines, along railroad tracks, and on public lands and/or other sites that had been occupied illegally. Most of the houses were made of light-weight materials such as corrugated iron sheeting, cardboard, and wooden timbers. Most of damage ... resulted not from the collapse of housing, but from landslides. (A large number of the victims were displaced persons who had moved to the city to escape the violence of the civil war in the countryside.)"

NORTHERN ECUADOR: In March 1987, "...the earthquake occurring at the end of the rainy season resulted in colossal mud slides that swept away 40 kilometres of oil pipeline. Ecuador's economy is dependent on oil and as the pipeline was the only link between the oil fields and the ports the whole economy was brought to its knees." The following month, heavy rainfall triggered several landslides and approximately 100 people were killed.

RIO DE JANEIRO (Brazil): In February 1988, after very heavy rainfall, landslides in Rio de Janeiro destroyed 500 homes and killed 94 people. Fifteen thousand people lost their homes and found refuge in local public schools. The rain induced damages included 300 complete and 150 partial building collapses, over 800 landslides and nearly 200 accidents from rock slides or falls. More than 600 emergency calls for assistance from floods were recorded. Other rain induced damage included disruptions to sewers, collapsed walls, fallen trees, damaged water reservoirs and electricity pylons. The city's Civil Defence Coordination body assists on average 200 accidents per year, 21 per cent of which are building collapses and 30 per cent are landslides. Forty per cent of the help in the *favelas* is for shacks which collapse as a result of a lack of technical or financial resources to construct safe, rain-resistant housing.

BRAZIL; Early in 1992, there was a landslide in Teresópolis, Rio de Janeiro; a civil defence worker had warned a household about the risk at 17.30 hours the previous evening, but they refused to abandon their home. The next morning, after a night of rain, the landslide occurred. The seven members of the family were reported dead.

SOURCES: *San Salvador: Barraza, Ernesto "Effectos del terremoto en la infraestructura de vivienda" pages 83-90; Lungo, Mario (1987) "El terremoto de octubre de 1986 y la situacion habitacional de los sectores populares", pages 71-81 in "El terremoto del 10 de octubre de 1986", a special issue of* La Universidad, *Nino CXII No. 5, San Salvador, January-March; and Cuny, F. (1987), "Sheltering the urban poor: lessons and strategies of the Mexico City and San Salvador earthquakes",* Open House International, *Vol. 12, No.3. Ecuador: Dudley, R. (1987), "Houses for and by the rural homeless: supporting a rapid response to the March 1987 earthquake in Ecuador",* Open House International, *Vol. 12, No.3; Oliver P. (1987), Dwellings, The House across the World, Phaidon Press, Oxford, page 126; and UNDRO (1984), El alojamiento despues de los desastres, United Nations Disaster Relief Coordinator, New York, page 53. Brazil: Costa Leite, L. (1988), "Urban disasters in the Third World: the poor first in line",* UN Development Forum, *Vol. XVI, No.3, May-June; and* Jornal do Brasil, *6 January, 1992 .*

have been particularly evident in the *barrios* on the hillsides surrounding the city.

a. The Rapid Expansion of the *Barrios* and the Problem of Instability

Although Caracas has a history spanning more than four centuries,

it is in the last 30 years that rapid population growth has placed great stress on the physical fabric of the city. Between 1950 and 1990, the city's population grew from 712,000 to more than 3 million. The ways in which the population has increasingly occupied the valley within which the city is located, and the configuration of the valley itself have had an important role in the occupation process. The flat areas have facilitated a continuous urbanization process towards the east. As pressure on the limited space increases, urban growth has taken place in the surrounding hillsides as a result of the development of both squatter settlements and middle and high-income urban developments. Problems with slope instability have been largely ignored in the squatter settlements which means a very large population is at risk. Although some public works have been carried out to stabilize slopes, the purpose is usually corrective engineering. The cost is often considered to be unjustified when squatter settlements are at issue, and investments are only undertaken when new residential areas or roads are being planned.

Very few of the landslides in Caracas can be considered "natural". The incidence of slope failures in Caracas has been partly a result of the establishment of urban areas within a planning process which does not take into account the stability of the terrain. A public statement by the Venezuelan Geological Society in 1988 stated that only 40 per cent of the capital region presented an "...acceptable degree of safety."[7] However, slope failures frequently occur in *barrios*, not only because of the already unstable natural conditions, but also as a result of changes to the slopes from human activity.

According to FUNDACOMUN (the government body in charge of the *barrios*) the population in *barrios* formed 77.6 per cent of the total population of the metropolitan area of Caracas.[8] As a substantial proportion of all *barrios* are located on hillsides, this figure provides an idea of the number of people and properties at risk as a result of slope instability. Bolívar, using official figures, estimated that between 1978 and 1985, on average only 37 per cent of all housing construction taking place each year in the city had a planning permit.[9]

In Caracas, there is great variety in the housing conditions evident in squatter settlements, ranging from precarious shelter to consolidated houses. Housing units found in these *barrios* are known as *ranchos* (huts), and they are often built initially using waste or non-durable materials.

b. Land Ownership

An important aspect to be considered within the expansion of *barrio* settlements in Caracas is land ownership. According to data published in 1984 by the city's authorities (the *Gobernación del Distrito Federal*), 49 per cent of the total area occupied by *barrio* settlements belonged to the state, 15 per cent was private property and 19 per cent mixed property (state and private sector).[10] The ownership of the remaining 17 per cent was not known.

Thus, according to this information, nearly half of the *barrios* have developed on lands belonging to the state. When squatters invade an area, they may meet with official disapproval but, as these figures suggest, the situation is often tolerated by the state. The complicity of the state contributes to the production of *barrios*.[11] This attitude occurs partly because the political system needs popular votes.[12] These settlements, in exchange for political support, are later pro-

7. *El Universal*, 15 February, 1988.

8. Xiomara Alemán, FUNDACOMUN *pers. comm.*

9. Bolívar, T. (1988), "Los agentes sociales articulados a la producción de los barrios de ranchos, Sector de Estudios Urbanos", FAU, UCV. Caracas, mimeo.

10. Camacho, O. and T. Bolívar (1987), "La propiedad y el inquilinato en los barrios de ranchos del area metropolitana de Caracas, una investigación necesaria", paper presented at the workshop "Land and Housing in Latin American Cities", University of California.

11. See reference 9.

12. See reference 10.

vided with the infrastructure and services necessary for the consolidation process. In some cases upgrading programmes for *barrios* are limited to the aesthetic aspects of housing. This lack of continuity in the policies towards the *barrios* has contributed to the sporadic service supply. The resources could have been more effectively allocated to social, legal and physical aspects of the problem. Physical conditions are considered only when landslides occur.[13] Improvised locations for the homeless sometimes fail because land stability is not tackled.

c. Who Deals with the Problem?

In 1987 the *Defensa Civil*, drew up a *Plan de Operaciones en Emergencias en Caso de Inundaciones y Derrumbes* (operational plan in the event of flooding and landslides).[14] The plan is both preventative and operative. It is an attempt to deal with the problem, but a *barrio* can occupy several hectares and unfortunately in a city with 408 such *barrios*, it is often difficult to be aware of the emergency situation that can arise almost anywhere. Without a means to identify the unstable areas, with no warning system, and with the communication problems which arise from damage as a result of heavy rainfall (flooded streets, power failures, etc.) emergency planning becomes a difficult enterprise for any coordinating body. The lack of resources is evident as soon as the *Defensa Civil* visits locations where the inhabitants have reported unstable areas. *Defensa Civil* can propose the evacuation of the house or houses, but alternative housing is not available.

If the *Defensa Civil* is to cope with the emergency, it needs adequate resources, personnel and information. Its response cannot only be when the disaster occurs. Preventive action, coordination during and after the disasters, and the provision of shelter as a long-term solution are all needed. After a disaster, hundreds of homeless are given only "provisional solutions" sometimes for four years or more or, as in *Nueva Tacagua* where the "provisional" shelters in *barracas* (ravine and trailers) have been occupied for more than 14 years.[15]

d. An Argument for Eviction

The instability of the terrain could be used to justify the eviction of 67 per cent of the total area occupied by *barrios*.[16] But this would affect 573,949 people living in such settlements - 53 per cent of the total *barrio* population considered in the study "*Barrios Urbanos del Area Metropolitana de Caracas*" in 1984.[17] As Baldó and Bolívar pointed out in a document issued to discuss the subject, the riot that occurred in February 1989 showed that the *barrio* dwellers are hardly likely to accept this argument for eviction.[18]

IV. THE INCIDENCE OF LANDSLIDES IN CARACAS

UNTIL THE 1960s, the majority of slope failures recorded in Caracas was associated with earthquakes.[19] From the 1970s onwards, the occurrence of slope failures in Caracas was more noticeably associated with the rains. Awareness of the occurrence of slope failures has increased as a growing number of people have been affected.

In terms of the link between the spatial distribution of the occur-

13. Davis, I (1987), "Safe shelter within unsafe cities: disaster, vulnerability and rapid urbanization", *Open House International*, Vol.12, No.3, p.11

14. As a result of the creation (*Instructivo Presidencial* N.5) in March 1986, of the *Comisión Nacional para la Prevención Control y Defensa contra Inundaciones y otros Daños Producidos por las Lluvias* (National commission for prevention, control and defense against floods and other damages caused by the rain). The commission is formed by INOS, INAVI, Ministerio de Relaciones Interiores, Ministerio de la Defensa, MTC, MSAS, MINDUR, MARNR, OCEI, FUNDACOMUN. It also involves IMAU, Metro de Caracas, CANTV, Dirección de Obras Municipales (GDF), and CSB.

15. See Brumlik, A. (1984), *Reflexiones sobre autoconstrucción*, FAU, Universidad Central de Venezuela, Caracas; and *Ultimas noticias*, 12 July 1988.

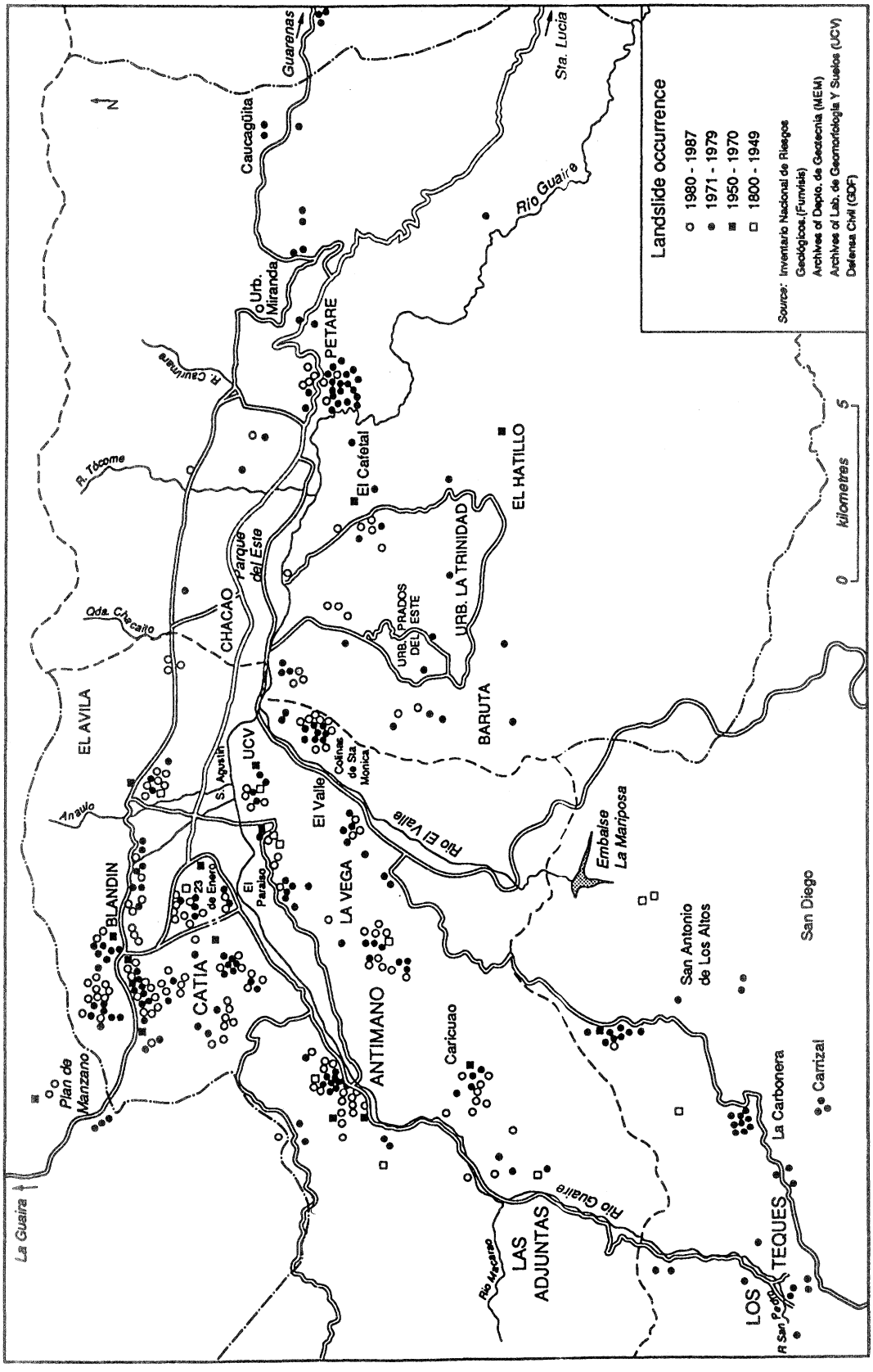
16. Baldó, J. and T. Bolívar, T. (1989), "La investigación de los terrenos como causal de desalojo de los barrios caraqueños", Sector de Estudios Urbanos, Universidad Central de Venezuela, Caracas, (mimeo).

17. Gobernación del Dtto. Federal, ORCOPLAN R.C., MINDUR, FUNDACOMUN, O.M.P.U.

18. See reference 16. In February 1989, there were riots in the main cities of the country as a result of popular discontent. The uprising led the government to declare a curfew and the suspension of constitutional safeguards. There were about 300 victims (or thousands, information differs depending on the source).

19. Singer, A., C. Rojas and M. Lugo (1983), "Inventario nacional de riesgos geológicos", estado preliminar, serie técnica, FUNVISIS, Caracas.

Fig. 1: Landslide occurrence in the metropolitan area of Caracas



rence of landslides and urban growth, the areas increasingly affected by landslides are similar to those where a rapid development of new settlements has been taking place. Figure 1 shows the locations of the slope failures that have taken place since the 1800s. The spatial distribution of these failures gives some indication of the effect of population pressures on most of the hillsides in Caracas. The areas where landslides occurred between 1800 and 1970 have suffered increased deterioration during the 1970s and 1980s. Between 1800 and 1949, 12 landslides occurred. In the next 20 years, there were 23. In the recent past, their number has grown considerably - 221 landslides took place between 1971 and 1979, and a further 266 between 1980 and 1987.

The main areas continuously affected by slope failures have been identified. In the period considered, more than 20 landslides, ocurred in Petare, Carapita-Antímano, and Blandin-Gramoven; and between 15 and 20 in Santa Mónica and La Vega. With the exception of Santa Mónica and El Cafetal, most of the areas where the landslides were concentrated are in *barrios*. It could be argued that the process of urban growth has led to an increase in the number of vulnerable areas although there is a possibility that these areas were unstable before occupation took place.

In the course of the research on which this paper is based, slope failures in the metropolitan area of Caracas were analyzed both spatially and over time to identify some of the factors responsible for their incidence.[20] A data set of 205 slope failures which occurred over a six-year period (1974-1979) was created. This included all recorded landslides for this period. Besides location and date of occurrence, the data set incorporated seasonality and cumulative rainfall values, lithology, slope angle, type of mass movement and location within the metropolitan area. The vast majority of the 205 slope failures (81 per cent) occurred mainly during the rainy season. The highest concentration of slope failures in Caracas were in *barrio* settlements (56 per cent); the next highest proportion was associated with road-cuts (20 per cent), followed by failures in residential areas other than *barrios* (15 per cent).

The main purpose of the research was to identify the relationship between *barrio* settlements and the incidence and severity of slope instability in Caracas. Thus, the study tried to identify the effects on slope instability of those factors directly associated with housing conditions in *barrios*, namely drainage systems, sewerage, and changes in slope geometry produced by building.

The role of rainfall as a trigger for slope failures was examined. Cumulative rainfall values were considered for three periods: 10 days, 30 days and seasonally. When considering the period of 30 days, residential areas other than *barrios* showed less vulnerability as more rain was needed before slope failure took place. When considering the 10-day period of cumulative rainfall, *barrios* needed slightly more rainfall than other artificial cuts or areas in order to reach the slope failure threshold. This may be because the closely spaced houses, cemented paths and stairs in the *barrios* intercept the rain and promote surface runoff, thus draining the water out of the slope. More water seems to be needed to trigger the event. This is of some predictive significance locally, for it can act as a warning that failures are imminent and local emergency services need to be activated.

Although the different situations illustrated are all on slopes which have been settled, Crozier quoted an example where the amount of

20. Jiménez-Díaz, V. (1992), "Slope failure in Caracas, Venezuela: the influence of squatter settlement", PhD thesis, Department of Geography, University College London (mimeo).

rain required to cause a landslide was higher on unmodified slopes than on ones modified by houses built with a cut and fill construction method.[21] This method is where soil is removed from the back of the site and deposited at the front in order to increase the flat area available. This is a common practice in the settlement process of the *barrios*.

It is not only the amount of rainfall that is important but also the role of paved areas in concentrating runoff water. A case study shows that the configuration of artificial "channels" (stairs and paths) for water concentration was important when assessing the role of the accumulation of water in the slope. The increase in the amount of water in the slope from sewage or waste waters and drains, and the modification of the channels determines the concentration of water at different points in the slope. As Sidle points out in the case of the residential areas and unmodified slopes "... natural rainfall and intercepted drainage as well as introduced water tend to be discharged onto the developed hill slope less uniformly than is natural rainfall on undisturbed slopes."[22]

The incidence of slope failures was also taken into account in terms of the supply of services in the *barrios* for the whole of the metropolitan area (notably water supply and sewerage) as a first step in analyzing their possible relationship. The largest area covered by services is found in the eastern zone, which is also one of the areas with a high landslide incidence. The least serviced area at the time (the south-west zone) also coincided with the areas which presented fewer incidences of slope failure. The provision of basic services or the consolidation process in the *barrios* might not be entirely beneficial in terms of slope stability. The supply of services in many *barrios* is outstripped by the permanent growth and the physical expansion of the settlements. The situation is exacerbated when such services (especially water supply and sewerage) are provided, but not maintained.

In considering the different factors that contribute to slope instability, the effect of changes in the weight of houses as a result of the use of heavier building materials was not fully assessed. Yet, in the lower part of the *barrio*, where slope failures occurred, there was a larger concentration of houses built with durable materials at the time of failure.

The physical conditions existing before the settlement process can also influence slope failure. For instance, previous soil movements can be reactivated by triggering factors such as heavy rainfall or earthquakes. An instrument often used in predicting slope failure is a landslide susceptibility map. Such maps are normally based on an assessment of the main physical features of slopes (such as angle, type of rock or soil and so on) but they disregard other possible external causes of slope failure. The case study in this research has shown, however, that other important contributing factors such as human induced modifications to the physical environment should have an equally important role in an assessment of pre-failure conditions.

IV. CONCLUSIONS

IN THE SQUATTER settlements of Caracas, many improvements in terms of water supply, sewers, paved roads and building materials

21. Crozier, M.J. (1986), *Landslides: Causes, Consequences and Environment*, Croom Helm, London.

22. Sidle, R., A. Pearce and C. O'Loughlin (1985), *Hillslope Instability and Land Use*, Water Resources Monograph Series 11, American Geophysical Union, Washington, D.C..

have taken place. These are the result of both public and community interventions. However, ways have to be found to ensure that sectoral interventions are coordinated so one does not contradict the goals of another. For example, piped water supplies and sewers are important improvements in terms of health but they have to be maintained and pipes should be built with resistant materials to avoid leakages that would concentrate water on the slopes and thus contribute to slope failures. Similarly, improvements in the quality of buildings which, in Caracas, generally means the use of heavier materials and the development of heavier structures, can place extra weight on the slope and may make instability more likely.

The occurrence of landslides and their consequences could be minimized in *barrios* if more was known about the mechanisms by which these movements were accelerated. Many of the specific solutions for the problems of landslides are in the hands of specialists but no solutions are possible without interdisciplinary work. And as is so often the case, the solutions may have to rely on political decisions, even if the actual problem is a physical one.

The different components of the problem of slope instability in the squatter settlements of Caracas have to be linked, especially at the prevention stage. This paper has only highlighted part of the problem as relates to the physical characteristics of the slope and to services in the squatter settlement. But a great part of what needs to be done lies in improving inter-institutional coordination and gathering the necessary political will to act more effectively in improving conditions in squatter settlements.

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