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Disaster mitigation planning for the Grau Region, Peru

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ABSTRACT: This paper deals with the results of the pilot research done in the Grau Region of Peru using microzonation analysis for regional development planning. Through the study of the physical and socio-economic conditions and the natural disasters that occur in the area, land use planning is effected for the future safe development of cities in the area. Nevertheless, political level awareness is necessary for the full use of this kind of information. The final goal is to reduce the impact of natural hazards through prior planning and countermeasures.

1 INTRODUCTION

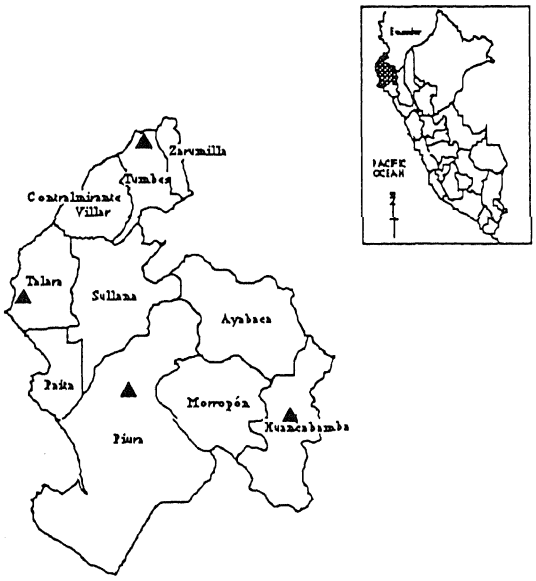
The Grau Region is located in the coastal north-western border of Peru (Fig. 1)

It is a disaster prone area due principally to earthquakes with intensities between VIII and IX MM (1912, 1953, 1970) and heavy rain (1925, 1983). The most recent disaster was produced by "El Niño" induced heavy rains which produced flooding that destroyed houses, infrastructure and agriculture in 1983.

Grau was the first Region to be established under the new "regionalization process" started by the government and so the timing was appropriate to convince local authorities about the necessity of regional disaster prevention studies.

Due to understandable economic restrictions, the result of this research has limitations. The contents of this paper are based on overall research and 5 civil engineering graduate theses advised by the authors. Seven more studies are still being developed including the work of professors and students of other Faculties such as architecture and environmental engineering.

The studies were done by the Peru-Japan Center for Earthquake Engineering Research and Disaster Mitigation (CISMID) of the Faculty of Civil Engineering (FIC) - National University of Engineering (UNI), and were supported by the Japan International Cooperation Agency (JICA) and the United Nations Centre for Regional Development (UNCRD-Nagoya, Japan).



▲ selected study cases

Figure 1. The Grau Region and provinces

2 METHOD

The research is based on the microzonation method in a wide sense, not only from the seismic point of view but including all other possible natural hazards present in the region. Using this information and the vulnerability assessment, the risk potential can be obtained. Also, the areas for safe future urban expansion can be determined and as a next step land use and disaster prevention planning enforced by local governments will reduce the risk of disasters to provide a better and safer living environment.

Some studies can cover region-wide aspects like socio-economic conditions, seismicity and natural disasters, but more detailed studies are necessary to assess the possible impact of natural disasters in specific locations like major cities.

For the selection of study cases the most fast-growing cities and cities with specific hazards were selected:

- Tumbes and Piura, the capital cities of the former Departments of the same names that jointly became the Grau Region.
- Talara, a city with an oil-based economy which suffered from sand invasion during the 1983 El Niño phenomenon
- Huancabamba, a city in the highlands area that suffers a creep process.

In order to catch the attention of the local authorities, a meeting was held in February 1990 with the cooperation of regional organizations and universities. Also in June 1991 an "International Workshop on Regional Disaster Management" was held with the support of JICA and UNCRD.

3 RESULTS

The results of the research for each location are summarized as follows:

3.1 Microzonation of Tumbes and guidelines for its urban development (Tapia 1991)

Tumbes is located in the northern part of the Grau Region, with a population of 60,000 and a population growth rate of 5%. About 60% of its population is continuosly moving to and from the border area with Ecuador.
The main activities are touristic services, commerce, agriculture and fisheries.

The city can be divided into three sectors: "Old city" (consolidated older part), "Intermediate city" (urban settlement limited by the topography) and "new Tumbes" (proposed expansion area) (Fig. 2)

The city on the right bank of Tumbes river is crossed by small and medium size ravines that become drainages when rain occurs. Also erosion and river flooding are possible. The water table is superficial (0.5 mts in dry season). Seismic wave amplification and settlements (soft soil) are highly probable.

Military areas are an obstacle for the good expansion and consolidation of the city.

The periphery of the city has a high risk against an "El Niño" phenomenon and the central area against an earthquake. (Fig. 3)

There are two expansion areas from the security and function points of view: The lower part, with restrictions due to flood danger, and the higher part, behind "new Tumbes" (Fig. 4)

The recommendations are to consider seismic and "El Niño" effects in any development plan, to implement the land use reorganization, make lifelines evaluation and build drainage systems.

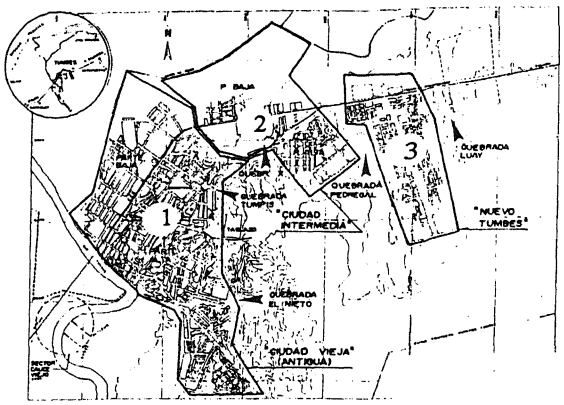


Figure 2. Tumbes city and sectors.
1: Old city; 2: Intermediate city ; 3: New Tumbes

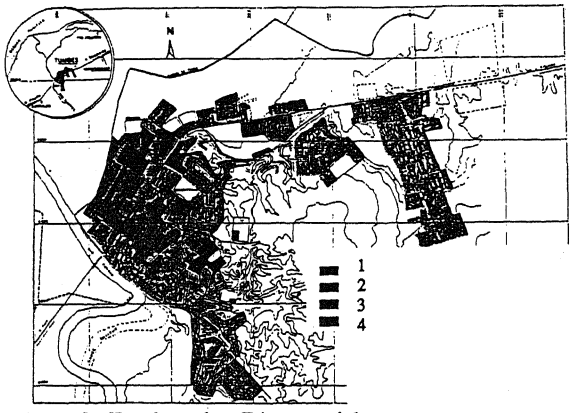


Figure 3. Tumbes city: Disaster risk zones.
1: Earthquake and "El Niño" high risk
2: Earthquake high risk
3: Moderate "El Niño" and fire high risk
4: Earthquake and "El Niño" medium risk

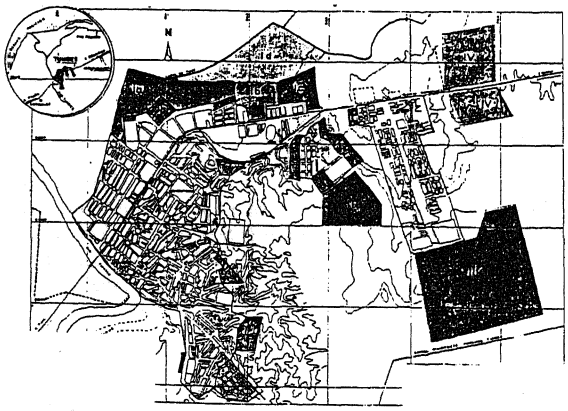


Figure 4. Tumbes city: Areas for proposed urban growth.

3.2 Microzonation of Piura and guidelines for its urban development (Madrid 1991)

Piura is the seat of the Regional Government. It has a population of 334,000 and covers a surface of 3,480 Has. More than 50% of the population live in informal settlements where the predominant building material is "quincha" (wood frame with cane and earthen covering, very resistant in case of seismic movements, but weak against heavy rain and flooding) (Fig. 5)

Superimposing the flooding, soil type and local seismic effect map a potential risk microzonation map was obtained with identification of zones prone to be inundated and with possible seismic induced sand liquefaction. This map is useful for land use planning and for determining the areas of high risk of disaster.

The areas occupied by informal settlements are vulnerable, specially the ones in the south-east and west of Piura and south and east parts of the Castilla district.

The present urban growth is adequately developing towards the north, north-east and west. Towards the south-east there are low areas with unfavorable soil conditions (Fig. 6).

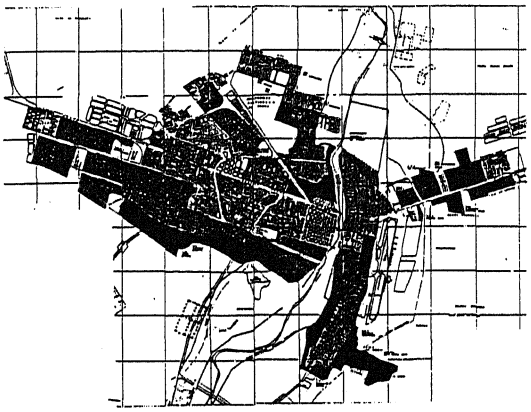


Figure 5. Piura city: Vulnerability of the urban structure. The darker areas are vulnerable informal settlements

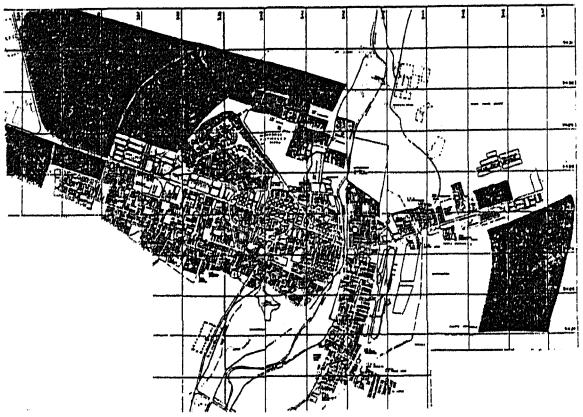


Figure 6. Piura city: Areas for proposed urban growth.

3.3 Microzonation of Talara and guidelines for its urban development (Yamunaqué 1991)

Talara is centered in the petrochemical industry and with a disordered rapid anual urban growth of more than 5%. By 1995 it will probably have a population of 125,900.

The city has two main well-differentiated areas "Low Talara", between 0-25 mts. and "High Talara", over 80 mts. above sea level.

The heavy rains of 1983 produced the deposit of more than 300,000 m3 of sand in Talara Baja, due to soil erosion from the upper parts. The water supply was cut, houses and roads were destroyed and high rise waves affected the coastal areas.Tsunamis of 8-12 mts. of wave height and 7-10 minutes of arrival to the coast are possible. Soil failure is also possible in some areas.

The recommendations are to make a integral drainage system, forest the slopes surrounding Talara Baja and the coastal line, develop the city towards the Negreiros sector, develop an educational program about the natural disasters in the city and make a land use plan .

3.4 Forestation of Talara's slopes (Vilela 1991)

As a complement to the microzonation studies, this study focused on the sand erosion problem to be solved using treated sewage water (stabilization lagoon) from Talara Alta for the forestation of the slopes towards Talara Baja as a complement to drainage systems. The use of native plants like Prosopis juliflora ("algarrobo" or carob tree) and Desmodium heterophilum with a low pressure aspersion irrigation system is recommended.

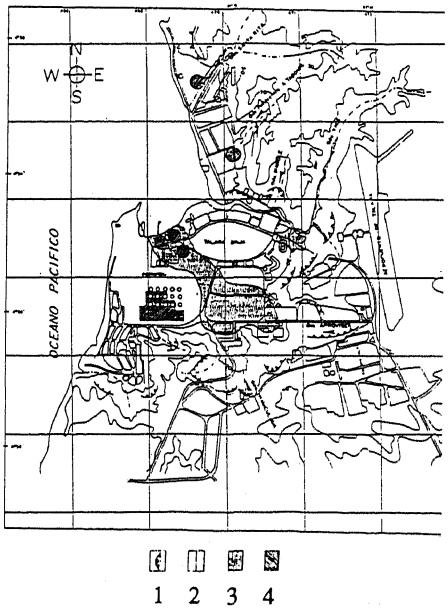


Figure 7. Talara city: geodynamic problems
1: unstable slopes; 2: ravines; 3: sand vulnerability; 4: water accumulation

3.5 Microzonation and urban planning of Huancabamba (Gonzáles 1991)

Huancabamba (pop. 10,000) is a town located in the highlands and known as "the walking city" for the continuous soil creep down the slope. The rain water that infiltrates in the upper part of the city contributes to the instability of the slope.

This mass movement affects existent infrastructures and buildings. About 85% of the buildings are of adobe masonry so the city is highly vulnerable in case of a seismic movement.

The recommendations are to construct a drainage system for the upper parts of the city in order to avoid water infiltration that contributes to the slope instability. Change of land use of critical areas to recreation areas and a new expansion area in Quispampa, an almost flat area with great stability.

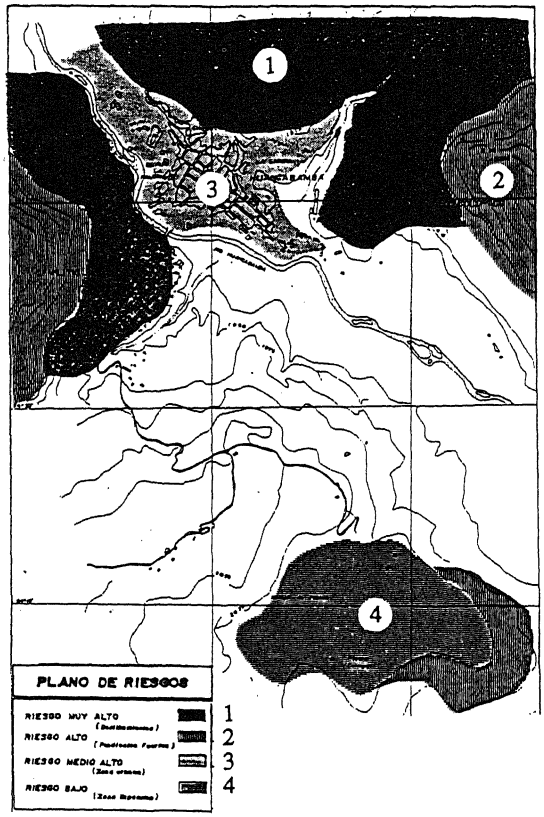


Figure 8. Huancabamba town: Risk map
1: Very high risk (land-sliding); 2: High risk (step slope): 3: Medium-high risk (urban zone); 4: Low risk (zone for proposed urban growth)

4 CONCLUSIONS

It is necessary to consider disaster prevention studies in the socioeconomic development plans and raise people's awareness about possible disasters and their countermeasures.

A continuous program for maintenance and improvement of defenses is of vital importance.

Disaster prevention research and countermeasures are a difficult task in a developing country with serious economic restrictions like Peru. Nevertheless, with the manpower of available professors and students at universities and the opportune support of international organizations like JICA and UNCRD, it is possible to start studies and raise the concern about the need for such kind of studies.

Decision making authorities must be provided with the information and feasible specific proposals in order to convince them of the need to do disaster mitigation planning in order to mitigate the social and economic impact of natural hazards.

The results of the studies done in the Grau Region must be extended to the other 11 regions and finally complete a national program for disaster prevention and mitigation.

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Note: for more detailed information see the explanations and colored maps of the poster session.