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EVALUATION OF THE OUTCOME OF THE IDNDR PROGRAMME AND EARTHQUAKE RISK REDUCTION IN PERU

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SUMMARY

Peru's programme for the IDNDR was started in 1989. From 1989 to 1995 two regional programmes were developed. The new Grau region located in N-W Peru was severely hit by El Niño 1982-83 and has high seismicity. A project to included natural disaster mitigation in its social and economic development was implemented from 1989 to 1992. Some seismologist stated that there is a seismic gap in the subduction zone near the Peru-Chile border. Assuming an earthquake of magnitude of the order of 8, its possible impact on a 700 x 200 km^2 rectangle was investigated from 1992 to 1995 to define a scenario for preparing a contingency plan and a disaster mitigation programme.

In 1995, at mid Decade a campaign to convince political decision- markers at the national and local level, that reducing natural disasters is a national problem was resumed with renewed energy. The El Niño 1997-98 that caused severe damage in the country helped in the campaign.

The Ministry of Education has decided to officially introduce basic knowledge on disaster prevention and mitigation at elementary school. The publication to be used has been prepared by the author after a call of public bidding and it has just been selected. It is part a larger programme for improving education in Peru. CEREN the Executive Committee for El Niño Reconstruction headed the Minister of Transportation, Communication, Housing and Construction, accepted the author proposal to develop "Sustainable Cities I Stage", in which the physical safety is the prime objective. This time well motivated mayors are actively participating in the programme and it is being conducted by CEREN and UNDP - The United Nations Development Program.

INTRODUCTION

The IDNDR 1990-2000 has just concluded, so it is time to evaluate the outcome of the national programmes for the Decade, apply the lessons learned, and start to formulate the programme for earthquake risk reduction for the decade starting in the year 2000, to address the critical problems yet to be solved.

Peruvian delegates attended the 8WCEE in San Francisco, CA in 1984, where the Dr. Frank Press proposal for a decade in which the natural risk reduction be made through international cooperation with a special effort on the part of the country concerned, was unanimously endorsed by all delegates present (Press F., 1986). The first version of Peru's National Programme for Disaster Prevention and Mitigation - PNPDPM for the IDNDR was formulated from 1986 to 1988 and presented at the 9WCEE, in Kyoto, Japan (Kuroiwa & Tanahashi, 1988). The revised version of the PNPDPM was presented to the 10WCEE held in Madrid (Kuroiwa et.al., 1992a). The final and adjusted program was approved and published by Peru's National Committee for the IDNDR in 1994. At the same time that the Programme was being improved, implementation of PNPDPM actually started in 1989. Partial results of the advancement of the Programme including aspects of technological disaster reduction were presented at the World Conference on Natural Disaster Reduction in Yokohama, Japan (Kuroiwa, 1994).

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The two most important sub-programmes included in the PNPDPM were on the Regional Approach to Multihazard Natural Disaster Mitigation Planning, which covered two different topics and locations:

- Sustainable regional development applied to the new Grau region, located in Peru's N-W region from 1989 to 1992.

- Earthquake scenario for Peru's S-W region, where a seismic gap is said to exist, developed from 1992 to 1995.

Other significant programmes for the IDNDR are:

- A series of experimental shaking tests to improve the seismic resistance of adobe dwellings carried out in two periods. At scale 1/6 from 1991 to 1993. Full-scale tests from 1996 to 1998.

- Educational programmes 1993 ~

- Development of sustainable cities I stage. 1999 ~

This paper will place emphasis on the last two topics since they are being implemented at present and will make it possible meet in an acceptable way the PNPDPM's main objectives for the Decade, as defined early in the 90's. Results of the previous sub-programmes have been published elsewhere, so only short abstracts will be included here.

REGIONAL APPROACH TO MULTIHAZARD NATURAL DISASTER MITIGATION PLANNING

During the early 1990's it was still possible to obtain financial support for natural disaster reduction projects from the international community, in keeping with the spirit of the IDNDR. In this way two relatively important projects were conducted from 1989 to 1995.

Grau Model Regional Development Planning 1989-1992

With 41,000 km2 and some 1'900,000 inhabitants Grau is the northernmost region in Peru and one of the country's richest. It has high seismicity and was severely hit by the 1982-83 El Niño phenomenon. It was the first region to be politically organized and to appoint its authorities. It was thought that Grau could be a good model case study, where natural disaster mitigation planning would be included in its social and economic development; the experience could then be replicated in other regions of Peru. (Kuroiwa, 1990)

The strategy was for urban growth to be effected according to the lessons of Nature, by applying microzonation investigation results to land-use planning. The microzonation methods and techniques take into account all natural events threatening the area of interest: earthquakes, floods, soil failures etc. The investigated area is divided into different hazard sectors. The resulting microzonification map is a very useful tool for use in urban planning, and easy to apply. The prioritization criterion was to select the most important and fastest growing cities in the region: Piura, Tumbes, Sullana, Talara and Paita, and those with critical physical safety problems as Huancabamba that is sliding down a slope. For all those cities, microzonation investigation included: earthquake effects, floodings, and soil characteristics. In addition, tsunamis were included for the ports of Paita and Talara; and landslides for Huancabamba.

The investigations were developed as Civil Engineering professional theses at CISMID-The Japan Peru Center for Earthquake Engineering Research and Disaster Mitigation of the National University of Engineering, in short CISMID FIC/UNI. Most of the expenses were covered by JICA-Japan International Cooperation Agency. In 1991 an International Seminar was held in Piura organized by the United Nations Center for Regional Development-UNCRD and CISMID FIC/UNI. During the investigations and the seminar, the two most import universities of the region, the private University of Piura and the National University of Piura participated actively. The application of the microzonation results in land use planning for disaster mitigation by the local authorities was not as efficient as expected, and in general the implementation was extremely slow up to recently.

Regional Earthquake Scenario 1992-1995

Some Chilean, Peruvian and American seismologists have stated in their papers that there is a seismic gap in the subduction zone near the Peru-Chile border. There had not been significant release of energy since the very destructive magnitude 8, 1868 earthquake, which covered a large macroseismic area in southern Peru and northern Chile. The working hypothesis was that an earthquake of the order of magnitude 8 might occur in the subduction zone of the Peru-Chile border. The area included in the investigation was a 700 km. long and 200 Km. wide strip, parallel to the border of the Pacific ocean, according to the isoseismical lines of past earthquakes. Most of the people of the region live in that rectangle.

The investigation considered the microzonation studies of the 3 main cities: Arequipa, Tacna and Moquegua. Seismic effects, geotechnical characteristics and floodings were included for all cities. For Arequipa the menace of the Misti volcano was added. The city is crossed by valleys head on the volcano summit which is located only 13 km. from the city border at present. For Tacna, landslides were also included. The seismic risk of those 3 cities and typical towns in the coastal strip and the highlands were assessed. The tsunami inundation zones and the arrival time of the first tsunami wave were estimated for all ports and low-lying towns from the border with Chile northwards, for some 700 kms. Tsunami evacuation plans were also prepared and evacuation drills were conducted.

The study's main conclusions were that in the old sections of the main cities, where adobe and volcanic ash block constructions exist, such buildings are very risky for their inhabitants. The towns located in the highlands are more risky than those located along the coast, in spite of the fact that the latter are located closer to the possible seismic epicenter. The higher risk in the highlands is due to several factors: the lower socioeconomic level, implying poorer quality of construction; wet soils (in the coastal region soils are very dry); and the effects of past earthquakes on the adobe constructions. The name of the project was "Disaster Mitigation Programme in Perú 1992-1995". It was sponsored by the Canadian International Development Agency-CIDA and implemented by the UN Department of Humanitan Affairs-DHA/Geneva and Peru's Civil Defense-INDECI. The author was the chief technical adviser-CTA (Kuroiwa & Zupka, 1996).

The institution mainly responsible for the investigations was CISMID FIC/UNI, with important contributions from the National University of San Agustín Arequipa-UNSA and the University of Tacna. The development of 4 professional theses on Civil Engineering, one focusing on Geology and one on Geophysics were advised by professors of these universities. The resulting documents provided the background data for preparing the regional earthquake scenario for S-W Peru and response measure which was provided to the III Peru Civil Region to which the investigated area belongs.

ADOBE, THE KILLER OF THE THIRD WORLD COUNTRIES' POOR

One of the most frustating results of the IDNDR 1990-2000 in Peru may be that no effective progress has been made in reducing the seismic risk of those people living in adobe constructions. In fact, surveys made at different locations in Peru during the last few years have shown that adobe dwellings are being built with the same defects that caused nearly 40,000 victims during the Peru 1970 earthquake, when people lost their lives under the debris of their own earthen homes. The situation is worsening since in many places in the country, because of scarcity of clay, the sizes of adobe blocks have been reduced significantly, resulting in more slender walls, increasing their seismic vulnerability. It seems to be that the problem in other earthquake-prone Latin American countries is similar. So this is one of the problems to be solved in the next decade. (Kuroiwa, 1998)

There is enough expertise at present to drastically reduce the risk of adobe constructions by selecting adequate locations where the soil is dry, compact, with good bearing capacity and flat or with a gentle slope. According to damage surveys made in the last few decades, the seismic intensity has been consistently low on such a type of soil. As for example in downtown Lima, where old adobe constructions were built on dry and very compact conglomerate and have taken with minor or no damage the 1940 (M = 8.2), 1966 (7.8), 1974 (7.6) earthquakes with epicenters located less than 100 km. away.

Systematic dynamic tests carried out on the shaking table of the Structural Laboratory of CISMID FIC/UNI on a 1/6 scale model, have shown that continuous tie beams well fixed in the corners, located at the door and window lintel level increase seismic resistance by about 300% (Kuroiwa, 1992c). The Catholic University of Peru - PUC has developed strengthening methods for existing adobe constructions in full-scale tests on its shaking table (Giesecke at. el.,1999). These investigations were carried out in Peru during the 1990's. The results of extensive investigations made during the 1970's and 1980's after the Peru 1970 earthquake are also available. They were

sponsored by USAID and JICA. The 1997-98 El Niño phenomenon has reminded us that floods also cause severe damage in adobe constructions. In Peru more than 30,000 houses were completely destroyed or made uninhabitable during early 1998. Again, location is a key matter to consider, since earthen constructions are dissolved, after being a few days under water.

DEVELOPING COUNTRIES' CITIES ARE INCREASINGLY VULNERABLE TO INTENSENATURAL EVENTS.

Because of the explosive population growth in developing countries, poor people in large cities are occupying with increasing frequency marginal and highly hazardous sectors, where they build very vulnerable dwellings. Since no effective action has been taken to reverse such a worrisome situation, disasters in the next century will be even worse than today's. (Kuroiwa, 1995)

Earthquakes and floods are the two most frequent threats to people. The Colombia, Quindio earthquake of January 1999 and the El Niño effects in Ecuador and N-W Peru in 1998 are two recent examples. The flooding hazard map of the main cities of Peru's N-W coastal region were drawn in 1998. As may be expected, the flooded sectors were, with minor differences, the same as those affected during the 1982-83 El Niño. Again, the knowledge and tools to develop sound urban centers exist (Kuroiwa et.al. 1978), (Kuroiwa, 1982), (Kuroiwa & Alva, 1991), but political decisions on the part of the central and local authorities are neccessary.

A LIGHT AT THE END OF THE TUNNEL

When the PNPDPM for the IDNDR was designed it was clear that to effectively reduce natural disaster, it was necessary to concentrate efforts on diffusing the investigation results among the people who need them most (Kuroiwa, 1992b), and to convince political decision-makers at the local and national level that it is absolutely necessary to develop safe cities. Most of the poor people who live in earthen dwellings, that account for nearly 50% of the total housing existing in the country, complete elementary school only or are even dropouts. So the only chance to reach them is during the short time they attend school, and the logical vehicle is school teachers.

Educational programes

In 1993 in coordination with the Minister of Education the special publication "The Need for Knownledge on Disaster Prevention to be part of the Basic Culture of Peruvians" was used for training hundreds of school teachers (Kuroiwa, 1993). In 1996 with the saving of the "Disaster Mitigation Programme in Perú" 5,000 volumes of the improved previous publication were edited and published by SENCICO of the Ministry of Transportation, Communication, Housing and Construction - MTC. Almost at the end of the IDNDR the Ministry of Education through the General Directorate of Primary Education, has officially decided to include knowledge on disaster prevention and mitigation at elementary education level and is taking the necessary steps to effectively reach even the most remote areas with basic, easy to understand knowledge, thus complying with one of the main objectives of PNPDPM.

The Ministry of Education has called for a national bidding for preparing a special publication on disaster prevention and mitigation to be used by elementary school teachers and students all over the country. The author has prepared a 112-page book and the token volume has been edited and printed by Bruño, a prestigious Peruvian editorial. The publication contains numerous figures, charts and pictures. The latter are photographs taken in the wake of the most disastrous natural events in Peru and other Latin American countries during the past 30 years. These full color pictures "worth a thousand words" are in keeping with the level of the publication, which must be easily understood by young school children. The Ministry of Education has just selected the publication and the first edition will consist of 59,000 volumes to be distributed in all public elementary schools.

Bruño will make a great effort to introduce the publication to students at all levels, including universities, and to the general public. It is expected that, if things go well, that number of volumes may be multiplied several times the above figure.

Actions to reduce risk in urban centers

In 1995, at mid-IDNDR, it became clear that to reduce risk in urban centers much more needed to be done than developing practical useful theses on microzonation in the universities as academic exercises. The political

decision of the central and local governments to develop safe cities and to provide the necessary funds are absolutely necessary.

The Chief of the Peru's Civil Defense sent the volumes containing the microzonation maps to all mayors whose cities and expansion areas had been included in the microzonation investigations, for them to take action on land-use planning for disaster mitigation. The theses were presented as one of the acts on the Commemoration of the 25th Anniversary of the 1970 Peru Earthquake, which left over 50,000 victims. In 1996, when new local authorities took office, the author met them in a national assembly to let them know the safety problems facing their communities; and published in the editorial page of "El Comercio", Peru; most prestigous newspaper, a message to the local and national authorities on the necessity of developing urban centers according to the lessons Nature has taught us.

We were having a hard time getting the authorities to listen, then the 1997-98 El Niño occurred, and eventually caused about two billion USD in direct losses. The worst-hit area was again Peru's N-W region near the border of Ecuador where the Intertropical Convergence Zone-ITCZ displaced south from its usual location north of the Ecuatorial line. The lakes which provided water for the Panama Canal were almost empty but in Ecuador and northern Peru there was torrential rain. The 1982-83 El Niño also caused direct losses of some two billion USD, but the consequences remained for years because the productive facilities of N-W Peru were completely disrupted including the Panamerican Highway and other roads. The irrigation canals remained out of service for a long time, so the indirect losses were also huge.

Based on that negative experience of the previous catastrophic event, and the fact that the El Niño indicators had shown that a large event was incubating (the El Niño Southern Oscillation-ENSO had shown negative value and the anormality of the superficial Sea Water Temperature-SSWT was unsually high, which could by easily obtained from NOAA/Internet), the Peruvian Government took a series of preventive actions during the second semester of 1997 and early 1998 to reduce the impact of El Niño. These measures were taken under the leadership of the president Mr. A. Fujimori and CEREN - The Executive Committe of Reconstruction of El Niño which was headed by the then prime minister Mr. A. Pandolfi who continues as chief of CEREN and was appointed Minister of Transportation, Communication, Housing and Construction - MTC to be directly involved in the reconstruction task of the most affected sectors. In September 1998, by mutual approach, Mr. Pandolfi nominated the author as ad-honorem adviser of CEREN.

In November 1998, the author proposed CEREN the development of Sustainable Cities I Stage which was accepted. At the same time the United Nations Development Program-UNDP that was already assisting CEREN approved its participation in the Programme. At the present this CEREN-UNDP programme is being developed jointly. The requests from mayors of the places that were hardly hit by the 1997-98 El Niño to participate in the programme have surpassed the capacity of the working group, so the necessary and important participation of the local universities in the programme implementation has been agreed in a public ceremony held in Piura very recently.

Those two mentioned opportunities represent the "light at the end of the tunnel", a tunnel which was very dark up to 1997. Because of the importance and timeliness of the Sustainable City Development Programme, it will be included separately.

SUSTAINABLE CITY DEVELOPMENT-SCD FIRST STAGE

We define a sustainable city as one which is safe, orderly and efficient in its functioning and development. If we are able to develop such a type of city, we can leave to the future generations sound urban centers, where the inhabitants will not have to suffer a drastic reduction in their standard of living because of an intense or extreme natural event. It is a very difficult task to implement, especially in third world countries, but not impossible. This may be another important task for the century starting in the year 2000.
In its first stage the objective is more modest: to reverse the increasing risk of the important cities of developing countries located in natural disaster-prone regions. As has been stated, the knowledge to do so already exists, and the decision to go ahead has been taken at the highest political level and also by local level authorities in Peru. This an opportunity and a challenge to succeed.

Approach of the SCD 1st stage

The strategy for success in Group A, which includes 10 cities, is that the programme is comprehensive, simple to apply and the process of approval of land-use planning results involves the conscious active participation of the

citizen. The selected cities were severely affected by El Niño 1982-83 and 1997-98, except Ica that was hit only by the last event. So the city mayors and the communities are highly motivated.

All the mayors have had working meetings with the CEREN-UNDP Working Group. They have readily requested to participate in the Programme. Large municipalities such as Piura and Tumbes are also providing own funds and have set up working groups.

The steps of the programmes with some commentaries are as follow.

a) **Initiative** of the city mayor. Request to CEREN-UNDP to participate in the Programme, which has already been made by all the mayors of Group A cities.

b) **Programme formulation** for each city according to a model developed. The programme of some cities has already been formulated and field work is underway.

c) **Preparation of city and expansion areas hazard map**. This is a simplified microzonation map. Six of the cities have microzonation investigation results in which the flood hazards have been drawn by the Nature in 1983 and 1998. The respective professional theses were developed at CISMID FIC/UNI. The University of Piura and the National University of Piura will review and improve the previous investigations and will develop the studies for 3 new cities. The study for the city of Ica is being jointly made by CISMID FIC/UNI and the National University of Ica.

d) **Land-use planning**. Most of the plans are the responsability of National Institute of Urban Development - INADUR of MTC, but some private consultants are also participating. The Ica plan is in the hands of a local architect who is developing her master degree thesis at the Graduate School of Architecture of the National University of Engineering. Lima.

e) **Approval process**: City Council (Provisional) Professional Associations Public Assembly City Council (Final)

f) **Municipal Ordinance**. The model ordinance in which all legal problems have been solved is ready.

The main aim of the Programme is to prevent occupancy of highly hazardous areas for urban purposes. The geologists and architects have been especially advised to delimit such sectors carefully, for designation as ecological reserves and recreational areas.

The highest degree of hazard is “exceptionally high”, and in sectors belonging to this category urban development is not permitted under any circumstances. In the cities under consideration, there are only a few areas in this category. Most of the cities have sectors of “high”, “medium” and “low” hazard.

Sectors included in the category of high hazard are, for example, areas which are flooded at low velocity, or soil consisting of eolian sand. Earthen constructions are not permitted in either of these cases. Such constructions are highly vulnerable when under water for several days. Also, on eolian sand, settlement and high seismic intensity is expected, which cannot be supported by the heavy, weak adobe construction. Lightweight materials such as wood and bamboo have behaved well in past earthquakes, including in Armenia, Colombia, in January 1999.

The experience of recent past disasters, such as the El Niño 1997-98 is being taken into account. For example, San José, in the lower part of Tumbes, has been flooded several times. All adobe constructions have gone, but brick and wood and bamboo buildings have remained standing, with minor damage only. A special manual is being prepared with a guide to suitable construction materials and methods, and the soil coefficient of the new 1997 Peruvian Seismic Code to be applied in each sector.

CONCLUDING REMARKS

Peru designed its first programme for the Decade in 1986-88. This was subsequently improved and finally approved by Peru’s National Committee for the IDNDR in 1994. Frustrations and advancements in the implementation of the PNPDPM are included in this paper. With each point there is an indication of the important remaining problem to be addressed in the years to come. A comprehensive programme for the decade starting in 2000 is being prepared. In the last two years of the IDNDR 1990-2000, the Peruvian Government and local authorities have decided to commit themselves to disaster reduction in the cities hard hit by the El Niño

1997-98. Their commitment will make it possible to start providing physical safety to some Peruvian cities. This case study is expected to be followed by other cities, for which special legislation could be of great help. Peru's Congress is currently being lobbied on this matter. If the publication written by the author is adopted as a text book, there is a good chance of reaching primary school students all over the country, and supplying them with basic knowledge on disaster mitigation, in a massive but organised way.

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